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8th Conference on Information and Graphic Arts Technology

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Invited lectures

BIOMASS UTILIZATION IN POLYMER SYNTHESIS AND NANOCELLULOSE PRODUCTION

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ABSTRACT: *Biobased platform chemicals can be provided through lignocellulosic conversion in biorefineries. Acid catalyzed glycolysis of biomass wastes is such example. The liquefaction reaction was the basic platform for production of polymers, adhesives, energy and nanocellulose. We used the liquefied wood as a polyol in the polyester synthesis, which was applied in polyurethane foam production. Liquefied biomass reacts with thermosetting systems containing melamine–urea–formaldehyde resin and it was found that a 50% addition of liquefied wood met the European standard quality demands for particle boards. Two fuels, namely liquefied cotton fibres and liquefied biomass, were used in gas turbine. Stable combustion was achieved and experimental results indicate successful utilization of these biofuels in professional gas turbines. The same liquefaction process was used for isolation of nanocrystalline cellulose (NCC) from biomass. This method represents a novelty and is a model procedure for NCC isolation from different natural cellulosic sources with high yields and with high crystallinity index.*

Keywords: biomass, lignocellulosic sources, liquefaction, nanocrystalline cellulose, gas turbine.

1 INTRODUCTION

Biobased platform chemicals can be provided through lignocellulosic conversion in biorefineries. However, to make such a process economical, the combination of high value products generation with bioenergy production is essential. An overview of some applications and methods are presented in this contribution. Since the petrochemicals may soon be limited, considerable attention has been given to the selective conversion of biomass into chemicals such as 5-hydroxymethylfurfural and dimethylfuran by selective chemical catalysts. The conversion of biomass by depolymerization and fermentation is presently the most potential approach. Recent studies of acid catalyzed depolymerization with organic solvents have allowed to increase yields of basic chemicals such as furfural, hydroxymethylfurfural and levulinic acids (Jasiukaitytė, 2009; Dutta, 2014). Although biomass based lignocellulosic materials are complex, three major transformation pathways are more commonly used:

- fast pyrolysis at high temperatures and subsequent conversion into the liquid products and the gaseous products that are used for energy production;
- thermochemical conversion, at elevated temperatures and with the use of different liquefying agents and catalysts. Here, solvolysis and depolymerization take place simultaneously with the liquid final product being rich in hydroxyl groups;
- biochemical modifications (enzymatic conversion into ethanol and other depolymerization products).

1.1 Chemicals from biomass

Biomass is primarily composed of cellulose (40–50%), hemicellulose (25–35%) and lignin (15–20%). The composition varies considerably depending on types of biomass, part of the plant, etc. Cellulose is the major structural component of the plant cell walls and is organized into fibrils, which are aligned parallel to each other, surrounded by a matrix of hemicellulose and lignin.

A multitude of different types of biomass has been tested, for example: algae, cultivated crops, agricultural waste, forest resources, etc. The term that is usually associated with such conversion is biorefinery. A variety of technologies have been used, including fermentation, pyrolysis, thermochemical conversion, hydrothermal liquefaction, catalytic conversion, etc. (Zhang, 2010).

1.1.1 Hemicelluloses

Hemicelluloses, hetero polymers that are present along with cellulose in plant cell walls contain xylose, mannose, galactose rhamnose and arabinose. They can easily be isolated from the plants by different purification methods using acids, organic solvents and alkaline reagents. Other methods include steam explosion, ultrasonication, extrusion and microwave irradiation. Further conversion into hydroxymethyl furfural, furfural and even propionic acid can be achieved by reaction in a catalyzed ionic liquid, fermentation processes or hydrothermal processes (Peng, 2012).

1.1.2 *Lignin*

Lignocellulosic biomass is mainly cell wall material and lignin is one of three principal components beside cellulose and hemicelluloses. Lignin serves as a binding agent adding strength to the cell walls. It is a cross-linked amorphous polymer synthesized from aromatic alcohol precursors, p-coumaryl, coniferyl and sinapyl alcohols and has a very complex structure.
Lignin without chemical modification can be used as a filler, anti-oxidant, UV-stabilizer, surfactant, etc. The chemical modification of lignin (Azadi, 2013; Khalil, 2012) has much better potential for multiple applications and can be classified into three main categories:

- fragmentation;
- modification by creating new chemical active sites;
- chemical modification of hydroxyl groups.

1.1.3 *Nanocellulose*

Nanocellulose, the carbon neutral and sustainable material with outstanding mechanical properties, is one of the most promising materials and has been a subject of recent interest. Many new nanocomposite materials with attractive properties have been prepared by physical incorporation of NCC into a natural or synthetic polymeric matrix and also holds promise in many different applications such as in nanopapers, coatings, adhesives, optical sensors, biomedical scaffolds, filtration membranes, electronic devices, foams, aero gels, etc., which make NCC of significant interest from a scientific and industrial perspective. Major studies over the last decades have been dedicated to the use of nanocellulose as a filler in nanocomposites to improve mechanical and barrier properties. It can be easily chemically modified due to the abundance of -OH groups on the surface of the nanocellulose through the acetylation reaction, TEMPO oxidation, silylation, polymer grafting, all with the purpose of modifying the polarity of the nanocellulose surface and of improving the compatibility with different polymer matrices (Habibi, 2014). Due to the nanocellulose high functionality and so many possible chemical modifications the material applications for nanocellulose are almost limitless.

1.2 The liquefaction process

The liquefaction of wood and other lignocellulosic materials in the presence of phenol or polyhydroxy alcohols has been intensively studied by several authors and has been described in details (Yamada, 2001). Such a liquefaction process is usually carried out at elevated temperature and in the presence of an acid catalyst. The liquefied wood contains depolymerized products from the β 1-4 glucosidic bond cleavage of the cellulose and hemicelluloses molecules as well as from low molar mass oligomers. The complex structure of the lignin molecule is broken to smaller fragments. According to Lin et al., the dominant products were guaiacylglycerol-α-phenyl-β-guaiacyl ethers, followed by guaiacol, triphenylethanes, diphenylmethanes, benzocyclobutanes and phenylcoumaranes (Lin, 1995).
While a large number of papers have been published describing the liquefaction process, the characterization of the product and the reaction pathways, little information is available on the application of the more specialized techniques in biomass liquefaction. One of these is microwave driven wood liquefaction, where microwave heating has been used in a very efficient and fast liquefaction of wood. The efficiency of liquefaction and the time needed for the complete liquefaction was reduced significantly (Kržan, 2006).
A novel approach to very efficient energy input during the thermochemical conversion of lignocellulosic biomass into liquefied depolymerized products is the use of ultrasound technologies (Kunaver, 2012). High energy ultrasound has been used in liquefaction reactions with different wood waste materials. The most common wood waste materials were chosen in order to prove the efficiency of the ultrasound process and to establish a different way for recycling wood wastes, found in the municipal waste deposits in large quantities. The reaction times were shortened up to nine times when using the ultrasound process with smaller residual particles and with no influence on the hydroxyl number of the final products.

2 EXPERIMENTAL

2.1 Biomass liquefaction

The liquefaction of wood was carried out in a 1000 mL three-neck glass reactor, equipped with the mechanical stirrer and condenser. The reactor was charged with 100 g of wood and 300 g of glycerol – diethylene glycol mixture (4:1). 9 g of p-toluenesulfonic acid was added. The proportion of the constituents in the reaction

mixture was chosen after the initial trials, with the goal to maximize the glycerol content as a by-product of the biodiesel production. A certain proportion of glycerol was replaced with diethylene glycol to provide the required degree of viscosity reduction for the final product. The mixture was heated for 3 hours at 180°C while being constantly stirred. A sample was withdrawn from the reaction system periodically and immersed in cold water to quench the reaction.
The extent of liquefaction was evaluated by determining the residue after the washing out the sample with dioxane and water (4:1 v/v). The residue was dried in an oven at 105°C to constant weight. The conversion yield was calculated as the weight percentage based on the starting wood material.

3 RESULTS & DISCUSSION

3.1 Polyesters

The hydroxyl value of the liquefied wood has been determined by several authors and is generally determined to be between the equivalent of 200 and 500 mg KOH/g. The actual value depends on the liquefaction time. This large number of hydroxyl group sites means that the products have applications in those areas in which the hydroxyl component can be used in complex polyester synthesis. Kunaver et al. used the liquefied wood as a polyol in the polyester synthesis (Kunaver, 2009). Saturated polyesters are defined as polyesters whose components contain no polymerizable double bonds, the opposite of what occurs with alkyd resins and unsaturated polyesters. Saturated polyesters are synthesized by the condensation of bifunctional or polyfunctional monomers containing hydroxyl or carboxylic groups. The hydroxyl groups in the current investigation originate from liquefied wood. The polycondensation process takes place at temperatures of 150 to 260°C. Water as the main reaction byproduct, is removed from the system by the creation of a slight vacuum, gas stream condensation or an azeotropic process.
The products were characterized using FTIR, GPC/SEC and viscosity measurements. The polyesters have hydroxyl values that were reduced due to esterification, from 1043 mg KOH/g of the liquefied wood to 400 to 800 mg KOH/g. 22 to 23% of the polyhydroxyl alcohols in the polyester formulations were replaced by wood derivatives. A rise of the average molar mass was achieved together with a reduction of the hydroxyl group content. Such modification of the polyester reactivity and complexity is favorable for further utilization in polyurethane synthesis.

3.2 Adhesives

Hydroxyl groups in liquefied lignocellulosics can also react with different reactive sites in thermosetting systems as well as in two component systems.
Kunaver et al. applied a mixture of liquefied wood and melamine – urea – formaldehyde resin as an adhesive in wood particle board production (Kunaver, 2010). The properties of laboratory prepared particle boards are presented in Table 1, together with the values required by European standards.

Table 1. Properties of laboratory prepared particle boards (simulation of the industrial process).

Property (corresponding EN standard)	Required values	Achieved values
Board thickness (EN 324) [mm]	16.00 ± 0.30	16.10
Density EN 323 [g/cm3]	/	0.72
Internal bond strength (EN 319) [N/mm2]	above 0.35	0.94
Surface soundness (EN 311) [N/mm2]	above 0.80	1.96
Bending strength (EN 310) [N/mm2]	above 13.00	21.10
Swelling in Thickness (EN 317) [%]	below 15.00	8.20
Formaldehyde release Perforator method (EN 120) [mg/100 g board]	below 8.00	3.20

Formaldehyde release was lower than 8 mg/100 g in all experiments due to the positive influence of the liquefied wood components. It can be concluded that the products of the liquefied lignin with their aromatic character behaved as a formaldehyde scavenger. Lower formaldehyde emissions from particle boards due to the use of the liquefied wood, are extremely important in the provision of better quality of life. On the basis of the presented values one can conclude that liquefied woods can be used as a substitute for synthetic resin precursors in adhesives that are used for particle board production.

3.3 Polyurethanes

Liquefied lignocellulosic materials are considered to be an alternative feedstock for polymer synthesis. Recently, considerable attention has been given to the preparation of environmentally friendly polymeric products from liquefied biomass materials and their derivatives.

In the liquefaction process, the hydroxyl group-containing species in the wood components can be used as polyols for several different purposes. The polyhydric units that are present in the resulting liquefied/derivatised wood can be used in the creation of polyurethane foams, polyurethane resin precursors and in the recently developed wood-polyalcohol based urethane adhesives (Čuk, 2015).

We combined the recycled PET polyester with liquefied wood polyester for the production of the polyurethane/polyisocyanurate foams. Glass transition temperature, density, and water absorption of the foam increased with increasing amount of glycerol in liquefied wood, compressive stress increased too, while thermal conductivity was not affected.

3.4 Liquefied biomass as a fuel in gas turbine

Second generation biofuels are increasing their share in the energy source portfolio, which is mainly driven by the availability of low quality residual biomass and other lignocellulosic materials as well as by their inoffensive production in comparison with food competitive feedstocks. Two fuels with low carbon footprint, produced by liquefaction in acidified polyhydroxy alcohols were tested with one being made from cotton fiber (90% cellulose) and the other one from lignocellulosic biomass (Seljak, 2012). Lower calorific value of the product is 20.2 $MJ \cdot kg^{-1}$ and thus only 20 $kJ \cdot MJ^{-1}$ of energy value is consumed for fuel production when ultrasonic assistance is applied. For comparison, production of bio-oil, which has lower calorific value, uses 72 $kJ \cdot MJ^{-1}$. Additionally, both fuels were also neutralized to analyze the impact of product reactivity on combustion performance.

To analyze impact of fuel properties on the combustion performance and exhaust emissions, multiple parameters were varied in an experimental study conducted on a laboratory scale gas turbine. To examine effects of viscosity, fuel was preheated to different temperatures, ranging from 80 to 110°C and airflow varied between 0.15 and 0.23 kg/s. Turbine inlet temperature varied accordingly. Combustion chamber inlet temperature was kept between 400 and 500°C by means of regeneration. In this way, evaporation of droplets was promoted and conditions closely resembled those in commercially available systems. Results were compared to those obtained with diesel fuel, which provided an insight into phenomena influencing performance and exhaust emissions in small co-generation plants.

Stable combustion of all fuels with CO emission measurements below 500 ppm was achieved even in a flow field un-optimized combustion chamber. THC emissions remained reasonably low, while NOx emissions increased with increased turbine inlet temperature and to a lesser extend with increased fuel temperature. Although pollutant emissions while utilizing the analyzed biofuels, especially those of CO, are higher than corresponding emissions with the diesel fuel, experimental results indicate successful utilization of the analyzed biofuels in professional gas turbines.

3.5 Nanocellulose

The same liquefaction process was used for the isolation of the nanocrystalline cellulose from biomass (Kunaver, 2016). The method is a novelty and a model procedure for NCC isolation from different natural cellulosic sources with high yields and with high crystallinity index. The process of preparing NCC from different natural sources uses glycols as the main reactant and an acid catalyst in low concentration (only 3%). Here, during the one step reaction, lignin, hemicelluloses and the more disordered components of the cellulosic fibers are liquefied, only the crystalline cellulose remaining as a solid residue. The yields, crystallinity index and morphology of thus produced NCC were comparable to those NCC products that were described in recently published papers (Fan, 2012; Texeira, 2010).

The liquefaction reaction, using glycols and mild acid catalysis, was optimized and applied to four model materials, namely cotton linters, Chinese silver grass, spruce wood and eucalyptus wood. The liquefaction reaction took place in a glass reactor with constant mixing at 150°C for 180 minutes. Afterwards, the reaction mixture was diluted 1:1 with 1,4-dioxane and centrifuged at 8000 rpm for 20 minutes, re-dispersed and centrifugation repeated until a clear supernatant liquid was obtained. The % recovery of the nanocrystalline cellulose, the crystallinity index of the nanocrystalline cellulose and the average crystal dimensions are presented in the Table 2.

The SEM micrographs of the isolated NCC are presented in Figure 1. The method can be applied to different cellulose-containing biomasses. The main benefit of the process arises from the ability to prepare stable NCC suspensions in an organic medium at 10 times greater loadings than can be achieved in aqueous suspensions. The liquid residues contain significant quantities of levulinic acid and different sugars that were derived from cellulose and hemicelluloses.

Table 2. The NCC recovery percentage, the crystallinity index (C_rI) and the average NCC crystal length and crystal width

Biomass	NCC recovery [%]	C_rI [%]	Avg. NCC crystal length [nm]	Avg. NCC crystal width [nm]
Cotton linters	74.5 ± 6.0	80.0	242.0 ± 8.0	12.7 ± 0.4
Chinese silver grass	55.6 ± 4.0	62.8	250.0 ± 17.0	8.9 ± 0.2
Spruce wood	61.5 ± 3.2	63.0	235.0 ± 23.0	8.9 ± 0.1
Eucalyptus wood	63.0 ± 8.5	66.0	306.0 ± 13.0	9.0 ± 0.1

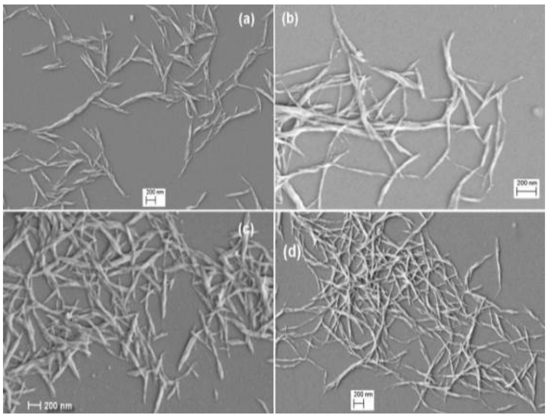

Figure 1. SEM micrographs of NCC: cotton linters (a), Chinese silver grass (b), spruce wood (c) and eucalyptus wood (d).

When dealing with wood or similar lignocellulosic materials, some sugars derived from hemicelluloses were identified as was some glucose. It is possible to isolate the levulinic acid selectively from liquid residues and sugars that were identified in the liquid residue from the wood liquefaction process could be used as a feedstock for several fermentation processes in ethanol production.

3.6 Nanocellulose applications in paper and wood coatings

This NCC was mixed in various concentrations into the starch and polyvinyl alcohol coatings (PVA), as an additive for improving the printability and mechanical properties of selected printing materials (Medvešček, 2017). The main purpose of the study was to optimize the surface properties and thereby to improve the printability of paper as well as to improve the quality of digital personalized data prints on the security documents. Uncoated as well as coated paper samples were coated with the prepared starch and PVA coatings and with the addition of different NCC concentrations. Mechanical measurements and printing analyses were made. It was established that the addition of 3% of NCC improved the printability of the paper with ink jet printers since the NCC gives more interlinked structure of the paper and due to its high hydrophobic character, a better absorption of water-based inks.

NCC was mixed in different concentrations in three different wood coatings and applied to three different surfaces: wood, glass and metal (Skok, 2017). By increasing the proportion of the NCC, the viscosity and hardness increased. There were no major changes in the contact angle. Gloss and roughness of the surface were inversely proportional. The gloss increased to some extent, and the roughness decreased. According to some published papers a slightly positive effect of nanocellulose addition on the hardness and modulus of the coatings was observed while scratch resistance improved consistently (Veigel, 2014).

4 CONCLUSIONS

The possibilities of converting lignocellulosic biomass and biomass waste in particular into valuable chemicals and raw materials for further use in polymer chemistry are numerous. Intensive studies of this challenge have been governed for the last two decades. The biorefinery concept has been firmly established and the only danger that has to be guarded carefully is that the production does not compete with food production. It provides new prospects of utilizing renewable resources for production of energy, organic chemicals and polymers through complex processing technologies. Lignocellulosic biomass, the most abundant sustainable feedstock on earth contains cellulose, hemicellulose and lignin in various proportions. Each of these three biomass components can then be converted into different platform chemicals. One of the newest challenges is the isolation and application of nanocellulose, an outstanding material which is carbon neutral, sustainable, recyclable and non-toxic. It has the potential to become a true green nanomaterial, which can be used in high performance applications. The final cost of bioproducts depends upon the processing costs therefore; high tonnage, high yields and the reduction of the synthesis steps are the most important development trends nowadays and in the future.
All the products can be regarded as higher added value materials, decreasing the dependency to the crude oil production and at least not increasing the greenhouse gas emissions.

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COMPUTATION APPROACH FOR REALISATION OF CONTEXT-AWARE ROBOTS

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ABSTRACT: *Humans are using memories, guesses and other implicit information stored or collected to reason about most appropriate solutions. Unlike humans, robots do not understand context by default. Compared to conventional approaches where robots are preprogramed to react to a finite number of environmental occurrences, contextual awareness can enable modeling of humanlike adaptation skills. Computational models presented in this work could be understood as context-to-data interpreters that transform contextual information into data, allowing machines to make context-driven decisions. The basic model contains three main parts. The first part is used to track and collect significant environmental information. The second part represents formal knowledge about the domain of interest. The model also contains a probabilistic component realized by a Bayesian Network. The overall methodology is presented through three separate examples illustrating reasoning based on: (i) phenomenon of social capital, (ii) human bodily awareness and (iii) human emotions.*

Keywords: Affective robotics; Context-awareness; probabilistic reasoning; knowledge representation.

1 INTRODUCTION

Contemporary systems are usually programmed for a limited range of activities foreseen in advance by a system developer. Such systems cannot act in any unpredicted situation by default. Their reactions are based only on expected environmental stimuli. Such a reactive system can be very fragile if something unexpected occurs. This is why robots are so impressive in factories, but so incompetent in any human environment. In contrast, the system that is able to partially realize context can potentially do both: it can act reactively and it can comprehend the present and predict future results or actions. It seems that humans and animals are adapting to their natural environment in a similar way (Barrett, 2017). In most cases, contemporary machines are using explicit knowledge. In contrast, contextual perception presumes much more implicit understanding. Research into new methodologies and paradigms is therefore directed toward the development of adaptive, anthropomatic and cognitive agent capabilities. To achieve this kind of technology it is good to bear in mind a couple of things. It is not possible to predict all occurrences or changes that arbitrary environment could derive. Deterministic chaos as a phenomenon of the real world that inevitably obstructs absolute expectations, always producing slightly changed situations (Stipancic, 2008). Chaos is present in both, temporal and space continuum, resulting in inconsistencies and uncertainties in all dimensions. Every environment is naturally unstructured, which can be revealed if observed by using an appropriate scale. In other words, if a sub-molecular level is neglected from this analysis, it is not possible to completely determine any environment, no matter how tight the applied tolerance ranges may be. This is connected with issues of sensitivity and instability and may result in malfunctioning, even if small environmental changes occur. How to deal with such challenges? One way is to accept deterministic chaos as a natural phenomenon just as it is accepted by nature.

This paper emphasises the direction in context modelling where insights taken from three separate use case scenarios are discussed. In Section 1context modelling is outlined. In Section 2 theoretical explanation of the model is given together with the structure of the proposed model. In this way, detailed insights into "rational" and "probabilistic" parts of the computation mechanism are provided. Three use cases where the methodology is tested are presented and discussed in Section 3 together with directions for future work together with conclusions.

2 THEORETICAL EXPLANATION OF THE MODEL

To mathematically describe the model, a multi-agent approach is used. In the model of interaction (Fig. 1), all agents (artificial agents or humans form a part of the same environment) and are able to communicate mutually, interact and share information within the same time domain.

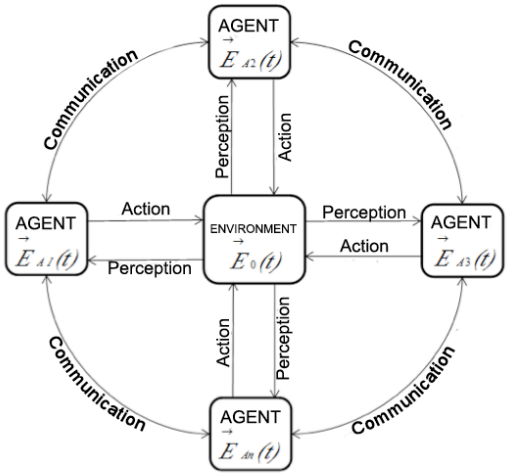

Figure 1. The model of interaction.

In this way, agent-to-agent and agent-to-environment interaction can be both mathematically described as:

$$\exists G\left(\vec{E}_{A1},\ldots,\vec{E}_{An}\right)\forall t_i \rightarrow G_{opt}\left|\vec{F}\right. \tag{1}$$

where the information collected by sensors and the model are mathematically defined as:

$$\vec{E}_A = \left[\vec{E}_{A1},\ldots,\vec{E}_{An}\right] = \left[f_{A1}\left(S_{11},\ldots S_{1m}\right),\ldots,f_{An}\left(S_{n1},\ldots S_{nm}\right)\right] \tag{2}$$

$$\vec{F} = \left(CO, BN\right) \tag{3}$$

In (2), vectors $\left[\vec{E}_{A1},\ldots,\vec{E}_{An}\right]$ representing sensors S_{nm} are used to detect a targeted phenomenon. Information acquisition represents the first step in contextual perception of the environment. Therefore, these vectors contain information acquired by sensors that are placed ubiquitously into the environment in a meaningful way (4).

$$\vec{E}_A = f\left(S\right) \tag{4}$$

Based on (1), there is at least one function G to describe context of an environment at a given moment t_i, using information from (2) altogether with a set of criteria $\vec{F}$ defined in (3) that generates a desired (optimal) robot behaviour, G_{opt}. As a part of the vector $\vec{F}$, the marks CO and BN defined in (3) are abbreviations for Case Ontology and Bayesian Network, respectively.
By following the presented mathematical formulation, a hypothesis of this paper is:
By finding the function G_{opt} defined in (1) and respecting the information stored in (3) along with other information collected by sensors (2), it is possible to alter a behaviour of an artificial agent based on targeted implicit or contextual information.

2.1 The model as a computation mechanism

In essence, all human cognitive processes are seen here as context-driven. In (Dey, 2010), context is defined as any information that can be used to characterize the situation of an entity. A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on user's task. Context-aware applications look at who's, where's, when's, and what's of entities and use this information to determine why a situation is occurring.
To provide implicit or context driven decision-making capabilities to the artificial systems it is proposed a new computation mechanism that contains the following components: (i) data acquisition and transformation, (ii) semantically defined knowledge, and (iii) Bayesian Network (BN), as shown at (Fig. 2). The overall methodology is presented in this paper through three separated use case scenarios, which are explained in detail in (Stipancic, 2016, Jerbic, 2015, Stipancic 2017).

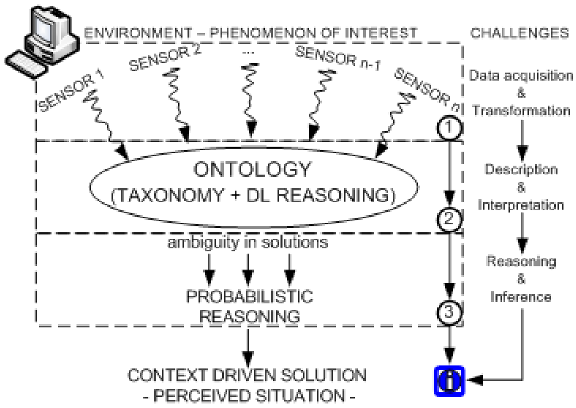

Figure 2. Computation mechanism for context to data transformation.

An environment in this vision becomes a space constantly analysed by smart sensors to detect significant changes. In relation to the real world, humans perceive only the information currently classified as significant and the majority of other occurrences remain hidden because the nature of such events is not relevant at the moment. This work adopted the conceptual framework from situation theory, a mathematical theory of information, where "…recognition is made of the partiality of information due to the finite, situated nature of the agent (human, animal or machine) with limited cognitive resources. Any agent must employ necessarily limited information extracted from the environment in order to reason and communicate effectively…" (Devlin, 2008). The second part (ii) holds an expert's knowledge about the domain of activity. This part is used for logical or rational reasoning. It is called Case Ontology because it represents just a small part of the world in relation to the model application. The computation mechanism highly relies on predefined knowledge about the environment. In this case, knowledge is a subjective view of the system designer about targeted context or situation. Some authors consider certain types of context as important while characterizing a situation of a particular entity (Dey, 2010). Such contextual information can answer questions like: where, who, when and what. These represent the core of the knowledge implemented in Case Ontology. Ontology Web Language (OWL), used to define Case Ontology, follows the principles of Open World Assumptions (OWA) (Loyer, 2005). Such ontology can respond to a query by providing more than one right answer, thus allowing ambiguities in solutions. By combining inputs from sensors, ontology defines possible solutions in the form of robot responses.

The third part (iii) of the mechanism enables reasoning under uncertainties implemented in Bayesian Network and is used to ensure a single solution in relation to perceived context. Bayesian (Believes) Networks (BNs) reflect beliefs about the most appropriate solution in relation to perceived phenomenon. They allow the use of prior knowledge needed for capturing domain concepts, variables and probability values as well as building a graphical representation. BNs are convenient if evidence is not provided. While building BN in this work, a handcrafted approach is used (Daniel, 2003). This approach is usually time consuming and can be used to build small BNs. At the same time, this approach is very convenient when subjective experiences of a real human expert need to be coded in a computation model. The overall procedure of BN development is depicted in (Fig. 3). The first step in a BN development procedure is to define variables of interest, which are network nodes, and place them into a network topology. Arcs in BN connect the nodes with the direction indicating causal relationships. Condition Probability Tables (CPTs) quantify relationships between connected nodes. In the methodology used in this work, information about conditional probabilities has to be calculated in advance. By altering such information, the system designer gets the opportunity to define system priorities and/or to achieve certain goals. Each node in accompanied CPT contains probabilities emerged from influences of parent nodes. Given the specification of BN, it is possible to compute posterior probability distributions for each of the nodes, so-called "beliefs".

Determination of probability values within CPTs is the most important task in a design of BNs because those probabilities directly alter the network behaviour. Such values are often determined by using data mining techniques applied on some larger amount of data that describe a targeted phenomenon. In the approach used in this work, conditional probabilities are determined by analysing qualitative descriptions of relations between network nodes. A more comprehensive description of this procedure can be found in (Jerbic, 2015, Stipancic, 2017, Stipancic 2016).

The next phase in the development of BN is testing the network performance through three scenarios (or more than three, if needed). In that phase, the model designer fine-tunes the network behaviour. The first scenario represents an extremely positive situation. The second scenario represents a neutral situation and the third one represent an extremely bad situation. The main goal of this procedure is to ensure general network behaviour in all situations.

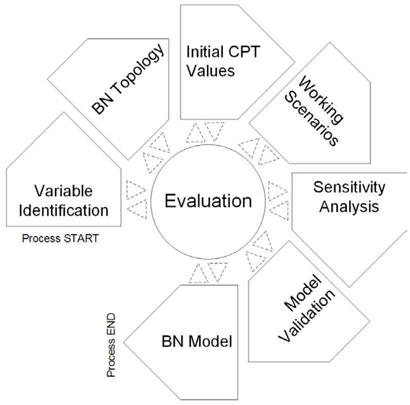

Figure 3. BN development procedure.

To find out secret or inner influences that parent nodes have on child nodes and to test a quantitative part of BN the method called Sensitivity Analysis (Oakley, 2004) is used. The procedure can provide more insights into inner reasoning mechanisms of the network based on different node inputs and reduction in the system entropy. Shannon's Entropy is a measure for uncertainties of a particular event associated with a probability distribution of a possible event (5).

$$H(P) = -\sum_{s \in S} P(s) * \log_2 P(s) \tag{5}$$

This study employs the entropy reduction method to determine a decrease in query node's entropy before – H(Q), and after – H(Q/F) the evidence is provided to some particular node in the network. The method helped in determining those nodes to which query nodes (robot response variables) are significantly sensitive (6).

$$I = H(before) - H(after) = H(Q) - H(Q/F) \tag{6}$$

The aim is to provide proofs to all BN nodes one by one and to validate and measure how that affects query nodes. These nodes that cause the most significant reduction in entropy are the most influential ones for making decisions or changing the network reasoning output. Such insights can be used in the following two steps of the BN development procedure (Fig. 3) where the network reasoning could be additionally tested or refined. The last step in this procedure represents the integration of the model in accordance to the model application.

2.2 First Use Case Scenatio – reasoning based on social capital phenomenon

In sociology, the concept of SC indicates the expected mutual benefit emerged from cooperation between individuals within a group. A value realized through social contacts can be measured by determining the increase in group productivity. In (Daniel, 2005), SC is defined as a common social resource that facilitates sharing of information and building knowledge through continuous interaction.

By implementing this concept into a group of industrial robots on assembly assignments some interesting system capabilities emerge, such as: system scalability, auto-recovery and partial contextual awareness. The system scalability resulted with increased overall group productivity because all the system components (robots and other system equipment) are classified and defined within the core ontology. By adding new Working Places, which are defined as a class along with all accompanying subclasses within the Case Ontology, it is easy to increase the overall production capacity. The second principle of auto-recovery can be recognized in such cases where some Working Place fails in performing its primary function, due to a defect or something similar. By using the Bayesian Reasoning part of the model, other working places can rearrange priorities and continue production. The third principle of partial context-awareness can be found in the way sensors are used while collecting information from the environment. Sensors are placed seamlessly to provide continuous flow of information. A final BN for this use case contains fourteen nodes in total where five of them represent query nodes used to control robot reactions. Detailed explanation of this work is available at (Stipancic, 2016).

2.3 Second Use Case Scenario – reasoning based on bodily awareness

Some authors emphasize the process of perception as the very first step in qualia development (Haikonen, 2012). Among various definitions, qualia is defined as: the ways things look, sound, and smell, the way it feels to have a pain, and more generally, what it is like to have experiential mental states (...) qualia are experiential properties of sensations, feelings, perceptions, and, more controversially, thoughts and desires as well (Guttenplan, 1994). It seems that qualia appear in the human mind as a mental picture (subjective interpretation) of perceived environmental occurrences. How perceived information appears in the form of subjective experiences today still remains a question. Bearing this in mind, qualia in this work are used with extreme caution. To simulate bodily-awareness qualia, a new cognitive model is proposed. The developed model additionally combines the visual perception of the robot itself, enabling it to build a kind of "mental" representation of its own body/existence within the environment. In the robot's workspace, the human operator as well as any other dynamic obstacle can appear as an object that can arbitrarily change its course and speed. By using the cognitive model, the robot is able to avoid, approach or escape from any kind of object while performing its spatial movements. If an obstacle is too near, the robot will decrease its speed to further ensure the safe operation and to plan its next movements while heading to the final movement point. Detailed explanation in (Jerbic, 2015).

2.4 Third Use Case Scenario – reasoning based on bodily awareness

The main hypothesis of this study is the idea that emotion may perform an adaptive function that requires a certain degree of processing complexity. Several studies reveal that cognitive processes in humans are highly intertwined with emotions. Emotions are considered to signal a person and motivate appropriate responses in relation to situations (Kim, 2005).
Emotions are necessary information for our wellbeing, our everyday experiences and even cognitive processes (Balduzzi, 2009). Ortony, Clore, and Collins defined emotions as valenced reactions (e.g., affective reactions based on the perceived goodness or badness of things) and asserted that emotions are determined by how the eliciting situation is understood by a person (Ortony, 1988).
A final BN for this use case contains 22 nodes in total, where six of them represent query nodes used to control the robot reactions. Detailed explanation of this work is available at (Stipancic, 2017).

3 DISCUSSION & CONCLUSION

The approach presented in this work builds on the notion that human cognition has the ability to handle uncertain information (Doya, 2007). It does not, however, attempt to explain how the brain interprets perceived phenomena. This work is more focused on human representations, meanings and manipulation of uncertain information in order to examine the effect of uncertainty on the design of technical systems. In this way, the aim is to reflect subjective experiences of real human experts as they pick up information from the environment. This methodology is highly convenient when big data used to describe some phenomenon and build a model is not available.

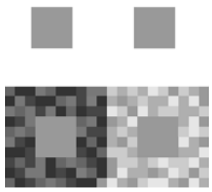

Figure 4. The simultaneous – contrast illusion.

Desired robot reasoning can be explained by examining (Fig. 5) where two squares are having exactly the same gray color value. By adding different backgrounds to both squares, the square on the left is perceived as different from the square on the right. It seems that a change in context where objects are placed can change the way how people see them Adelson, 2000, Stipancic, 2010). This change in perception is triggered by mechanisms that are much more abstract than a simple true – false logic.
To validate a methodology, the third part of the computation mechanism is assessed in all use cases. BN is validated from the aspect of information entropy reduction. Some hidden and relative influences between the network variables are revealed. In this context, the method leads to better understanding of the overall system behaviour in relation to a particular application. Query nodes are sensitive to more then one variable whereby those nodes that are the closest to query nodes and those with the strong positive connections are

the most influential. In this way the methodology presented in this paper shows potential contribution to the design of context-aware robots.

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3d PRINTING FOR DESIGN AND ART

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Abstract: *3D printing has been known around the world for at least three decades. Different technologies exist,* and consequently, different materials with which they can print. Originally, 3D printers were used for the production of prototypes, above all in the fields of industrial design development, construction and the production of technical products. With the development of new materials, the use of 3D printers is spreading day-by-day to new areas, from printing food, bio-printing, and 3D printed electronics, to the building industry and art.
A German company Voxeljet which produces larger format industrial printers, with a consequently greater work volume (maximum platform 4m x 2m x1m) in the last four years, has stepped up its search for solutions to different applications in the fields of art and building construction. In the article, different unique, specific and demanding applications are presented, which were produced with the assistance of various 3D technologies, from scanning, the preparation of suitable data for 3D printing and manual post-production processing of printed parts to their placement in the environment.

Keywords: 3D printing, building construction, art, Voxeljet.

1 INTRODUCTION

Voxelyet 3D printing technology is based on the principle of depositing droplets, or rather spraying a binder (furan resin) onto a base material (foundry sand of different granulations) or depositing a binder onto a powder-based material PMMA, which is further strengthened with an epoxy resin for better durability and solidity (1, 2). Printed items, produced on the basis of foundry sand or the polymer based material PMMA can be later kitted, which allows for additional sanding, polishing and painting. The advantage of such production methods is a shorter production time and a short time to market, lower production costs in comparison to conventional processes, but above all the WOW FACTOR, as everyone asks: "How is that possible?"

2 EXPERIMENTAL

In the following projects from the fields of archaeology, art, architecture and building construction:are presented.

A facade and a uniquely designed ceiling

The design and production of a unique ceiling is one of the most expensive elements in building a home. The price can exceed USD 30,000 even without the costs of planning and construction (3, 4).
Aztec Scenic Designs, a company specialised in the creation of unique facades and ceilings, found a solution for their design in 2014, by using 3D printing. Their designer, Benjamin Cremer, drew up the desired form, while an outside contractor, Marc Leonard, transformed it via the use of a computer programme into a data file, which enabled it to be 3D printed. All parts were additionally worked on: golden decorative flakes were added, and it was given it an 'aged look'. They were then fixed to wooden panels, which enabled them to be attached to the ceiling (Figure 1).
The advantage of this method of production was in the speed of it, as 8 printers were used. They printed the demanding and precise patterns simultaneously, and in the end, the material used in producing them was rather negligible, costing cca. USD 200.

Figure 1. Uniquely designed celling.

The final product and attachment to the ceiling took only 2 days. In this case, the designer designed the ceiling, but it is also possible that archaeological finds be 3D scanned, and in the same manner, reproduced and 'brought to life'.

A replica of an existing portal in Berlin and a source material for sculptors

This huge project relates to the reconstruction of the Liebkencht historical portal in Berlin. Upon deciding that a city palace be built in Berlin, there was also a wish to have a full-sized replica of the Liebkencht portal (Figure 2) in it, with the goal being to maintain the originality and historical meaning of the structure. TrigonArt, 3D scanning specialists from Berlin, scanned the structure three-dimensionally and created a high-resolution model. In addition, they prepared a 3D model of it for presentation purposes and also for its reproduction, which was taken care of by the Voxeljet company from Augsburg. The entire construction encompassed approximately 100 individual printed parts, their dimensions being 1.5 × 1.0 × 1.0 metres. It would have been possible to print them in even bigger dimensions, 4 × 2 × 1m, but this would have created handling and transportation problems, due to the weight and size of the pieces.
The historical portal replica completely matches the original, both geometrically and scale-wise, which was a huge advantage for sculptors, as the 3D printed structure served as a source material for their work, enabling them to produce a perfect copy of the Liebknecht portal in sandstone. The advantage of this method of production was in the speed of it, but more importantly in maintaining the original, as there would have been a risk of it being damaged if it were replicated in the classical method of doing so (5, 6).

Figure 2. full-sized replica of the Liebkencht portal.

Film and entertainment

"In the film, Zero Dark Thirty, the filmmakers couldn't get the right night-vision goggles, because they were $60,000 per unit. So, I modelled them from some photos that had leaked on the internet." PROP SHOP 3D SUPERVISOR, JET COOPER. On the basis of a computer- drawn image, a plastic model was printed using a VX1000 3D printer . The primary material was PMMA plastic, which was impregnated with epoxy for greater strength. The produced goggles and mask were additionally hand worked, kitted, sanded and painted, so that the achieved final look was that as shown in the accompanying pictures (Figure 3), and were used by the actors during filming (7, 8).

Figure 3. Original and printed night-vision goggles.

Building construction and interiors

The Voxeljet company, in first testing the application of their sand prints, chose to produce a 'mini- concrete wall' into which their company logo can be seen, which now stands in front of their office building. The company decided to use the classical method of concreting (pouring concrete into a wooden panelled mould) for the main part, while use a 3D printed wax insert in combination with a sand mould for the text and the company's logo, in order to make them 'stick out', which was later on impregnated with epoxy. This gave the mould better strength and thus enabled easier concreting, as shown in the figure 4. The 3D printed 'negative' of the logo, that allowed concreting through an opening in the text.
Cast concrete and the removal of the printed mould. The advantage of such a solution is, that the concrete can be poured in a more desirable and sheltered place, where weather and light do not impact on the production process. In the same way, the process is ideal for demanding, and non-linear lines. 3D printed sculptures can enhance interior spaces, for example, in homes, halls, exhibition places, shops, hallways .... Imagination knows no boundaries.

Figure 4. Sand print of company logo.

The basis for the production of any kind of sculpture, non-bearing columns or shapes is a 3D computer drawing, which enables the 3D printing of those desired elements. Size is also not a problem, as it is possible to assemble and glue, post production, just like blocks. Knowledge of postproduction surface finishing gives us the advantage that seams are no longer seen, and the finished products take on an even more pleasant appearance. Into such finished products, we can fit many different devices, such as room scent fresheners, speakers, temperature gauges ....

The company, Chemets, has taken advantage of this by printing a torso (Figure 5), utilizing Voxeljet's technology. With post-production impregnation, the required hardness was achieved, allowing the possibility of post-production finishing. Half of the raw printed torso was painted in black, while the other half was professionally finished and painted.
The lower part has an opening for a room freshening device. The torso is intended to be used at trade fair presentations, the purpose being that the company 'stands out from the crowd', and that potential business

clients are attracted to take a closer look at the company's showcased products and services. The inner part of the sculpture contains a device for 'aroma marketing', which releases a pleasant scent into the air at predetermined intervals. The intertwinement of scent and visual image enhances the company's recognition and consequently assists in increasing sales.
In such cases, we can see that companies which deal in 3D printing and 3D printers, together with manufacturers, tradesmen and craftsmen are changing the way we think and use 3D technologies and are looking for the advantages, which these new technologies bring with them.

Figure 5. Sand printed natural sized torso.

3 CONCLUSIONS

The trend is moving faster in the direction that design is, and will be, all the more important, above all because there is a trend towards personalization, uniqueness and quick implementation.

In this way, companies active in 3D printing and with 3D printers, together with manufacturers, craftsmen and artisans are changing the way in which 3D technologies are understood and the manner in which they can be used. The trend is moving all the more quickly in the direction that design is more and more important, above all because trends are moving towards personalization, uniqueness and short times to market.
For the general recognisability of a company and its brand name, it is necessary to connect with other companies, and with their products, favourably influence our senses, eyesight, smell, hearing and taste. Therefore, it is crucial, that we turn to technology, and use it to our advantage.

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Oral presentations

BIOCOMPOSITE PLA FILAMENT FOR 3D PRINTING

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ABSTRACT: *In Fused Deposition Modelling (FDM) usually ABS, PLA, and PA are used as thermoplastic materials. Nowadays, the focus is in developing biocomposite thermoplastic materials, among others to produce 3D filaments. To improve some properties and broaden the applicability, PLA polymer is blended with bio- and non-bio-degradable resins and mixed with fillers, such us micro-and nanoparticles or fibres. In our research the biocomposite filament was produced from PLA, with added 50% of corrugated cardboard dust, which was composed of broken fibres, fibrils, fines, starch glue and other particulates resulting from corrugated cardboard production. Structural, morphological and mechanical properties of the biocomposite filament PLA/cardboard dust were compared with the properties of the pure PLA filament. Compared to pure PLA, biocomposite PLA filament had lower density, inferior tensile properties, relaxation transitions occur at lower temperature, thermal stability is lower, while the bending resistance is the same and the compression resistance is higher.*

Keywords: 3D filaments, PLA, biocomposite, cellulose, structure.

1 INTRODUCTION

The most spread 3D printing technology nowadays is material extrusion of thermoplastics filaments, commercially named as Fused Deposition Modelling (FDM). Usually acrylonitrile butadiene styrene (ABS), polylactide (PLA), and polyamide (PA) are used as thermoplastic materials. PLA is biodegradable aliphatic polyester, obtained from corn, sugar cane, potato or other plants. PLA has some positive as well as some negative properties, such as low density resulting in lightweight products, low flammability, high moister absorption ability, high ductility and low toughness (Gupta et al., 2007). To improve some properties and broaden applicability, PLA polymer is blended with bio- and non-bio-degradable resins and mixed with fillers, such us micro-and nanoparticles or fibres (Poh et al., 2016; Honglin et al., 2014; Atsuhiro et al., 2008).

Nowadays, the focus of different researches is in developing biocomposite thermoplastic materials, therefore our goal was to determine the properties of the biocomposite 3D filament. The biocomposite filament was produced from PLA, with added 50% of corrugated cardboard dust, which was composed of broken fibres, fibrils, fines, starch glue and other particulates resulting from corrugated cardboard production.

2 EXPERIMENTAL

The measurement of the thermal stability was determined by the sample inspection with the Mettler FP84HT Hot stage thermal measuring cell and microscope. With this method the changes during heating of the filaments, were analyzed and detected. The analyzed starting point began at 30ºC; with the heating speed 5ºC/min, while the final temperature of the heating ended at 200ºC.

Dynamic Mechanical Analysis (DMA) was performed using Q800 DMA analyser (TA Instruments). The measurement was performed in dual cantilever bending mode on the samples with the length of 35 mm. The measurement was performed at the frequency 1 to 10 Hz and the temperature range 0–160ºC, with temperature step 3ºC/min, rising up to 160ºC. Dependent on the temperature and the frequency, the transition temperatures in the polymer, the storage modulus (E'), the loss modulus (E'') and the tan delta (tan δ) were determined.

Analyses of the filament surfaces and the cross-sections was performed by the Scanning electron microscope JSM-6060 LV (Jeol) (SEM), at different magnifications (50× and 1.000×).

Time of the sound wave propagation through the filament at a frequency of 160 Hz was measured using the Puls Propagation Meter PPM-5R (H. Morgan, Co). The longitudinal speed of the sound waves traveling through the filament was calculated as a ratio of distance and time of puls propagation.

The filaments were qualitatively analysed with the FT-IR spectrometer Spectrum GX I (Perkin Elmer). All the spectra were recorded over the range 4000–800 cm^{-1}, with the resolution of 4 cm^{-1} and averaged from 64 scans.

The mechanical properties were determined using the tensile testing machine Instron 5567 (Instron). The tensile properties of the filaments were determined according to the ASTM D2256. The bending resistance was determined with the 2-point bending test and the compression load was measured by compressing the filament to half its thickness.

3 RESULTS & DISCUSSION

Results showed that after corrugated cardboard dust was added to the PLA polymer the density of the filament decreased from 1.26 g/cm^3 to 0.961 g/cm^3 while longitudinal speed of the sound waves traveling through the filament increased for 0.5 km/s. The later applies that the structure of the biocomposite filament was more oriented in direction of filament axes and more uniform compared to pure PLA filament.

ATR-FTIR spectra in the 4000 to 2000 cm^{-1} range showed typical cellulose peaks, which confirmed the presence of corrugated cardboard dust in the biocomposite PLA sample (Figure 1). The peak at 3312 cm^{-1} represents the vibration of the -OH group in the cellulose. With pure PLA filament, the peak of 3509 cm^{-1} was detected in this region, representing the asymmetric and symmetric expansion of C-H bond of the PLA. The same peak was detected for the biocomposite filament PLA/cardboard dust, but at a much lower intensity.

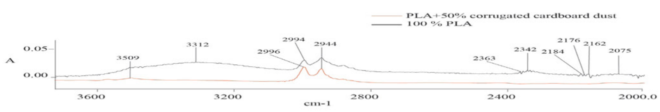


Figure 1. FTIR analysis of 100% PLA and PLA+50% of corrugated cardboard dust sample, in the range of 3600 and 2000 cm^{-1}.

In the range between 1800 and 800 cm-1 higher peak intensity was detected for the pure PLA filament, compared to the biocomposite filament PLA/cardboard dust (Figure 2). There were no other significant differences detected between the filaments in this range. For the biocomposite filament PLA/cardboard dust, at the wavelength of 1648 cm^{-1}, the peak represents the vibration of CH_2 group and the vibration of intermolecular hydrogen bonds in the cellulose. This again confirms the presence of the cellulose, though, despite the addition of 50% corrugated cardboard dust, the content of the PLA component stands out.

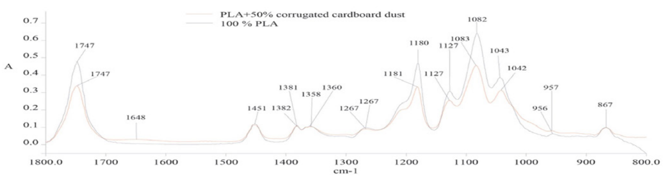


Figure 2. FTIR analysis of 100% PLA and PLA+50% of corrugated cardboard dust sample, in the range of 1800 and 800 cm^{-1}.

Thermal analysis has shown, that the first changes in the structure of the pure PLA filament occurred at 147°C and the melting was completed at 172°C. The results showed that the pure PLA filament was more thermally stable sample. At the biocomposite filament PLA/cardboard dust the first changes were noticed at 120°C. The part of the biocomposite, where the cardboard dust was present, firstly caused the color change (it yellowed) and then melted at 140°C, whereas the PLA component completely melted at 150°C.

In the Figure 3 to 5, the dynamic mechanical properties of the pure PLA and the biocomposite filament PLA/cardboard dust are presented. As it can be seen from the diagram in Figure 3, both samples have rather low storage modulus E', which applies to the high willingness and low elasticity of both materials. The temperature of the relaxation transition of the biocomposite filament PLA/cardboard dust was slightly lower (58.04°C) than for the pure PLA filament (59.39°C), while the belonging interval was wider (from 53.69 to 63.91°C) as in the case of pure PLA (from 56.53 to 62.26°C). According to the results of the longitudinal speed of the sound waves traveling, the biocomposite filament PLA/cardboard dust has shown slightly better uniformity of the structure, which could also be proven by the wider relaxation transition interval. Later also applies to the higher share of better organised segments. The peaks of the loss modulus E'' (Figure 4) for both samples were prominent and were reached at 56.56°C and 52.72°C for the PLA and the biocomposite PLA/cardboard dust, respectively. From the tan δ curves in Figure 5 can be seen that the values of the damping factors were higher in the case of the pure PLA, probably because of the more intensive movement of molecular segments.

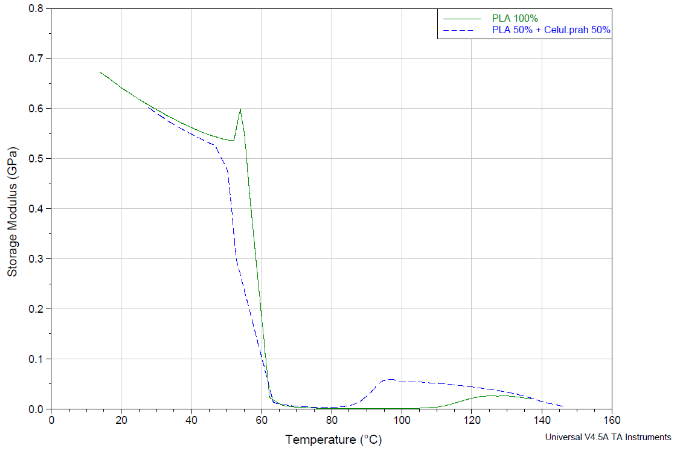


Figure 3. Storage modulus (E`) vs. temperature for the PLA and PLA/cardboard dust filament samples.

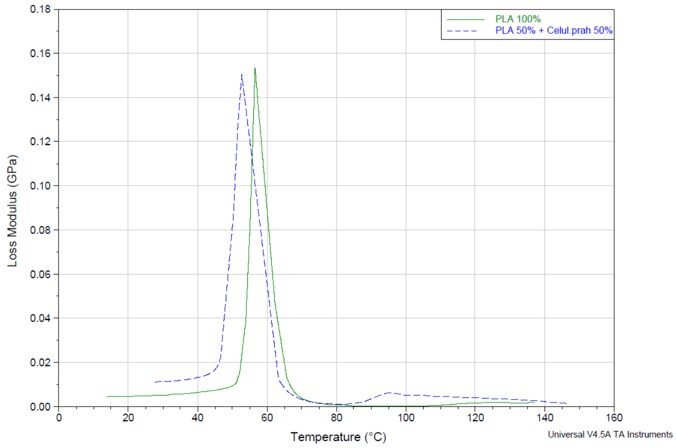


Figure 4. Loss modulus (E``) vs. temperature for the PLA and PLA/cardboard dust filament samples.

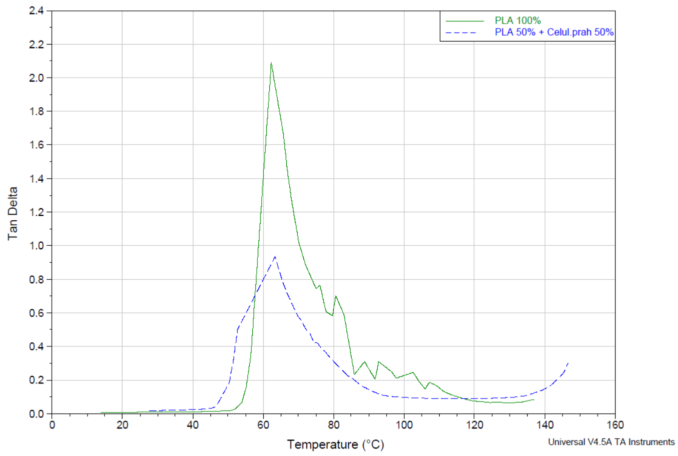
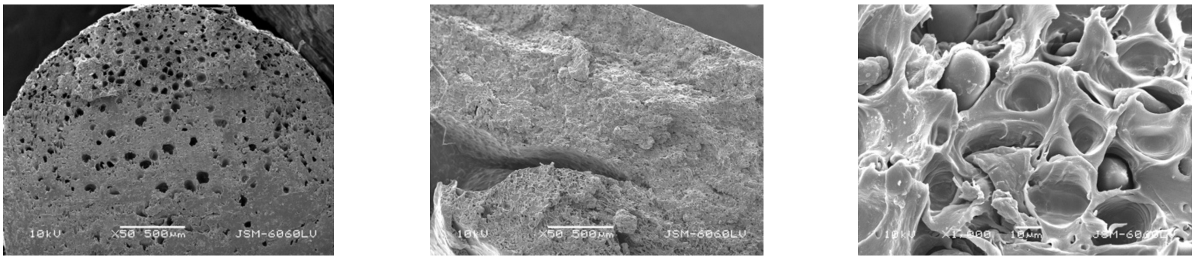


Figure 5. Loss factor (tan δ) vs. temperature for the PLA and PLA/cardboard dust filament samples.

Images of the filament's surface obtained by the SEM revealed no differences. The cross-section of the pure PLA filament revealed a porous structure. On the other hand, the cardboard dust in biocomposite filament acts as a filler in the polymer (PLA) matrix thus structure was less porous, more uniform and surface smoother (Figure 6).

PLA	PLA/carboard dust	PLA/cardboard dust



50-×	50-×	1000-×

Figure 6. Cross-section of the filaments (SEM; 50× and 1000× magnification).

Mechanical properties of the two analysed filaments under tensile, bending and compression load were also evaluated (Table 1).

Table 1. Mechanical properties of the pure PLA and bicomposite PLA/cardboard dust filaments.

	Tensile strength (MPa)	Strain at max. load (%)	Strain at break (%)	Elastic modulus (GPa)	Load at bending (N)	Load at compression (kN)
PLA	56.46	5.91	12.46	1.446	2.71	8.85
PLA/ card. dust	11.57	3.27	4.12	0.844	2.73	10.19

The addition of the corrugated cardboard dust to the PLA polymer influenced the mechanical properties in different ways. As the tensile strength and elastic modulus of the biocomposite filament were substantially lower, the load at bending was equal, whereas the load needed to compress the filament to half its thickness was 15% higher. The biocomposite filament PLA/cardboard dust was weaker only at loads acting in direction of filament axes, as the tensile strength was 5-times lower, strain at break 3-times lower and elastic modulus almost 50% lower compared to the pure PLA filament.

4 CONCLUSIONS

Structural, morphological and mechanical properties of the biocomposite PLA filament were compared with properties of the pure PLA filament. With the addition of the corrugated cardboard dust to the PLA polymer the changes in density, uniformity, chemical structure and transition temperatures of the samples were detected. The structure of both filaments was mainly amorphous, with low order of structural elements, nonhomogeneous, porous. The biocomposite filament had lower density, the relaxation transitions occurred at lower temperature, and lower thermal stability. The biocomposite filament also showed inferior tensile properties, much lower tensile strength, breaking length, elastic modulus and storage modulus in comparison with the pure PLA filament. Both filaments were tough thus bending filament till 15º didn't reveal noticeable difference in the bending load. By compressing the filaments to half their thickness higher load was determined for the biocomposite filament, which was in agreement with the morphological study of the filament cross-section. SEM image analysis has revealed less porous structure for biocomposite filament, which also showed a bit higher sound wave velocity propagation meaning more condensed structure in the longitudinal direction of filament.

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COLORIMETRIC CHANGES CAUSED BY UV VARNISHING

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ABSTRACT: *This paper examines the influence of UV LED varnish on color change of varnished substrates. Industrially manufactured dyed papers in 8 different colors (green, red, blue, cyan, yellow, brown, black and light yellow) were UV varnished on Roland VersaUV LEC-300 printing machine in UV LED Inkjet printing technique. Each sample of dyed papers was varnished in four different surface coverage in half-ton values of 20%, 40%, 60% and 80%. Varnished papers were submitted to colorimetric analyses using X-Rite eXact spectrophotometer. From the obtained L*a*b* values, the difference in coloration (ΔE2000) was calculated by CIE Lab ΔE2000 equation. The results of the colorimetric analyses were presented in the form of three-dimensional CIE Lab diagrams showing the color changes in brightness and chromaticity. Color change ΔE2000< 1 is considered visually unnoticeable in contrast to color change ΔE2000> 1 that is visually noticeable. Above the color change, some samples showed significant change in chromaticity.*

Keywords: color change, UV varnish, half-ton value, dyed papers.

1 INTRODUCTION

Paper, as the most important carrier of information in the past, has expanded its application. A large variety of paper grades are produced to suit the special requirements. Paper can be impregnated, coated, laminated, creped, molded etc (Holik, 2006.). One of the methods used for applying the impregnated layers on the surface of the paper is UV Inkjet printing technology. In this technology, the transparent UV LED varnish in liquid form is directly applied on the printing substrate and it is cured by LED UV light (Majnarić, 2012.). This paper analyze how different surface coverage of the transparent UV LED varnish applied by UV Inkjet printing technology influence on color change of varnished substrates. Varnished substrates used in the experiment are industrially manufactured dyed papers in 8 different colors (green, red, blue, cyan, yellow, brown, black and light yellow). Generally, materials are colored by the use of pigments or dyes that differ in their application. When a pigment is used to color substrate, the finely divided, insoluble solid remains throughout the coloration process (Lewis, 2006.). Dyes, in the other hand, penetrates the substrate in soluble form, after which it may or may not become insoluble (Vernardakis, 2006).
By the Herbert Holik's book »Handbook of Paper and Board«, dyes are the oldest class of synthetic specialty chemicals employed in the production of paper. Anionic direct dyes are the dominant class of dyes which account for 52 % of the total worldwide turnover. Anionic direct dyes are the sodium salts of azo dyes containing sulfo groups (for water solubility) or copper phthalocyanines which also contain sulfo groups. They have a high affinity to bleached chemical pulps and often do not need additional fixing agents. The colors attainable may not be as brilliant as with acid and basic dyes but the lightfastness is usually adequate. Basic dyes are the salts (chlorides, hydrochlorides, sulfates, and oxalates) of color bases. Although they are tinctorially strong, basic dyes have poor affinity to bleached furnishes, besides theirs mottling tendency and poor lightfastness. Acid dyes are all water-soluble salts of colored organic acids which dissociate in water to form colored anions. They have little affinity to paper fibers. Cationic direct dyes retain the planar molecular structure of acid direct dyes. Cationic groups, incorporated in the structure, accelerate their affinity to paper fibers. They are moderately adsorbed on bleached lignin-containing stocks and produce fairly good bleed fastness. Fixative is usually not required for these dyes.
For the most efficient usage, the dyes are mostly added continuously and fully automatically into the stock flow. Stock or internal dyeing is the most widely used paper dyeing process. The choice of dyeing conditions largely depend on the raw materials used in papermaking (recycled fibers, stone groundwood, TMP, CTMP, unbleached or bleached chemical pulp, type and portion of filler) and on its preparation process e.g. a higher degree of beating of the pulp results in a deeper coloring (Holik, 2006.).

The pH conditions are very important in stock dyeing and have tendentious toward paper production in the neutral or alkaline pH range. These conditions need dyes with a very good affinity to the paper stock in a neutral medium and/or very effective fixatives and retention aids.

Batch addition, as one of the stock dyeing processes, involve thorough mixing of the additives with the paper stock which increase optimal fixation due to longer contact time between the fiber and dye. In the other hand, the time required for color correction and color change is relatively long.
Continuous addition can attain the desired shade more quickly but have a lower color yield for intensely colored papers (Holik, 2006.).

2 EXPERIMENTAL

Four types of digitalized printing forms with surface coverage in 20%, 40%, 60% and 80% of half-ton values were constructed for the needs of experiment.
They were used for LED UV varnishing of industrially manufactured dyed papers in 8 different colors (green, red, blue, brown, cyan, black, yellow and light yellow) in four different surface coverage. Each standard printing substrate used in the experiment had a slight difference in weight (g_{min}= 112,45 g/m^2 for blue dyed substrate, g_{max}= 121,05 g/m^2 for green dyed substrate).
LED UV varnish was applied on the surface of industrially manufactured papers by LED UV printer Roland VersaUV LEC 300 in UV LED Inkjet printing technique.
By UV printing of felt side (FS) four characteristic samples were made: prints with the surface coverage of 20%, prints with the surface coverage of 40%, prints with the surface coverage of 60% and the prints with the surface coverage of 80%.
Varnished and not varnished papers were submitted to colorimetric analyses using spectrophotometer model X-Rite eXact Advanced (mode M1, light condition D50, standard observer 2°). Measurements were made on 10 randomly chosen samples.
Program x-Rite Datachatcher were used for calculating output results such as CIE L*a*b*, c*, H*, x, y, Y, and spectral reflection in the visible part of the spectrum. All values were measured three times and average values were used for further analysis. From the obtained L*a*b* values, the difference in coloration (ΔE_{2000}) was calculated by CIE Lab ΔE_{2000} equation. The results of the colorimetric analyses were presented in the form of three-dimensional CIE Lab diagrams showing the color changes in lightness and chromaticity. Color change $\Delta E2000 < 1$ is considered visually unnoticeable in contrast to color change $\Delta E_{2000} > 1$ that is visually noticeable. Above the color change, some samples showed significant change in chromaticity.

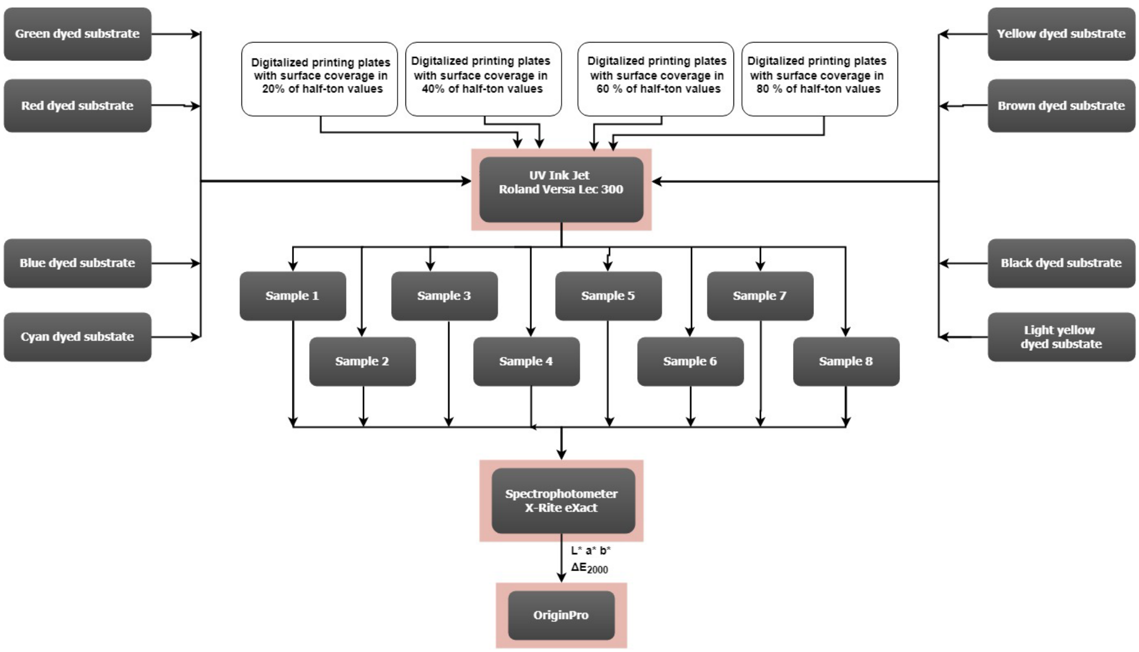

Figure 1. Schematic presentation of the performed experiment.

3 RESULTS & DISCUSSION

In this work the analysis is directed to LED UV Inkjet printing technique which enables the coating of transparent LED UV varnish which can result in color change on the surface of printing substrates, besides the visual effect of gloss. The color change is not the same for all dyed substrates neither is equal for the same amount of applied varnish (Dolić, 2014.).

Based on the measurements, the results showed that for some dyed substrates (i.e. for green) varnished by 20% half-ton coverage the color change is remarkably smaller (ΔE0-20%= 1,42) than for 40% varnish coverage (ΔE0-40%= 21,06) (Figure 2).

Red and blue dyed substrates showed the linear color change for subsequent increase of varnish coverage. For a minimum varnish coverage of 20%, the color change was barely visible (ΔE0-20%= 1.07-1.09) for both samples. For the maximum varnish coverage of 80% color change was visible (ΔE0-80%= 4.69). On 3D and 2D graphs the color change of three differenty dyed substrates (green, red and blue) is presented. Each color change is the result of 4 different ways of LED UV varnishing (varnish coverage of 20 %, 40 %, 60% and 80 % half-ton value) and all the differences in color change are compared with the unvarnished samples.

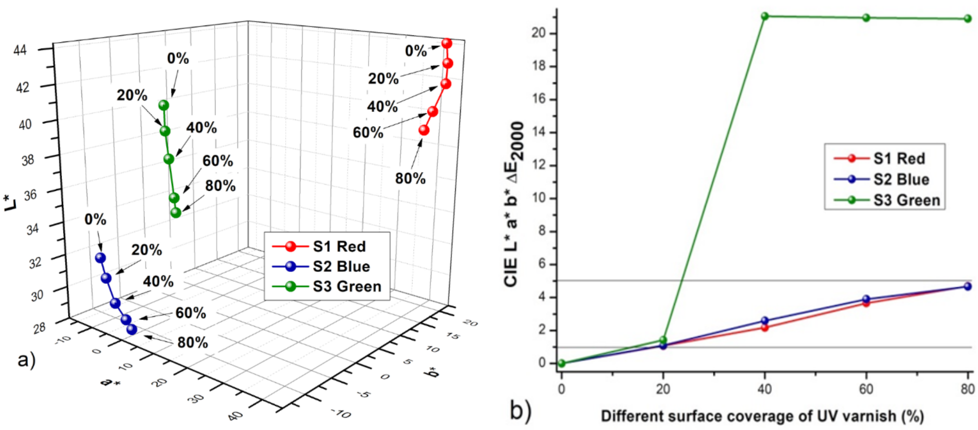

Figure 2. Color changes of red, blue and green dyed substrates caused by UV LED varnishing with the different surface coverage in half-ton values of 20%, 40%, 60% and 80%: a) 3D diagram of dyed substrates, b) 2D diagram of dyed substrates.

The brightest colored substrate (light yellow) showed low but slightly visible color change with the maximum varnish coverage of ΔEmax= 3.96 (Figure 3). The black sample was the only one to keep the color change at low level (ΔE0-80%= 1,39) for the maximum varnish surface coverage of 80% half-ton value. The common characteristic of both substrates (black and light yellow) is that minimum varnish coverage of 20% half-ton value is almost undetecteble.

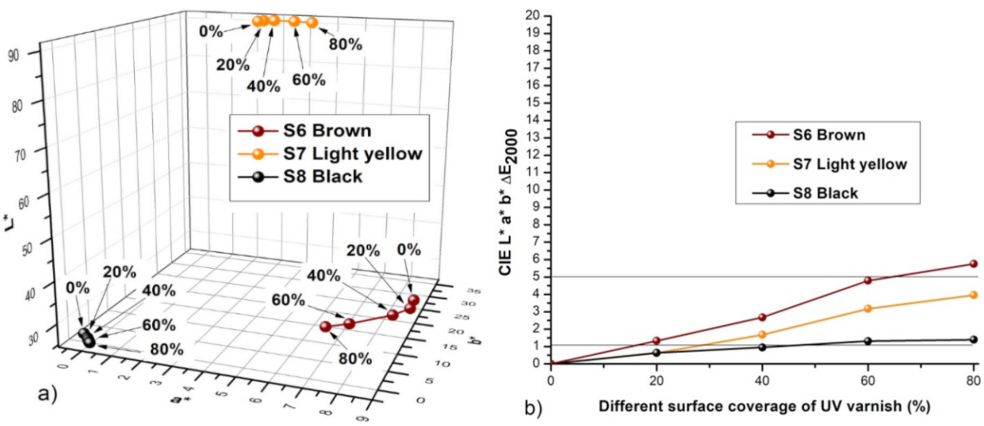

Figure 3. Color changes of brown, light yellow and black dyed substrates caused by UV LED varnishing with the different surface coverage in half-ton values of 20%, 40%, 60% and 80%: a) 3D diagram of dyed substrates, b) 2D diagram of dyed substrates.

Same samples (brown and cyan) showed a change in chromaticity for different surface coverage of UV varnish (Figure 4). Besides the visible color change at 20% of the surface coverage ($\Delta E_{0\text{-}20\%}$= 1.55), brown colored substrate also showed the color change of the tone (chromaticity) with tendency in direction of -b coordinate (blue). The largest change is noticeable between 40% and 60% of the surface coverage.
Cyan colored substrate showed the linear color change for subsequent increase of varnish coverage (ΔE_{max}= 6.65), but its color change is already visible with minimum varnish coverage of 20% half-ton value ($\Delta E_{0\text{-}20\%}$= 1.55). Cyan also showed the color change of the tone with tendency in direction of +a coordinate (red).

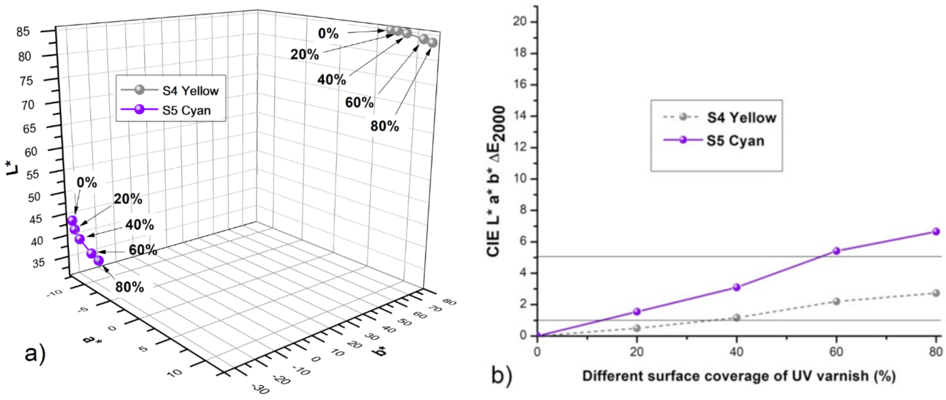

Figure 4. Color changes of yellow and cyan dyed substrates caused by UV LED varnishing with the different surface coverage in half-ton values of 20%, 40%, 60% and 80%: a) 3D diagram of dyed substrates, b) 2D diagram of dyed substrates.

4 CONCLUSIONS

By application of UV varnish on industrially manufactured dyed papers most samples showed visible color change (ΔE> 1) for varnish coverage of 80% half-ton value. Such effects are undesirable and could be adjusted for each sample by application of lower surface coverage (20%, 40% or 60%) of UV varnish.
The green sample showed the highest color change visible in 40%, 60%, and 80% of surface varnish coverage and is thus considered unsuitable for LED UV varnishing.
On the other side, all three samples (red, blue and cyan) with the linear color change showed barely visible color change for a minimum varnish coverage of 20% ($\Delta E_{0\text{-}20\%}$= 1,07-1,55). For the maximum varnish coverage of 80%, color change was noticeable ($\Delta E_{0\text{-}80\%}$> 4,5) and also unsuitable for LED UV varnishing in all three cases. The black sample showed the slightest color change, barely visible even with application of maximum surface coverage of 80% of UV varnish. It is thus considered to be the most suitable for LED UV varnishing applications. Visible color change of some UV varnished samples can be also used to provide additional aesthetic effect.

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COMPUTER GENERATED HANDWRITING SIMULATION BASED ON ALTERNATION OF CHARACTERS

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ABSTRACT: *The aim of this research was the digitalisation of a handwriting with the emphasis on designing several variations of a single individual letter. The development of a typeface that would successfully simulate a human handwriting was not possible in the past. OpenType enabled the creation of the so-called smart typeface. The most important features are the alternate substitution and the ligature substitution. We aspired to create a typeface supported both by professional and less advanced text editing programs. Therefore, our algorithm needed to be formatted into two functions only: the function for contextual alternates and the ligature function. Eva typeface consists of 1243 characters: 87 capital letters, 784 lowercase letters, 237 ligatures, 30 digits, 59 punctuation marks and 46 symbols. No intervention of the user needed, the font alternates among formative variations of individual characters in professional and less advanced text editing programs alike.*

Keywords: character, handwriting, OpenType, typeface.

1 INTRODUCTION

A double alphabet, consisting of capital and lowercase letters, represents the basis for a unique human handwriting that an individual begins to learn in their childhood. Over the years, the handwriting changes and evolves, finally forming a unique design that (to a certain extent) reflects the writer's personality. A literate human being develops a unique collection of characters sharing certain features. Due to the "hand-written" nature of a human script, its characteristics are never used in an identical design. The key characteristic of a handwriting is therefore minor inconsistency, which is also an important tool to identify an actual handwriting from its digitalised version.

The aim of this research was the digitalisation of a handwriting with the emphasis on designing several variations of a single individual letter. For a better understanding of letter-design, the development of Roman lettering (Možina, 2003) and of individual handwriting was researched (Trstenjak, 1986).

In typography, the development of digitalised typefaces induced the tendency to produce digitalised handwritings. Several such versions of handwritings exist; however, very few of them employ a random alternation among several versions of an individual character and thus succeed to imitate the actual human handwriting. The majority of digitalised handwritings include a single version of an individual character, which reveals its digitalised nature (Bear, 2017).

The development of a typeface that would successfully simulate a human handwriting was not possible until OpenType, as earlier file-formatting did not support a large quantity of characters inside a single file. OpenType and its different functions have enabled the creation of the so-called smart typeface (Adobe, 2017; Leming, 2017a). The most important OpenType features that contributed to the development of a quality handwriting digitalisation are two subspecies of OpenType substitution function, i.e. the alternate substitution and the ligature substitution (Leming, 2017a). There are four categories in the placement of the substitution function, namely an original point of the letter and the point of progression. Each point bears the value X and value Y, which can be controlled within the function. They can be written as a move of a certain letter, as the adaptation of space between two characters and a meaningful move of a letter, i.e. a move that happens under certain conditions (a preliminary character or a combination of characters) (Leming, 2017b). Visually, the substitution is the most perceptible change the function can make in a text. Two categories represent the foundation of each substitution, i.e. target and substitute. The same as there are several types of functions to change letter placement, there are also many types of substitution function. These are basically the substitution of one target with one substitute, the substitution of several targets with one substitute and the substitution of one target with several substitutes (Leming 2017b). In our research, a contextual substitution is of great importance. It is a simple substitution of one target (or several) with one substitute (or several) that occurs when specific conditions are met (Leming, 2017b). In OpenType, randomness is a long-desired function that has not been achieved yet (Leming 2017c). The "randomness" simply means a complex order that can be hidden by including several classes of letters, alternating under certain conditions. Another prominent OpenType deficiency is the order of code writing. OpenType code structure is extremely inflexible and enables only sequential rule writing – as opposed to branching in commands (Seinfert 2017).

2 EXPERIMENTAL

2.1 Methods and materials

Our first step was to define the requirements for the handwriting. It had to be at least partially connected (between letters in words), visually interesting, not too common and it had to reflect the author's style. Furthermore, the author of the handwriting had to be available to provide us with a suitable quantity of sample text. The next step was to provide sample texts in English and Slovenian. For the English sample, we used a text generator (Bibakis, 2017). The chosen lettering was the script of a dramaturg Eva Mahkovic. To translate the sample text into a digital format, we used Nikon D5000. For further processing, we used Adobe Photoshop CC (to improve the contrast and achieve better visibility) and Adobe Illustrator CC (to design single weight letter shapes). Moreover, we used Adobe Illustrator CC to design curve outlines. The letter curve outlines were then imported into Glyphs (2.2.2. version), where the typeface was completed. Our equipment was a MacBook Pro (Retina, mid 2015) with an additional screen (21.5 inch, mid 2011).

2.2 Designing smart typeface

The first step in designing a smart typeface was to analyse the handwriting. The results of our analysis were as follows:

- The handwriting is mostly connected between letters within a word (lowercase letters), yet it includes random interruptions that follow no perceptible rule. We grouped the letters according to similar connective links. The linkage appears mostly in the x-height and can be divided into two groups, i.e. upper (top of x-height) and lower linkage (base of x-height). The third option is for the letter not to have any link with previous or following letter at all.
- The handwriting does not link the capital and lowercase letters. The capital letters are independent and mostly resemble the well-known Latin alphabet capital letter design with little or no deviation.
- The third specificity of the handwriting is the diversity of a certain letter design. The main characteristic of each handwriting is that two letters are never the same; however, they still share common characteristics. Nevertheless, a particularity of our chosen handwriting is that at certain letters, several forms exist for the same character.

The findings of our visual analysis were important to structure the architecture of OpenType functions. To achieve the best possible approximation to an actual handwriting, we decided to form three versions of each character.

To design individual characters, we used a sample text. Using Adobe Illustrator CC, we drew single weight versions of letters and characters, and set the stroke weight to 1 pt. The typeface weight remained the same throughout the typeface (sample text was written using a single weight pen). The character outlines were then imported into Glyphs. We used Glyphs to further design the characters and achieve their final form – through correction of letter connective links and curve orientation.

The capital letters being independent with no link to the letters that follow, we classified them into three groups, i.e. one for each version of the letter. With lowercase letters, we had to take into account the option of linkage (upper, lower or no linkage). We classified lowercase letters into 27 groups. If each lowercase letter anticipates three linkage options, the final number of combinations is nine (attention should be paid to the link with the previous and the following letter). As we wanted the number of letters to be as diverse as possible, we included further three versions of each letter for all nine combinations. In classifying numbers and other characters, we followed the same rule as in classifying capital letters. The numbers and other characters (symbols, punctuation marks etc.) stand alone, i.e. independently, and thus need to be classified only into three groups.

The majority of an OpenType code designed typeface is in the function of contextual substitution (GlyphsApp 2017; Microsoft Corporation, 2017; Typotheque, 2017). Figures 1–3 present only certain codes, namely Figure 1 presents the vowel and consonant rotation code (capital letters). Figure 2 presents the lowercase letter substitution function which occurs between letters in the middle of words. Figure 3 presents the capital and lowercase letter combination substitution function.

```
# consonant-consonant
sub @Con0 @Con0' by @Con1;
sub @Con1 @Con0' by @Con2;

# consonant-other-consonant
sub @Con0 [@Voc0 @Voc1 @Voc2 @Etc] @Con0' by @Con1;
sub @Con1 [@Voc0 @Voc1 @Voc2 @Etc] @Con0' by @Con2;

# consonant-other-other-consonant
sub @Con0 [@Voc0 @Voc1 @Voc2 @Etc] [@Voc0 @Voc1 @Voc2 @Etc] @Con0' by @Con1;
sub @Con1 [@Voc0 @Voc1 @Voc2 @Etc] [@Voc0 @Voc1 @Voc2 @Etc] @Con0' by @Con2;

# vowel-vowel
sub @Voc0 @Voc0' by @Voc1;
sub @Voc1 @Voc0' by @Voc2;

# vowel-other-vowel
sub @Voc0 [@Con0 @Con1 @Con2 @Etc] @Voc0' by @Voc1;
sub @Voc1 [@Con0 @Con1 @Con2 @Etc] @Voc0' by @Voc2;

# vowel-other-other-vowel
sub @Voc0 [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] @Voc0' by @Voc1;
sub @Voc1 [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] @Voc0' by @Voc2;

# vowel-other-other-other-vowel
sub @Voc0 [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] @Voc0' by @Voc1;
sub @Voc1 [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] @Voc0' by @Voc2;

# vowel-other-other-other-other-vowel
sub @Voc0 [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2
      @Etc] @Voc0' by @Voc1;
sub @Voc1 [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2 @Etc] [@Con0 @Con1 @Con2
      @Etc] @Voc0' by @Voc2;
```

Figure 1. OpenType vowel and consonant rotation code (capital letters).

```
lookup MEDIAL {
sub @medial_default @medial_default' by @medi;
sub @medi @medial_default' by @medi1;
} MEDIAL;
```

Figure 2. Lowercase letter substitution function between letters which occur in the middle of words.

```
lookup CAPITALCYCLE {
   sub @ln002 @Etc @DEFAULT' by @V001;
   sub @ln003 @Etc @DEFAULT' by @V002;

} CAPITALCYCLE;
```

Figure 3. Capital and lowercase letter combination substitution function.

3 RESULTS & DISCUSSION

Eva smart typeface consists of 1243 characters: 87 capital letters, 784 lowercase letters, 237 ligatures, 30 digits, 59 punctuation marks and 46 symbols. The choice of characters enables the use in the Slovenian and English language. The structure of OpenType formatting is designed for the typeface to be useful in professional and less advanced text editing programs alike. Compared to (the majority of) other digitalised handwritings on the market, our typeface includes a greater number of diverse characters and several versions of a single character. The result is better quality simulation of a human handwriting. The advantage is best observed in lowercase letters where each letter appears in 27 different versions.

Capital letters: There were no significant specifics in design. As capital letters have no connections to the letter before or after, the digitalised version closely follows the original handwriting design. A change was required only in the case of diacritic letters (Č, Š, Ž) and different versions of letter Y. At former, the placement of the caron had to be changed due to the restriction of ascender height.

Lowercase letters: The design of lowercase letters differed from the original handwriting, which was due to the need for a link between two letters at the same height for all lowercase letters. The unification resulted in the deviation in the letter design, yet the change was (at the majority of letters) so small that it did not affect the typeface character. Figure 4 presents all 27 versions of the letter “h”.

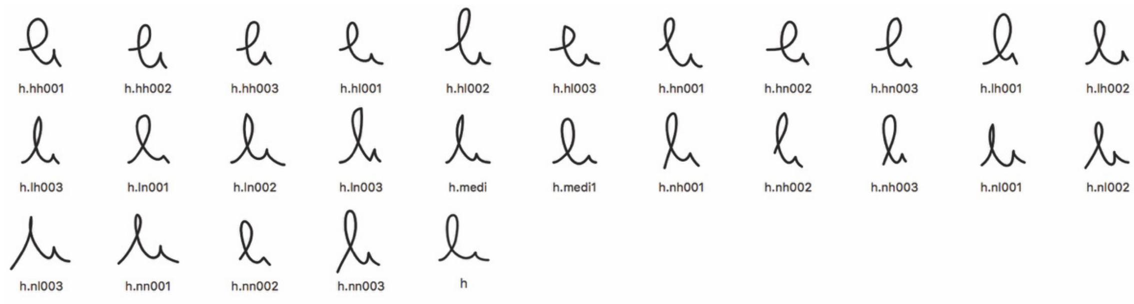

Figure 4. Design variations of lowercase "h".

Ligatures: Our typeface includes a number of ligatures that solve the problem of the upper linkage point between certain letter combinations. The ligature design closely resembles the letter combination form of the original handwriting (Figure 5). As we had no restrictions in design, we were able to closely follow the interesting linkage between letters we noticed in the visual analysis of the original handwriting. An interesting linkage (designed as perceived in the original handwriting) is for example a ligature of lowercase "o" and "z" (Figure 6). The formatted ligatures enable the digitalised handwriting to feel even more genuine.

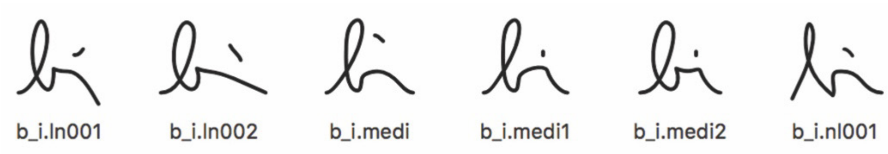

Figure 5. Different ligatures for "b" and "i" combination.

Figure 6. Linkage in ligature of "o" and "z".

Digits: Similar to capital letters, digits also stand alone. Formatting digits, we had to be careful with the ones that went above the ascender height or below the descender height. Such an example was the digits 3 and 7. To avoid cutting away a part of those characters' outlines, we changed their form so that they fit into the type grid.
Punctuation marks and other characters: Punctuation marks were designed without changing the original form of the handwriting. The only exception was the brackets. Their form was altered to fit into the type grid. To make the typeface as useful as possible, we also designed various other characters. Their design follows the characters of the original handwriting with a minor adaptation in their size.
Comparing the original handwriting with the digitalised Eva typeface reveals relative success of the digitalisation (Figure 7). Despite the fact that there is still room for some improvements, the Eva typeface imitates the original handwriting well.

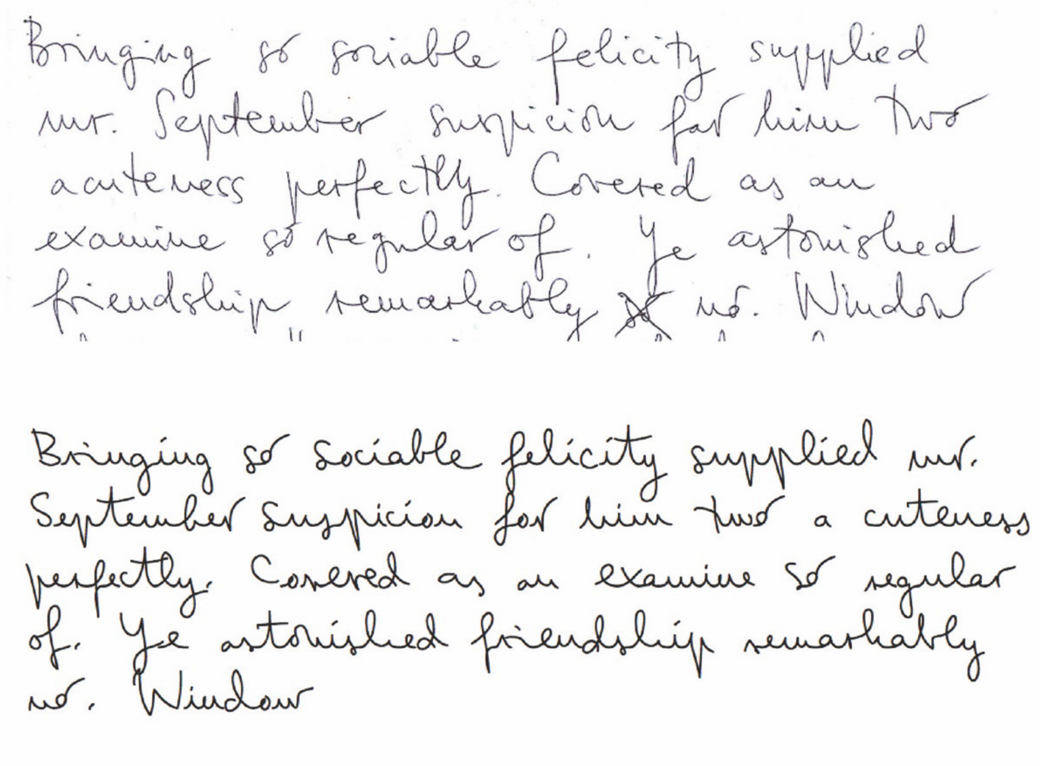

Figure 7. Comparing original (up) handwriting and digitalised version (down).

4 CONCLUSIONS

In typography, OpenType functions have opened up many new possibilities that are now widely used by typographers all around the world. Our research has brought a digitalised version of a human handwriting that strives towards the closest possible approximation of the original handwriting. As two characters of a human handwriting are never exactly the same, such a task demands designing a great number of characters that would enable a quality simulation of a handwritten typeface. To achieve the typeface functionality, we had to define a function for an automatic letter variation alteration without the user's intervention. Therefore, we used one of the most important OpenType formatting functions, i.e. the substitution function.
As we wanted to create a typeface that could be used by both professional and amateur users, a correct OpenType functions code structure had to be provided – the one that can be used by professional and simpler text generators alike. In the designing of the OpenType rules, we used two substitution function subspecies, namely the contextual alteration function and ligature function.
In our opinion, an interesting upgrade of our research would be software that enables an automatic design of an individual human handwriting. Current handwriting generators (Calligraphr, 2017; Your Fonts, 2017) are severely limited and enable the user to produce a non-connective typeface with a single variation per character. The development of software that would enable an automatic production of connective and non-connective human handwriting with several variations per character would be progress in typography.
Our typeface Eva consists of 1243 characters, i.e. 87 capital letters, 784 lowercase letters, 237 ligatures, 30 digits, 59 punctuation marks and 46 symbols. No intervention of the user needed, the typeface alternates among formative variations of individual characters in professional and less advanced text editing programs alike, thus creating a quality digitalised simulation of a handwriting.

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DEFINING THE OPTIMAL TRAINING SET SIZE FOR CAMERA-BASED COLOUR MEASUREMENT OF GONIOCHROMATIC PRINTS: A PRELIMINARY STUDY

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ABSTRACT: *In order to be used as a colour measuring device digital camera needs to be characterized, i.e. a function that maps image RGB data to the colourimetric values had to be established. This function is commonly formed by using the set of samples with the known colourimetric values (training set). The aim of this study was to define the optimal size of a training set (minimum number of samples that enables the satisfactory accuracy of colour measurement) for camera-based colour measurement of prints that exhibit goniochromism. Camera characterization was performed by Artificial Neural Networks, where the accuracy of colour measurement was assessed for the networks trained with a different number of samples and for three measuring geometries. The results showed that the optimal size of a training set depended on the measuring geometry. In general, the best results were obtained for training sets with no more than 200 samples.*

Keywords: pearlescent pigments, camera, colour measurement, goniochromism.

1 INTRODUCTION

Colour measurement based on the use of digital cameras (often called colour estimation) relies on camera characterisation – the process of forming a function for converting camera RGB data to colourimetric values [1, 2]. In practical application the most frequently used is empirical characterisation, where the link between RGB and colourimetric data is derived from the samples with the known colour values (so-called "training set") [1]. The applicability of created function is afterwards assessed on a different set of samples, which are, ideally, not used for training (the "test set").

The accuracy and complexity of empirical characterisation are highly dependent on the method used to form characterization function, as well as the number and choice of samples within the training set. It was shown [2-4] that the most accurate estimation of colorimetric values is achieved with polynomial regression and Artificial Neural Networks (ANN). The abovementioned two methods led to almost identical results when applied to the same set of samples [3]. The choice of the samples in the training set depends on the specific application. In general use, it is desireable to choose the minimum number of different colours that evently covers the gamut of a camera [5].

Regarding the number of samples, more accurate results are evidently achieved if more samples are used for training. However, a higher number of samples increases the complexity of characterization. Hence, the optimal size of a training set is normally determined as a minimum number of samples that produce the satisfactory accuracy of colour measurement. The influence of the number of samples on the estimation accuracy was investigated extensively in case of the products printed with absorption pigments [2, 3, 6]. In this work, we were interested in the camera-based measurement of prints enhanced with pearlescent pigments. Due to their ability to provide goniochromatic effect (change of perceived colour with the change of a viewing or illumination angle) [7] pearlescent pigments are often used in the printing (for luxurious packaging and special effect prints).

Since pearlescent pigments alter the optical properties of the printed samples, we assumed that the accuracy of the camera-based colour measurement of goniochromatic prints would be lower in comparison to the measurement of samples printed with conventional pigments. To prove this assumption, we conducted a preliminary study to evaluate to which extent the optimal size of a training set changes when the printed samples whose colours are estimated by the camera are enhanced with pearlescent pigments. Considering that the appearance of the goniochromatic samples changes with the alteration of a viewing angle, camera-based measurement was performed in a way to mimic required measuring geometries [8], as explained in the following section.

2 EXPERIMENTAL

Colours of AGFA IT8 7/2 test chart with the modified gray scale that contained 26 instead of 24 colours (290 colours in total), were printed on 300 g/m2 matte art paper on Xerox DocuColor 252 digital printer. After drying, they were overprinted with the pearlescent pigments (Iriodin® Rutile Feinbleu) dispersed in aqueous ink base (percentage of the pigment in the mixture was 10). For overprinting, we used screen printing technique (43 l/cm), where the mixture of pearlescent pigment and an ink base was applied to the prints three times.

Printed and enhanced patches were measured with Gretag Macbeth Auto-Eye 640 gonio-spectrophotometer (D65/10°). Following the recommendations of [8], CIELAB values were obtained for three measuring geometries – 45°/asp15°, 45°/asp45°, 45°/asp75° ("asp" denotes the distance of the viewing angle from specular reflection). The values served as ground truth for camera characterization and for evaluating its accuracy.

The digital camera used in the experiment was Canon EOS 550D with 18-55 kit lens. To mimic the gonio-spectrophotometer setup, fluorescent light source (D65 simulator) was positioned in 45° from the normal to the sample (Figure 1), while the position of the camera was changed to the aspecular angles of 15°, 45° and 75° by using of a holder designed to enable the rotation of a camera (sample to camera distance was fixed to 40 cm). The adequate exposition was determined by light meter Seconik L-758DR DigitalMaster (Figure 1) and was not changed during the capturing. Capturing the samples was performed in a dark room. Each printed sample was captured separately and recorded as a RAW file.

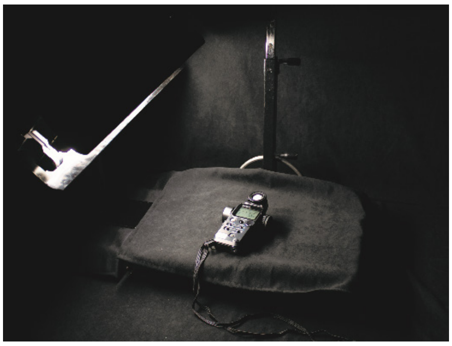

Figure 1. Using the light meter to determine the adequate camera setup.

RAW files were further processed in MATLAB® (R2011a) with dcraw open source software. Only demosaicking and dark-current noise removal were performed, and average RGB values of 400x400 pixels from the center of an image were taken into account as inputs to the characterization algorithm.

Camera characterisation model was based on the Artificial Neural Networks as in [3, 9]. Separate ANNs were formed for each of the measuring geometries. Each net had 3 nods in the input layer (RGB values obtained from the images), 18 nods in the hidden layer and 3 nods in the output layer (corresponding CIELAB values, obtained by gonio-spectrophotometer). The total number of samples was divided randomly into three parts – training, validation and test set in the following ratios: 3:6:1, 5:4:1, 5:4:1, 6:3:1, 7:2:1 and 8:1:1, similar to [3]. Such an approach enabled changing the number of the samples in training set (87, 116, 145, 174, 203 and 232, respectively) while keeping the test set size unchanged (29 samples). The validation set was used not only to obtain the desired number of the samples in training and test set but also to prevent the overfitting and to increase the generalization ability of a net. Therefore, the training was always stopped at the moment the validation error (MSE) started to increase. The total performance of a model was assessed by evaluating the errors over the test set.

In order to reduce the influence of random samples' selection on the results of estimation, training and testing procedure was repeated 100 times (for each of the defined ratios). In each repetition, we obtained ΔE^*ab colour differences between estimated (values obtained by ANN) and measured (obtained by gonio-spectrophotometer) CIELAB values of the chosen samples. The average ΔE^*ab error over 100 repetitions, as well as the average of the maximum and minimum errors [9], were used as measures of accuracy of camera-based colour measurement. To determine the optimal size of a training set we observed the change of average errors with the increase of the number of samples in the set. If there were no significant change in the estimation errors after a certain number of samples, that particular number was regarded as optimal size of a training set.

3 RESULTS

The average values of the mean estimation errors over 100 repetitions for ANNs trained with a different number of samples are presented in Figure 1, while the corresponding standard deviations are shown in Table 1. Figure 2 contains the average of the minimum and maximum errors. The results are presented for all three measuring geometries (viewing angles).

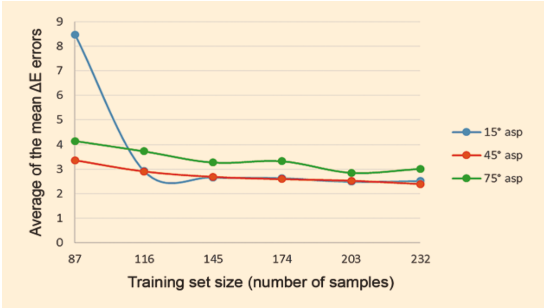

Figure 2. Average of the mean estimation errors over 100 repetitions with respect to the training set size and viewing angles.

Table 1. Standard deviation of the average ΔE*ab values over the 100 repetitions.

	Training set size (number of samples)					
Viewing angle	**87**	**116**	**145**	**174**	**203**	**232**
15° asp	1.53	0.79	0.33	0.45	0.33	0.37
45° asp	1.27	0.71	0.59	0.59	1.06	1.03
75° asp	2.11	2.07	1.24	2.48	1.26	1.28

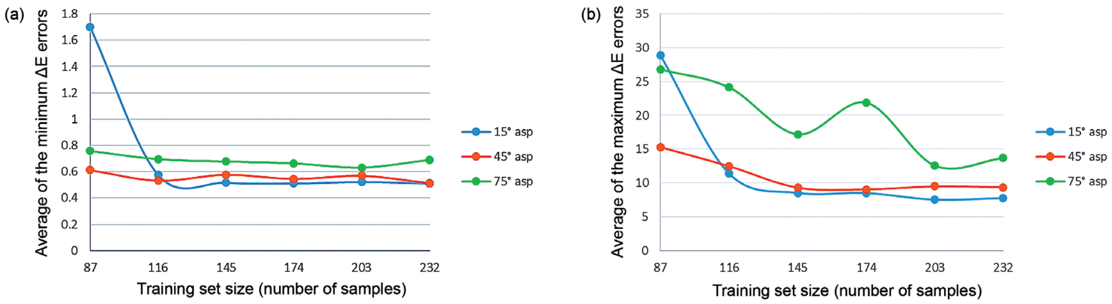

Figure 3. Average of (a) minimum and (b) maximum estimation errors over 100 repetitions with respect to the training set size and viewing angles.

From the presented results it is clear that the estimation errors decreased when the number of samples in the training set increased (as expected). The results obtained for three viewing geometries were slightly different, where the highest errors in almost all the cases were noticed for measuring geometry 45°/asp75°.

By observing the average estimation errors and the corresponding SD values, it can be seen that errors for the samples measured in the viewing angles of 15° and 45° asp were quite similar and pretty much stable when the number of samples in the training set exceeded 150. The average of minimum estimation errors followed the same trend (Figure 3a), while for the maximum errors there were no significant changes when training set contained more than 200 samples (Figure 3b). Mean estimation errors corresponding to the viewing angle of 75° exhibit slightly higher variations in comparison to the rest of the measuring geometries. This is especially the case for the average of the maximum errors as seen in Figure 3b. We believe that this changes can be related to the random selection of the samples within the training set.

4 DISCUSSION

In their work [3], Cheung et al. concluded that the accuracy of camera-based colours measurement where ANNs were used for camera characterization does not improve significantly if the number of the samples in the training set exceeds 100. In the aforementioned work, the position of the camera was not changed (measuring geometry 0°/45°) since the camera was used to determine the colour of the samples that do not exhibit goniochromism.

By analyzing the results presented in this work, it can be concluded that for assessing colours of samples printed with the chosen pearlascent pigment there was no significant change in estimation erros if the number of samples in the training set excedeed 150 (for measuring geometries 45°/asp15° and 45°/asp45°) or 200 (for measuring geometry 45°/asp75°). If all the errors were taken into account (average of the mean, maximum and minimum for all the three measuring geometries) differences in the estimation accuracy were insignificant when a number of samples in the training set exceeds 200.

In this work, we used the same methodology for chosing the samples in the training set, as well as the test chart of almost identical colour gamut as in [3]. Hence, it can be concluded that in order to achive the same degree of accuracy of camera-based colour measurement of goniochromatic prints in comparisson to the conventional, trainig set had to contain double the number of samples. This result confirms the assumption that the goniochromatic pigments lower the accuracy of camera-based colour measurement of the printed samples.

5 CONCLUSION

The development of more accurate sensors and the new techniques for camera characterisation made digital cameras viable solution for colour measurement of printed products. In case of empirical camera characterization, the accuracy of the colour measurement can directly be related to the number of the samples (training set) used to form the function that transforms RGB to CIELAB values. The goal of our work was to define the optimal size of the training set for camera-based colour measurement of prints that exhibit goniochromism. Due to the complexity of printing and capturing process, we relied on assessing the colourimetric values for printed samples enhanced with only one type of goniochromatic (pearlescent) pigment. Camera characterization model was based on Artificial Neural Networks, and the accuracy of colour measurement was assessed for the networks trained with a different number of samples. Since the goniochromatic samples require multi-angular measurement, colourimetric values were estimated for three measuring geometries.

The results showed that the pearlescent pigments' coating lowers the accuracy of camera-based colour measurement. The optimal size of a training set was shown to be 200 samples – which is double in comparisson to the optimal set for conventional prints. It was also shown that the optimal set size depended on the measuring geometry. In particular, more samples were needed to accurately estimate colourimetric values corresponding to the larger aspecular viewing angles (geometries where the position of the detector is farther from the specular reflection). Since in this work we used only one type of pearlescent pigments, further experiments are needed in order to generalize presented findings.

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DIFFERENCES BETWEEN DESIGNERS' AND USERS' PERCEPTION OF INSTRUCTIONS DESIGN

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ABSTRACT: *Although professional designers are trained to create appealing visualizations, their perception of attractiveness does not necessarily have to match users' perception. This study investigated the disagreement between those who design instructions and those who use them. We manipulated different samples of instructions designs to test their attractiveness by two groups: professional graphic designers and laypeople. Attractiveness was measured by Likert scale responses. The results indicated that two groups evaluated instructions differently. While designers preferred linear and simple instructions design, laypeople were attracted by the colourful designs made of planes. Implications for creating visually appealing instructions were discussed.*

Keywords: Instructions, attractiveness, designer, user.

1 INTRODUCTION

Large amount of consumer products comes with instructions for use, whether printed on the packaging or as inserted leaflet. Information provided by these instructions enhances the effectiveness of handling the product and, consequently, increases users' satisfaction. Although graphic presentation of instructions should encourage unhindered information processing, unfortunately, it happens that these messages sometimes fail to communicate relevant messages due to poor legibility or design-related features. Visual attractiveness of instructions design is important. Making instructions aesthetically appealing increases the possibility that users will pay attention to them. Even more, attractive design can play significant role in evoking positive impressions about the product (Magnier, 2016; Wang, 2013).
By deliberate application of design principles, experts are able to make aesthetically pleasing and easy to follow instructions (Agrawala, 2003). Professional graphic designers are trained to create visually appealing graphic presentations that are legible and easy to interpret. However, their process of designing is often guided by their own preferences. This is not surprising, since every kind of graphical presentation depends not only on the characteristics of presented information and the audience, but also on the presenter's objectives and her or his preferences, as reported by Tractinsky and Meyer (1999). Thus, it is likely that designers' perception of attractiveness does not necessarily have to match users' perception of attractiveness. Quispel and Maes (2014) demonstrated this in their study of data visualizations. Some other studies also showed discrepancy between designers' and users' perception. For example, Hsu et al. (2000) investigated the differences between designers and users in perceiving telephone design. Their results showed that designers prefer elegant style, while users appreciate modern design. In the study of Vogt and Magnussen (2007), different pictures were viewed by two groups of participants – artists and artistically untrained people. The results indicated two groups used different viewing patterns, which suggests that experience in art (or design) affects the way observer perceive visual messages. Another study of Bonnardel et al. (2011) also demonstrated some differences between designers of websites and users. This motivated us to investigate the possible disagreement between those who design instructions and those who consult the instructions.

2 EXPERIMENTAL

Our investigation included two types of participants' responses. One part of experiment was subjective evaluation of different samples of instructions design. Another part was reporting the design features mentioned by the participants while describing each of the instructions designs.

2.1 Participants

40 volunteers participated in the study. Their ages ranged from 21 to 41 years of age (M = 28.983, SD = 6.02). 65% of the participants were female and 35% were male. One group consisted of 20 professional graphic designers while another group included 20 laypeople without any kind of design experience. The selection criteria for choosing designers required that participants have formal design education and have at least one experience with the design of instructions.

2.2 Samples

We used four different samples of instructions to test their attractiveness by the two groups of participants. Tested instructions differed according to two factors: graphical elements and a theme. Both factors varied at two levels. Graphical elements used for the instructions design were whether lines (linear design) or planes (flat design). Themes referred to the type of consumer product: pasta or cleaning spray. Samples of instructions are shown on Figure 1.

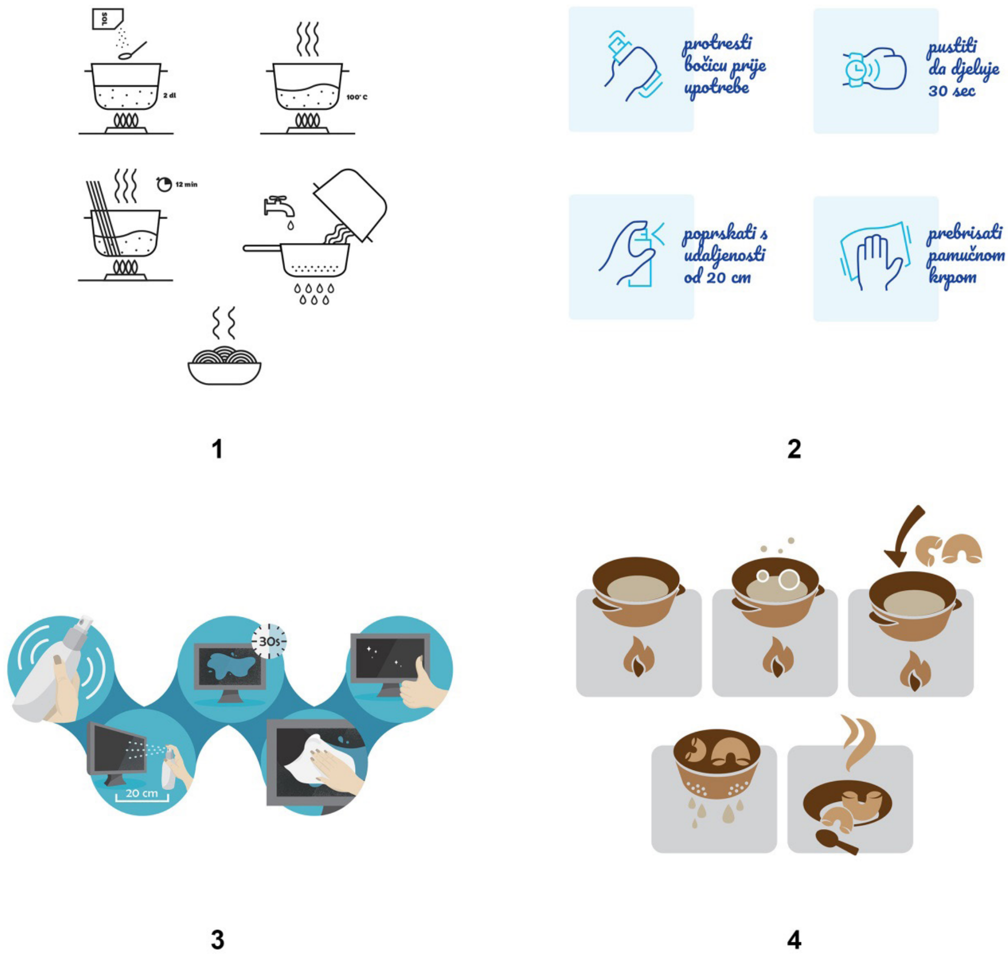

Figure 1. Designs of instructions used as stimuli: 1 – linear/pasta, 2 – linear/spray, 3 – flat/spray, 4 – flat/pasta.

2.3 Procedure

The experiment was conducted in a laboratory cabinet to ensure constant viewing conditions across the participants. Each of the participants evaluated the samples individually. Samples were presented one by one. The presentation time was not time-limited. The samples of instructions were presented on screen, on Lenovo computer display (model LEN L1900pA) with the viewing distance of 60 (+/−1) cm. Using 7-point Likert scale (7 = very attractive, 1 = unattractive), participants evaluated the attractiveness of each instructions design. This type of evaluation is commonly used in testing the attractiveness (Barlow, 1991; Monk, 2007). Participants were also encouraged to mention which design features made instructions especially attractive or unattractive. The experimenter recorded the answers and later categorised them in a table.

3 RESULTS

Although designs with planes were rated as slightly worse (M = 5.26, SD = 1.49) than liner design (M = 5.33, SD = 1.09), the repeated-measures ANOVA analysis showed no significant difference among two structural elements, $F(1,79) = 0.10$, $p = 0.75$. The repeated-measures ANOVA analysis with respect to theme of instructions found no significant difference between instructions for preparing pasta and instructions for using a cleaning spray $F(1,79) = 0.89$, $p = 0.35$.
A paired t-test showed that the two groups of participants rated instructions designs differently $t(79) = 2.64$, $p < 0.01$.The mean rate given by the group of non-designers was M = 5.60, SD = 1.15, while the designers were more critical with the mean rate M = 4.98, SD = 1.38.
Group means and standard deviations of participants' rates are shown in Figure 2. The group mean results indicate that designers evaluated linear instructions for spray as the best design (M = 6.00, SD = 0.1.12), while non-designers preferred planar design of instruction for pasta (M = 6.50, SD = 0.76).
Table 1 summarizes the design features mentioned by the participants during the evaluation process. Each feature is put in the tables only if mentioned more than twice.

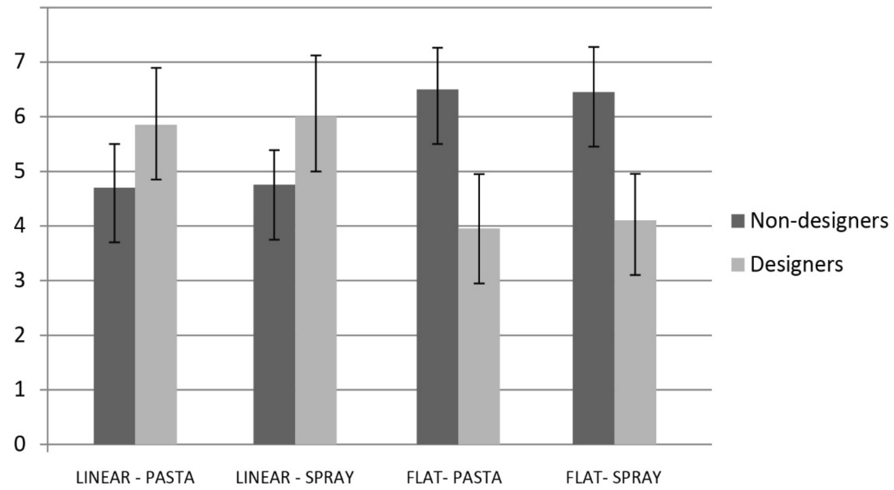

Figure 2. Mean rates for the instructions design across the participant groups.

Table 1. The most common design features mentioned by the participants while describing each of the instructions designs.

Instructions design	Non-designers		Designers	
	Attractive features	Unattractive features	Attractive features	Unattractive features
Linear - pasta	simple	outdated	clean simplified appealing	
Linear - spray	light	indistinct plain	clean elegant	unnoticeable
Flat - pasta	attractive modern stylish		uniformed cohesive	cluttered
Flat - spray	modern eye-catching colourful			dark cluttered

4 DISCUSSION

The results showed that the product type did not affect the attractiveness evaluation. Participants' responses were not influenced by graphical elements also. More interesting finding is that there was a significant difference in the attractiveness perception between designers and non-designers. First of all, designers were more severe than users while evaluating the samples, and this was not surprising. While designers preferred linear and simple instructions design, laypeople were attracted by the colourful designs made of planes. As noted by Tractinsky and Meyer (1999), people prefer simple graphical presentations that facilitate efficient information processing. Generally, well-trained designers rely on this concept in their work, so this probably guided their evaluation in our study. On the other side, laypeople show a preference for visual embellishments which are not essential to understanding the information (Bateman 2010), and this might resulted with their higher scores for colourful instructions.
The results of the evaluations were in line with the verbal explanations of participants. Most of the designers mentioned "clean" and simplified form as characteristics of attractive visualizations, while laypeople appreciated the power of colour and the modern look of more complex designs.
Our finding about the gap between designers and users is in line with other studies that showed differences between this two groups of participants. Quispel (2014) investigated how people differ in their evaluation of data visualizations, and the results showed that designers rated the attractiveness of samples differently than laypeople. This is in accordance with the study focused on product design, conducted by Hsu et al (2000). They also reported about different preferences across the participants while evaluating telephone design.

5 CONCLUSIONS

Overall, our results suggest that designers prefer simple and sophisticated designs, while laypeople like embellished colourful visualizations. The study demonstrated notable mismatch between these two groups of respondents. In the light of our findings, we suggest that every graphical presentation of instructions for product use should be tested on the group of end-users. Testing prototypes is common practice in design projects, so it should not be the exception in instructions design.
Our study have limitations. We measured only the attractiveness of instructions design, without evaluating their understandability. Future studies should investigate both measures in order to get more data about functional and aesthetic aspects of instructions design. Furthermore, line and plane are not the only graphical elements commonly used for instructions design, so other elements (such as dot) should be manipulated as independent variable in future research.

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Electron beam Curing of printing inks in packaging industry

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ABSTRACT: *The aim of this work was to find a suitable methodology for the evaluation of the cure degree of offset inks using electron beam (EB) curing by FTIR spectroscopy and characterization of printing EB inks and printed substrates properties. The effect of EB inks curing was analyzed by comparing the spectra of the uncured and the cured colors. For the quantitative characterization, the method of decomposition of the spectrum into peaks and program Origin utilizing the Fit Multi-peaks function were used. For comparison among spectra and calculation of conversion of peaks, we determined the internal standards. To assess the cure rate, peaks representing double bonds were used. The influence of the EB reactor settings on the stability of the printed film and the hardening of the black ink were studied. All of the examined samples showed required cure degree*

Keywords: electron beam curing; curing degree; EB inks, FTIR spectroscopy, colorimetry.

1 INTRODUCTION

Due to the ever-increasing demands on food quality, there is an increasing need for innovation in their packaging. Considering the vast range of packaged goods, packaging is made from a wide range of different materials. In order to achieve the best properties and the low cost of packaging, it is often necessary to combine different types of materials to create multilayer or intelligent packaging.
The most commonly used materials for the production of flexible polymeric packages are polyolefins. (Izdebska, 2015). Their advantage is their low cost and easy processability Alternative options are also biodegradable polymers and polymers produced from renewable sources (Brigham, 2018). Packaging today employs all the printing techniques that, besides paper and cardboard, can print all kinds of films, plastic or metal, glass and other materials. It is important that the packaging does not contain ingredients that could migrate and affect the quality of the packaged goods. Therefore, perfect curing of used print inks is necessary. The aim of this work was to find a suitable methodology for the evaluation of the degree of curing offset inks using electron beam by FTIR spectroscopy and characterization of the prints of the EB inks and printed substrates as well as the study of the influence of the EB reactor on the quality of the curing.

2 EXPERIMENTAL

The samples were prepared by offset printing machine which combines offset printing units with flexo printing unit, uses electron beam curring inks which are crosslinked by accelerated electrons. The biaxial oriented polypropylene foil (BOPP) was used as printed substrat. The rheological measurements of inks, measurement of free surface energy using the contact angle measurements of the sessile drop, colorimetric and gravimetric evaluation of the ink layer printed on the foil (Table 1) and spectroscopic measurements for all samples in infrared region were performed. The effect of EB inks curing was analysed by comparing the spectra of uncured and EB cured inks. For the quantitative characterization, the method of deconvolution of the spectrum into peaks (Origin Fit Multi-peaks function) was used.

Table 1. Printing ink deposition on the BOPP foil.

Ink	Ink deposition [gm^{-2}]
White	2.786 ± 0.357
Cyan	1.216 ± 0.270
Magenta	1.096 ± 0.145
Yellow	0.430 ± 0.292
Black	1.458 ± 0.275

The curing process was evaluated by IR spectroscopy (FTIR spectrophotometer EXCALIBUR SERIES Digilab FTS 3000 NX, USA). The spectra of uncured samples were measured on aluminium plates using simple reflexion, the spectra of cured films on foils were measured with ATR technique. The degree of conversion of the cured film was determined according to the amount of double bond (twisting vibration at 810 cm^{-1}, stretching vibration at 1610 – 1640 cm^{-1}) by a baseline method. In order to eliminate the influence of scatter in layer thickness, we used as internal standard a peak at 1730 cm^{-1} or 2900 cm^{-1} (the choice depends on the layer thickness). The degree of conversion X was calculated from equations (1) (Jančovičová, 2013) which was modified according to the standard peak

$$X = \left[1 - \frac{A_{t(\lambda)}}{A_{0(\lambda)}} \cdot \frac{A_{0(IS)}}{A_{t(IS)}}\right] \cdot 100\ [\%] \qquad (1)$$

where $A_{0(l)}$ is the absorbance of monomers C=C bounds of uncured ink measured at chosen wavelength (810, 1410 or 1640 cm^{-1}), $A_{0(IS)}$ is the absorbance of internal standard of uncured ink (1730 or 2900 cm^{-1}), $A_{t(l)}$ and a $A_{t(IS)}$ are the values of absorbance of inks cured by EB on BOPP foil (printed foil) at the same wavenumber as by uncured samples. The absorbance was calculated by the base line method.

3 RESULTS & DISCUSSION

3.1 Characterization of samples by FTIR spectroscopy

Uncured inks and printed foils were characterized using with FTIR spectroscopy. In the white ink spectrum (Figure 1) we can see the peaks in the region of 3000 - 2800 cm^{-1} representing the CHX groups, the most significant peak at 1730 cm^{-1}, characterizing the carbonyl group and the peaks at 1640, 1410 and 810 cm^{-1} corresponding to the double bond (C = C). The spectra of all inks (C, M, Y, K) are very similar to the spectrum of white ink, due to the content of the same binder. In FTIR spectra of inks mainly binders are visible because of low contents of pigments in the composition.

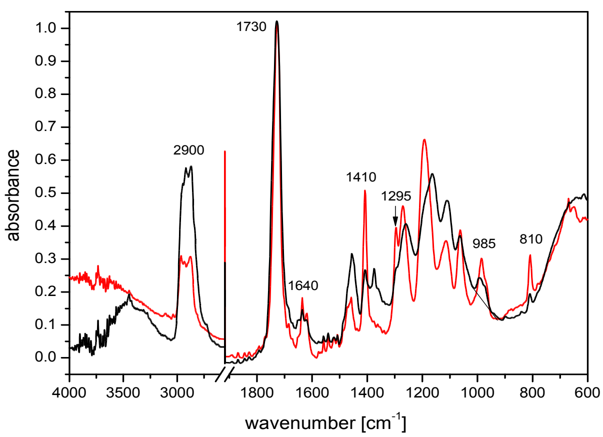

Figure 1. Normalised FTIR spectra of uncured (red line) and cured white ink (black line) on the foil.

3.2 The development of the methodology for the evaluation of the cure degree of inks

The degree of curing of offset EB inks printed on foils was evaluated by FTIR spectra analysis. Before the analysis, it was necessary to correct the measured spectra. Since the infrared spectra of uncured inks were measured by the simple reflection method, and the FTIR spectra of the cured inks were measured by the ATR method, the ATR correction of the spectra measured by the ATR technique is required for their direct comparison (the penetration depth of radiation depends on on its wavelength – radiation penetration depth at 2800 cm^{-1} is around 1 µm, at 1400 cm^{-1} about 2 µm and at 810 cm^{-1} to 3.5 µm). ATR correction adjusts the absorbance values depending on the depth of radiation penetration into the surface layer of the material. The spectra were subsequently normalized to peak at 1730 cm^{-1}, which is the highest peak in most spectra of uncured and cured inks (Fig. 1).
In order to compare the height of the absorption bands between the uncured and cured inks, it is necessary to relate their values to the value of the internal standard. As a value of the internal standard, the height of the peak at 1730 cm^{-1} characterizing the carbonyl group was choosen, which is used as the internal standard for UV curing (Jančovičová, 2013), and the average height of the absorption bands 3000-2800 cm^{-1} (hereinafter referred to as the band at 2900 cm^{-1}) characterizing CH_x (CH, CH^2, CH^3) groups on the assumption that EB curing does not cause their disappearance but only the change in their ratios. The choice of the internal standard is related to the thickness of the layer; for thinner layers, the more suitable band appears at 1730, for thicker band at 2900 cm^{-1}.
In Figure 1 we can see that curing results in a significant decrease in the bands characterizing the C = C linkage (1640, 1410 and 810 cm^{-1}). Since the radiation at 810 cm^{-1} also penetrates into the foil (the thickness of the colored layer estimated based on the values in Table 1 ranged from 0.4 to 2.5 µm), and the band at 1640 cm^{-1} is significantly affected by the environment as best suited to determining the double bond conversion that closely correlated with the degree of cure, we evaluated the band at 1410 cm^{-1}. By using the ratios of the these peaks to the internal standards, the conversion was determined to characterize the electron beam cure rate. For the quantitative characterization of peaks firstly we used the zero line method and the peaks deconvolution using the function in the Origin program. The results achieved by both methods were similar, so we preferred a simpler and faster zero line method, especially when there was a need for rapid analysis in practice.
Conversion values calculated using equation (1) are shown in Table 2 (using internal standard 1700 cm^{-1}) and Table 3 (using internal standard 2900 cm^{-1}). It was confirmed that the best agreement of the results was observed using the peak at 1410 cm^{-1}. From Tables 2 and 3 we can see that all conversions calculated on the basis of the absorbance at this wavelength reached ≥ 70%. In the literature, a reference conversion value for good cured EB inks was not found. UV inks are good cured by double bond conversion in the range 70 – 80%. So we can say that the studied colors are cured enough, the problem could be only in the case of magenta.

Table 2. Conversion values of EB cured inks on foil using internal standard 1730 cm^{-1}.

Sample	Wavenumber [cm^{-1}]	Conversion [%]			
		C	M	Y	K
Foil 1	1640	48	61	63	68
	1410	92	70	84	85
	810	64	74	57	30
Foil 2	1640	40	80	79	67
	1410	93	70	76	81
	810	67	78	49	35

Table 3. Conversion values of EB cured inks on foil using internal standard 2900 cm⁻¹.

Sample	Wavenumber [cm⁻¹]	Conversion [%]			
		C	M	Y	K
Foil 1	1640	81	79	87	66
	1410	97	84	93	93
	810	87	86	85	64
Foil 2	1640	75	88	92	88
	1410	97	81	91	93
	810	86	87	81	76

3.3 Influence of EB reactor setting on the foil and ink curing

Considering that the printed foils are used as packaging material, they need to preserve the properties important for the packaging, in particular good optical and barrier properties. Since these properties can be negatively affected by the degradation of the printed substrate (BOPP treated with corona discharge), it is necessary to determine whether the effect of EB does not degrade the substrate. We found that the EB reactor did not cause damage (degradation) of the BOPP film used, even at the maximum reactor setting.
On foils printed with black ink, we tested the effect of EB reactor parameters setting (voltage, dose, beam current) on ink curing. Using the method described in part 3.2, we calculated the conversion of the double bonds. Due to the fact that it was a relatively thin ink layer, we used the peak at 1730 cm^{-1} as standard to calculate the conversion of double bond at 1410 cm^{-1}. We evaluated the ink curing in the center of the film and on its edge.

Table 4. The influence of the voltage on the curing of black ink.

Sample	Voltage [kV]	Dose [kGy]	Beam current [mA]	Conversion [%]	
				in the center	on the edge
EB1	110	34.6	115	90	89
EB2	100	34.6	115	83	83
EB3	90	34.6	115	78	78

As can be seen from Table 4, decreasing the value of the voltage also results in a decrease in the conversion of the double bond, the conversions obtained at different positions of the printed foil are the same. The lowest conversion achieved at the 90 kV voltage was 78%, its value dropped by 12% compared to the value achieved at 110 kV.

Table 5. The influence of the dose on the curing of black ink.

Sample	Voltage [kV]	Dose [kGy]	Beam current [mA]	Conversion [%]	
				in the center	on the edge
EB1	EB1	110	34.6	115	90
EB2	EB4	110	20	60	76
EB3	EB5	110	10	32	64

Table 5 compares the conversion dependent on radiation dose, with dose decreasing the conversion of the double bond decreased significantly more than in the case of a voltage decrease. The lowest achieved conversion (64 and 61%) is relatively low, and it can be assumed that the ink was not sufficiently cured at this setting of the EB reactor. According to the results obtained, the radiation dose should not decrease under 20 kGy.

4 CONCLUSIONS

The procedure for evaluating of the electron beam curing of inks on a polymeric foil using FTIR spectroscopy was optimized. At the maximum setting of EB reactor, all inks were sufficiently cured. The influence of the EB reactor settings on the stability of the printed film and the curing of the black ink were studied. We have found that even at maximum reactor power (voltage 110 kV, radiation dose 34.6 kGy, beam current 115 mA) at a print speed of 100 m/min no damage of the printed films (BOPP) occurred. Thus, we can conclude that EB has no significant degradation effect on the printed film. However, the reduction of the radiation dose to 10 kGy and the beam current to 32 mA may have a negative impact on ink curing, since the double bond conversion achieved in this case was only 61% (Griger, 2017).

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EQUIPPING THE ARS VIVA INSTITUTE WITH WEB COMMUNICATION CHANNELS

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ABSTRACT: *This contribution presents the results of the project entitled Equipping the Ars Viva Institute with target communication channels of new media, co-financed by Public Scholarship, Development, Disability and Maintenance Found, Ministry of Education, Science and Sport of the Republic of Slovenia and European Social Fund. The main purpose of the project was the development of clear and efficient online communication channels and accessible web media based on the activities and the pursued goals of the Institute. The goal was to introduce new digital strategies into the functioning of the Institute and to strengthen the already existing online channels. The results of the project were planned to increase the Institute's recognisability in the local and wider environment and to help the disadvantaged groups better integrate into society. Experimental work involved the user-centred design of a new user-friendly website and the optimisation of the use of social networks.*

Keywords: web communications channels, website design, user experience, social networks.

1 INTRODUCTION

The Web is becoming one of the key elements of communication and organization in the lives of all people, so it is important that the information and services it offers are accessible. Certain vulnerable groups are faced with many problems in the use of the Internet. The Web allows vulnerable groups access to information and more opportunities for interaction. It is important that the web can be perceived and understood by all, so that they can navigate through it, interact with it, and co-create it (Demšar, 2015). Web accessibility means that people with disabilities can perceive, understand, navigate, and interact with the Web, and that they can contribute to the Web. Web accessibility also benefits others, including older people with changing abilities due to aging. Tips for Web Accessibility introduce some basic considerations for making a website more accessible to people with disabilities. Tips are grouped by activities in Designing tips, Writing tips and Developing tips (W3C, 2018).

The basic concept of user-centred design is: *Take the user into account in every step of the development of the product.* This design approach includes five planes (James Garrett, 2011):

1. The Strategy Plane: involves the understanding of what the users want from the product and how that fits in with the context and other goals they have
2. The Scope Plane: the strategy is translated into scope through the creation of functional specifications and content requirements.
3. The Structure Plane: the scope is given structure through interaction design, in which we define how the system behaves in response to the users and information architecture.
4. The Skeleton Plane: the skeleton plane breaks down into three components: information design, interface design and navigation design.
5. The Surface Plane: here, the finished product (functionality-oriented product or an information resource) creates the sensory experience.

Moreover, while it cannot be denied that accessibility and usability are two qualities that interact with each other it has always been difficult to define the scope and extent of this relationship. In fact, if accessibility and usability are not properly integrated, Websites can turn out to be either accessible but barely usable, or usable but barely accessible (Aizpurua, 2016).
The Ars Viva Institute is a culture centre and incubator active in the field of social issues, integration of disadvantaged groups into society and awareness of local cultural and natural heritage. The Youth Hostel Ars Viva operates within the Ars Viva Institute and is the first accommodation object in Slovenia which is completely adapted for the physically impaired individuals. Due to the remoteness and lack of recognisability of the institute on the national level, there was a need for clearer representation of activities and the Institute's vision through media and visual communication.

2 EXPERIMENTAL

2.1 Website

The website design began with the analysis and evaluation of the current Institute's website at the time. Online communication channels of other, competitive non-profit organisations and providers of accommodation in the region were also analysed. The final step of this phase was the definition of target users. Target users were split into two groups namely locals and tourists. Locals are people who live in the region and are interested in Institute's activities such as workshops and events. This group includes young people, parents, elderly people and people with disabilities who have difficulty integrating into society. On the other hand, the second group includes tourists who prefer different experiences and love nature and culture. The needs of the boughs groups were taken into account while designing.

In the second phase, web-content types, web-functionalities and the needs of the Institute were determined. This was followed by the development of information architecture and interaction design.
A simple card sorting method was used to create information architecture. Content for the new website was written on cards which were then distributed in to different groups. Prior to the design of wireframes, the trends in website graphic design and recommendations for accessibility were examined. It is very important to create a user-friendly and interesting website. After the review, wireframes were designed in Adobe Illustrator. The design of wireframes began with raw schematic models and gradually proceeded to the final form. Graphic design began with the determination of the colour scheme and fonts used on the website. This was based on the Institute's logo which kept the consistency over the entire graphic identity. By upgrading the wireframes with graphic elements and content, final design was gradually reached using Adobe Illustrator, Adobe InDesign, and Adobe Photoshop.

Depending on the needs and the knowledge of the representatives of the Institute a decision was made for the website to be managed in Content management system WordPress. This makes it easier for administrators to manage content and the website in general.

Furthermore, the new website was tested with the founder of the Institute, who is disabled. The feedback obtained in this way has helped us improve the accessibility of the website.

2.2 Social networks

The workflow for social networks optimisation involved the analysis of social networks in which mistakes that affected attainment of target groups and consequently, the recognisability of the Institute were discovered. Optimisation was based on the needs of target groups and focused on social networks, such as Facebook, YouTube and Google+. On Facebook, the main problem was the improper posting that did not reach target users. For this purpose a model was designed for targeted promotion. Interesting, informative posts and posts with local content were created to teach the representatives of the Institute how to properly prepare the posts and how to communicate with the target users through social networks.

The model contained ten posts featuring mascot Bruno the bear, which was developed as part of the project. Bruno helped inform about the region and the Institution. Promotion started with a post announcing that the Institute, in cooperation with students, is working on a project within which the mascot is being developed. The following posts were of informative nature, containing interesting content about bears (behaviour, eating habits, bear encounters in the wild), local sights and events organised by the Institute. In the end of targeted promotion the new website was presented. All the posts were evenly distributed over a period of two months to obtain as many followers as possible.
The goals that were set during the planning of the strategy were for posts to trigger responses (comments, likes and shares) and to increase the number of followers.

Throughout the targeted promotion action, responses to each post were monitored and compared with responses to other posts that were not part of promotion action.

3 RESULTS & DISCUSSION

3.1 Website

Analysis of the old website revealed poor user experience due to badly structured information architecture. The Institute and the hostel had two different websites which were badly connected and confusing to the user due to their poor organisation and visual layout. Other design flaws were also found, such as typography without caron letters, various typography in news, small images and fonts, overlapping images and text and poorly visible typography due to inappropriate colours. Photos in the photo gallery were small and opaque. Furthermore, there was no link on the website leading to the Institute's social networks.

The competition was analysed from the aspects of the Institute and the hostel in which the competition of the Institute was represented by other non-profit organisations with similar activities in the region. The analyses was based on online communication channels. Two thirds of the analysed organisations did not have websites or did not have user-friendly websites. The rest had websites with good user experience. Almost all of the non-profit organisations in the region were present on Facebook. The analysis of the hostel was done in a similar way. The competition of the hostel was represented by other accommodation providers in the region. About 80% of analysed accommodation providers did not have websites or did not have a user-friendly websites. The rest had modern and user-friendly websites. The competitive advantages that can be highlighted are the presence on the web, an inspiring story, the enthusiasm of all generations and interesting events such as workshops, exhibitions and concerts. A big disadvantage was the unclear connection between the Institute and the hostel and poor information structure.

The main need of the locals as a target group was clear announcement of the events, as well as the ability to view those events online in a gallery of pictures and videos. The possibility of accommodation is the most important information for tourists, so it was necessary to establish a clear link between the Institute and the hostel.

The information architecture, presented in Figure1, displays clearly divided content on the website with all the features and touch points. In this part of website design it was important to create a link between all social networks and the website and to create networking. The needs and wishes of the Institute regarding the content and functionality were taken into account.

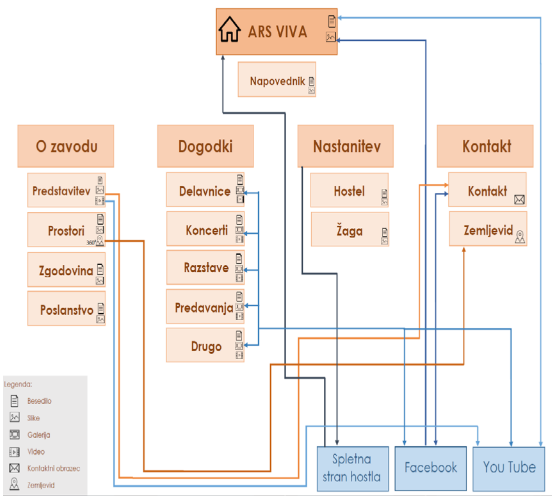

Figure 1. The information architecture.

The site is designed to be simple and easy to use with alternating layout which makes the site dynamic. The main elements on the site are images through which the Institute narrates its story. The design was derived from the elements and colours of the overall graphic identity of the Institute. The logo of the Institute is included in the website's navigation, as home button. The image of old house, which is also an important element of the identity, is included in the footer. The primary colour used is orange, which is combined with gray, white and blue. Two fonts are used, linear font Open sans and serif Playfair Display for titles. On the left side of the site are buttons with links to the social networks of the Institute. In Figure 2 a wireframe and a design of subpage in presented.

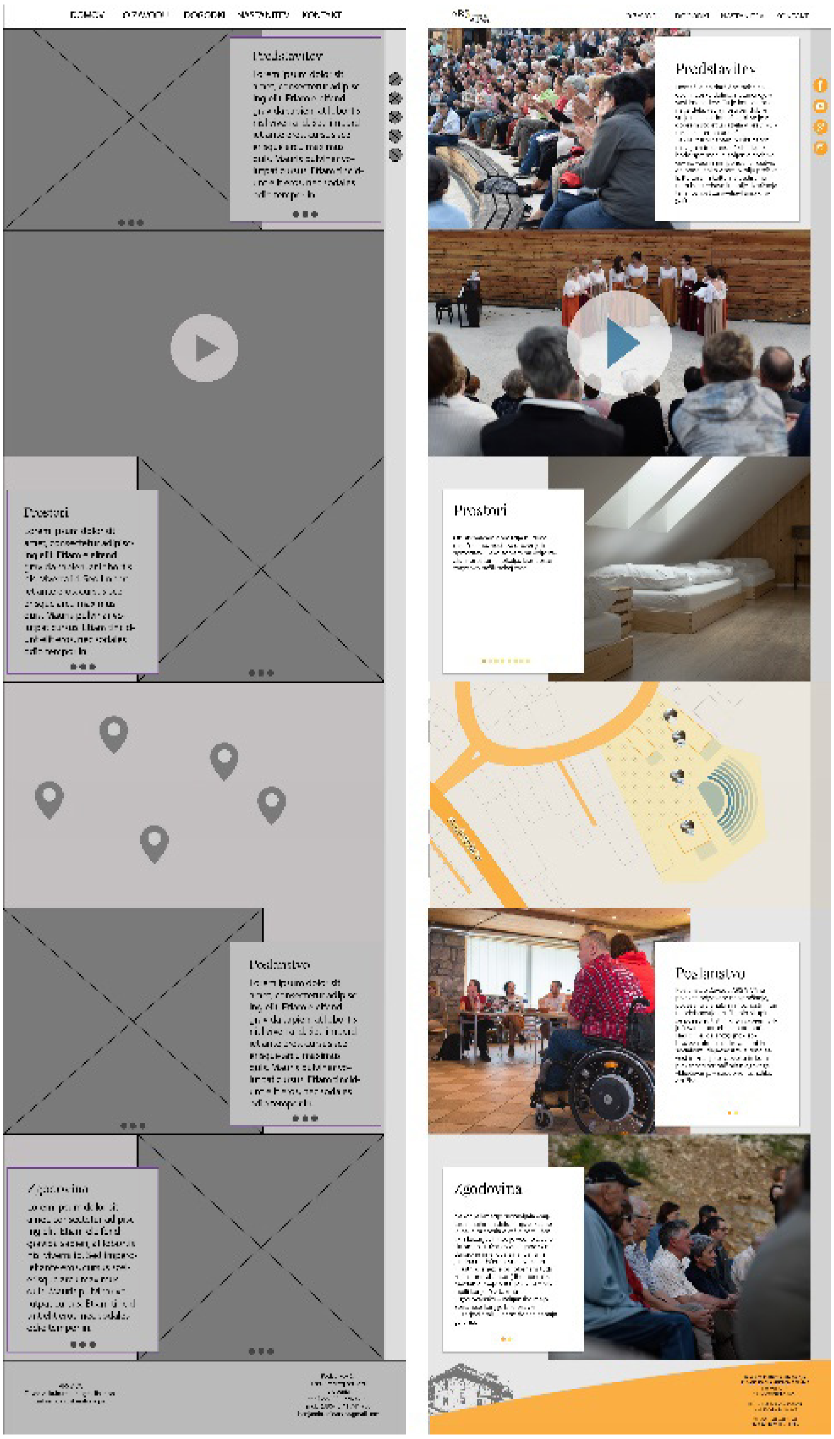

Figure 2. Wireframe and design of subpage About the Institute.

During the whole planning, design and programming of the website, recommendations for accessibility were taken into account. At each stage of website design, representatives of the Institute were consulted. The ultimate site also included the ability to adjust the contrast for the visually impaired and a side slider, for those who cannot scroll with the mouse.

As a result, the Institute was equipped with a freshly developed, responsive and accessible website that enables simplified communication between the representatives of the Institute and target users and high level of online communication. Finally, the sustainability of the project results was achieved with the transfer of knowledge from web developers to the representatives of the Institute.

3.2 Social networks

Facebook page analysis revealed that the page had a relatively small number of followers. It was also found that the founder of the Institute posted content from his private Facebook account instead of the Institute's page. Content was then shared on the Institute's page which is the reason why posts could not reach a larger crowd. The results of the target promotion showed that Bruno's posts and Bruno himself were well received (Figure 3). Responses to Bruno's posts were on average better than responses to other posts, when sponsored posts are not included.

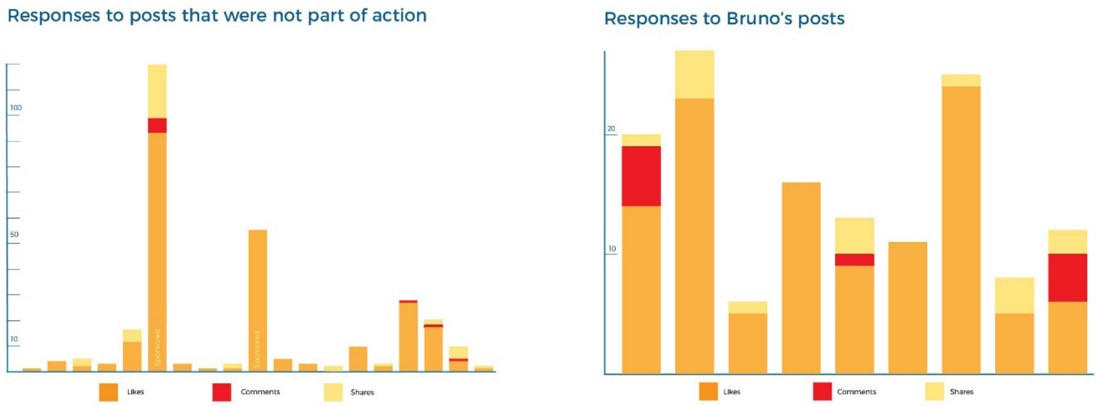

Figure 3. Responses to posts target promotion.

With the optimisation of the Facebook page and implementation of a model for targeted promotion of this network, the number of followers was increased and the informative and engaging level of content was improved.

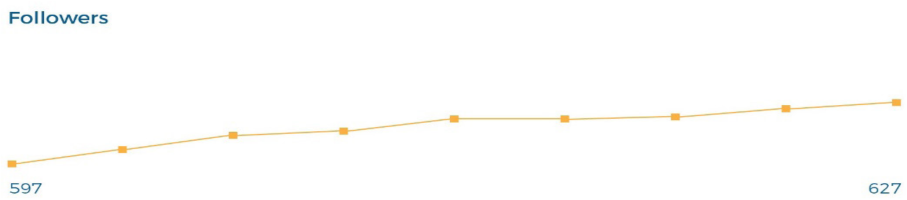

Figure 4. Numbers of followers target promotion.

YouTube channel review and analysis revealed that the Institute had an inoperable channel due to problems with access (problems with the e-mail administrator). The YouTube channel of the Institute was therefore transferred to another e-mail from which the representatives can access the YouTube channel. Video data was also optimised by editing it with descriptions and keywords.

4 CONCLUSIONS

When it comes to website design it is important to include target users and their needs at every step. That is the way to provide an interesting website with good experience for all users. Most websites are designed without the consideration of disadvantaged groups and other minorities which is why they might struggle when navigating online. Our website design was based on the needs of all groups including the disadvantaged. Analysis and constant communication with the target users was the key to reaching our final goal.
The results of the project were of a great importance and a benefit for the representatives of an Institution Ars Viva and also for local and regional environment. The project results' dimensions included networking, informing, introducing and especially connecting target groups with disabilities.
Moreover, the sustainability of the results were achieved with the transfer of the knowledge to the reresentatives of the Institute that through accessible web media can continue with transparent, modern and engaging comunication.

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ABSTRACT: *In the paper mill Papirnica Vevče, one priority remains, i.e. to develope coated papers with as little defects as possible, especially to reduce the number of coating pits and the extent of coat craking at fold at the end use applications (Brigl & Bergmeister, 2018). Among paper properties their basic phyisical (thickness, mass, grammage, specific volume, moisture and ash content), optical (specular gloss, ie. the coated side of a paper), surface (roughness), printing (print penetration) and morphological properties (SEM) were determined. To determine which coated paper has a greater tendency towards cracking, prints in offset printing techique were prepared. Paper samples were printed on the coated side with the black offset printing ink, just to ensure high contrast. Printed papers were than folded and the place of fold was observed under the optical microscope. Pictures taken with the optical microscope were processed using the ImageJ program. The extened of cracking at the fold was evaluated as the area where the printing ink has detached.*

Key-words: paper, coating, SEM, optical microscope, ImageJ.

1 INTRODUCTION

Base paper, when it comes from the paper machine is rough, and needs further treatment, such as coating, in order to improve optical and surface properties and also to optimize the printing characteristics of paper. With coating a uniform paper surface is created, as the irregularities of the paper are smoothed out, which results in high printing quality. Generally, the quality of a coated paper is in a close correlation to a base paper quality, which has to have appropriate mechanical properties, adequate optical and surface characteristics (Možina, 2017). Nevertheless, the mayor influence has the type of coating technique, performed either on- or off-line, coating speed and coating composition. Depending on the intending end use of coated paper, the coating consists of pigments together with other ingredients and binding agents, such as latex, starch, optical whitener, dyes and other additives, which give the paper desired rheological behavior and improve the performance of coated paper (Novak, 2004; Kimpimäki, 1998).

2 EXPERIMENTAL

Analyzed papers were one side coated, each with different recipe and different coat weight. The difference was also in grammage of base paper and therefore consequently coated papers also differ in the grammage. Two of the paper samples are used as a wet-strength papers that are alkali resistant label papers, with a grammage of 68 and 70 g/m^2. The other two paper samples with the grammage of 70 and 80 g/m^2 are non-wet strength and non-alkali resistant label papers. The third pair of paper samples included in our research are flexible packaging papers with a grammage of 60 to 70 g/m^2.

3 RESULTS & DISCUSSION

In experimental part, the main focus of our research was the evaluation of tendency of coating layer towards cracking. Therefore, the correlation among the studied papers was noticed. The lowest measured value of specular gloss was on S_3 (52,65%), on which the highest cracking area, i.e. 4,15% (Table 2) was measured. The highest amount of ash residue has S6, which has also the highest grammage and consequently due to the quantity of added $CaCO_3$, the highest specular gloss (Table 1). The highest measured value of print penetration (Table 1) was measured on S_2, i.e. 121 mm, which indicates that the specimen 2 has the lowest print absorbent capabilities. Overall evaluation of print penetration and air permeability of coated papers are collated. The paper surface is closed, with a few minor micro defects caused by the air bubbles caught in the coating mixture (Table 3).
Paper coating cracking occurred on specimens at a different extent, ranging from 1,13 (S_1, CD to 4,15% for S_3, MD) and it can be clearly noticed with an eye. While the studied papers are produced for packaging purposes, they are really implemented as white papers. Since packaging needs to be printed, the paper cracking of

coating layer becomes an issue. Even more is the problem emphasized when the majority of paper surface is covered with paint, e.g. black or dark blue. S4 has the lowest tendency towards cracking in either measured way, i.e. MD, 2,04% or CD, 1,53% (Table 2).

Table 1. Grammage, thickness, ash content, print penetration, roughness and specular gloss.

	S1	S2	S3	S4	S5	S6
Grammage [g/m^2]	66,6	60,9	69,1	70,2	69,6	78,4
Thickness [mm]	0,053	0,051	0,057	0,055	0,060	0,064
Ash content [%]	20,81	18,47	17,45	23,58	23,37	25,51
Print penetration [mm]	115	121	108	118	114	116
Roughness [ml/min]	13	14	18	22	14	18
Specular gloss [%]	66,85	72,05	52,65	78,80	54,60	81,55

Table 2. Measured values for air permeability (AP), average roughness (Ra) and cracking area (CA).

	S1		S2		S3		S4		S5		S6	
	MD	CD	MD	CD	MD	CD	MD	CD	MD	CD	MD	CD
AP [ml/min]	0	0	0	0	0	0	0	0	0	0	0	0
Ra [µm]	1,97	1,99	1,50	2,03	1,49	1,87	1,45	2,05	1,25	1,63	1,46	1,70
CA [%]	2,30	1,13	3,47	2,44	4,15	3,02	2,04	1,53	3,01	2,09	2,74	2,87

Table 3. SEM pictures of coated side of the papers.

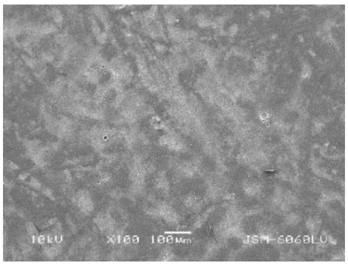
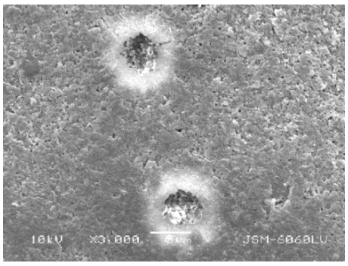
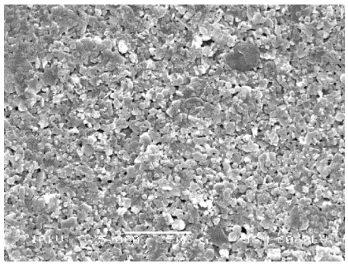
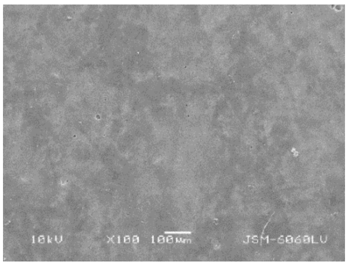
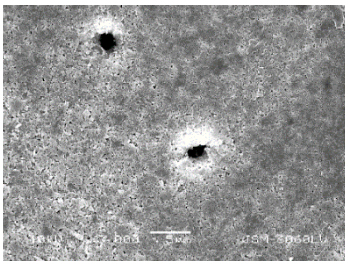
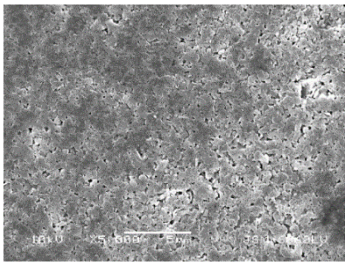
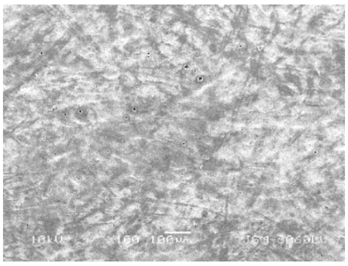
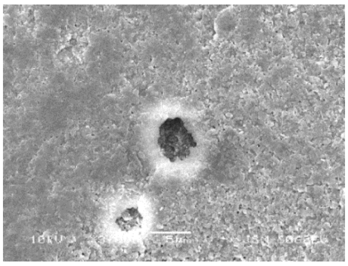
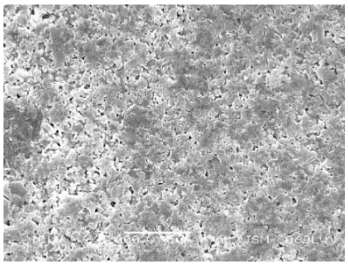
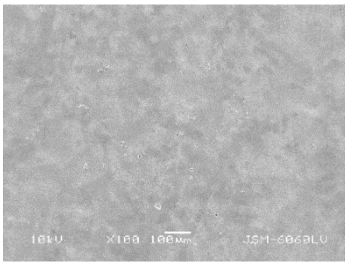
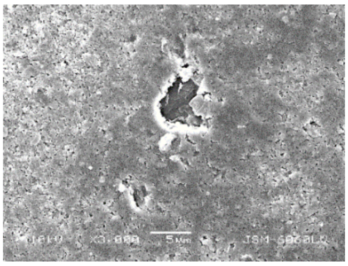
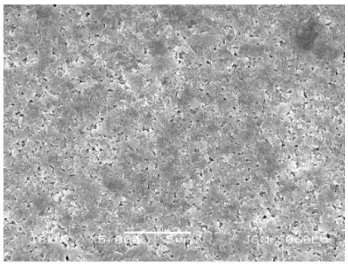
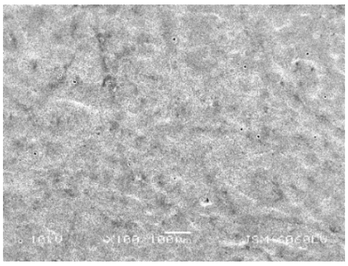
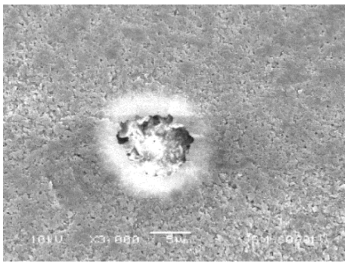
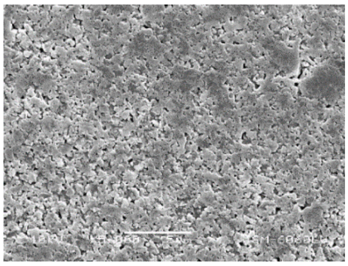
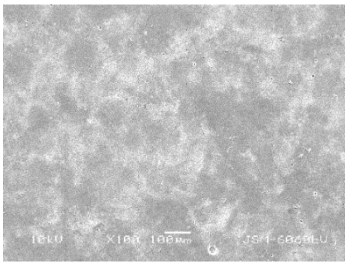
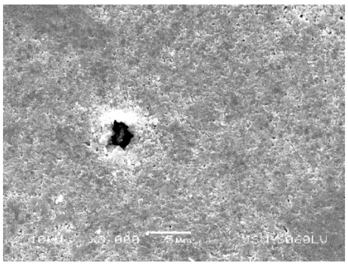
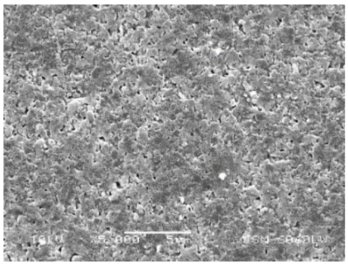
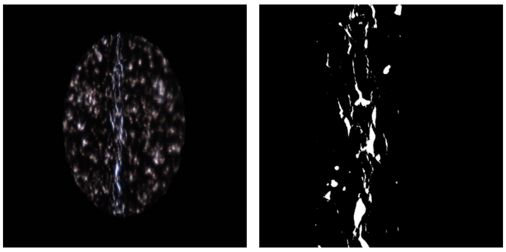
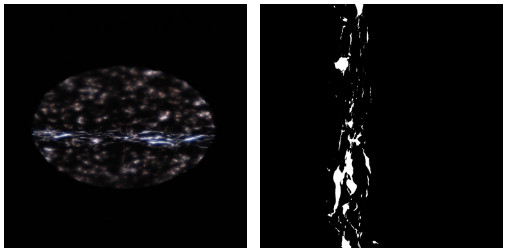
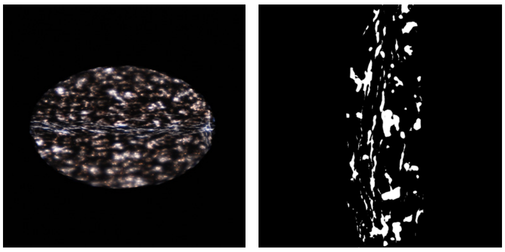
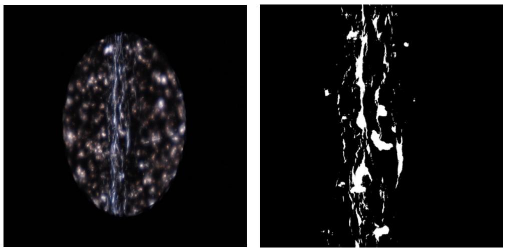
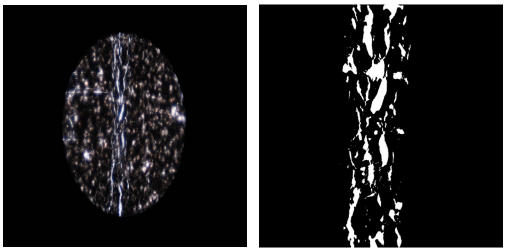
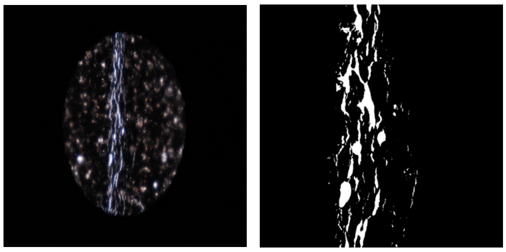
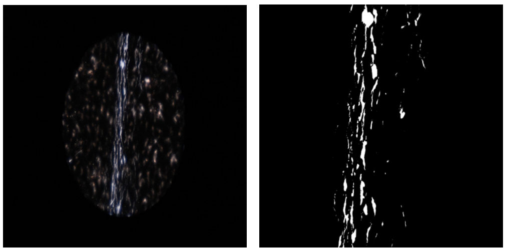
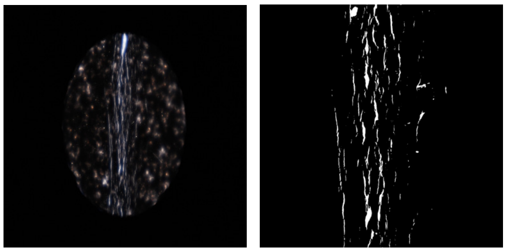
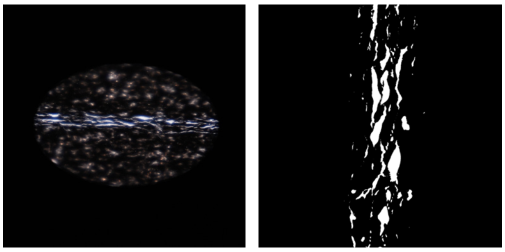
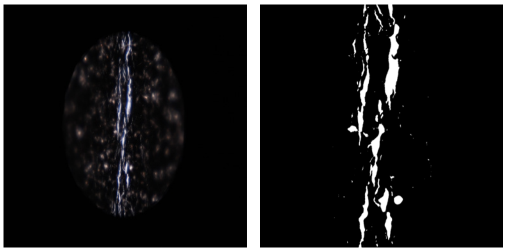
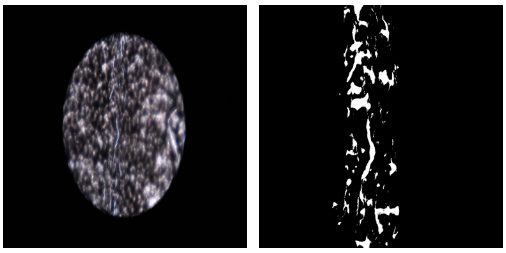
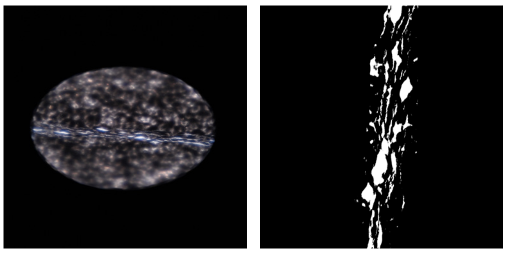
	Coated surface 100 x	Air bubbles 3000 x	Conglomerate 5000 x
V1			
V2			
V3			
V4			
V5			
V6			

Table 4. Pictures of folds, captured with optical microscope.

	MD	CD
V1		
V2		
V3		
V4		
V5		
V6		

4 CONCLUSIONS

In this study, extend of paper coat cracking was determined by using an optical microscope and pictures captured were than evaluated with ImageJ, to establish the extensiveness and range of papers coating layer towards cracking and the following conclusions can be made:

- cracking of coated papers has a negative impact on a aesthetics of the packaging and at costumer raises a question in products quality;
- the size of coat cracking depends on the base paper and the chemistry composition of paper coating;
- to achieve the highest possible quality of coated packaging paper, within the reasonable tolerance limits, the S4 has the best performance, i.e. lowest CA, among all six studied specimens.

5 REFERENCES

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FABRICATION OF CAPACITIVE SLIDERS

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ABSTRACT: *In this research different designs for printed capacitive sliders were made. In preliminary study the distance between sliders electrodes was examined and the optimal distance was determined. According to results of preliminary study 8 designs for big and 2 designs for small sliders were made. Slider designs were examined according to the distance between the electrodes, the shape of a space between the electrodes and the embraced conductive line around the electrodes. Based on this results the most optimal design for small and big sliders was determined.*

Key-words: printed electronics, printed sensors, printed sliders, printing, screen printing.

1 INTRODUCTION

Printed electronics is a technology that has paved the way for many interesting new uses in electronics and is steadily gaining traction in the market. Printed electronics can be applied on packaging (smart packaging), posters (smart posters), etc. It brings new application options for electronics that conventional electronics cannot reach (Mraovič et al., 2014).

After years of research, printed functionalities were developed using conductive, semi-conductive and dielectric materials for printing. These materials need to have the ability to be formulated into an ink. The printing technologies used for printed electronics allow us to use flexible and rigid substrates that are not suitable for conventional electronics. Electronics can be printed on plastic foil, thick plastic substrates, paper, cardboard, glass, ceramic, metal and other materials. Conventional printing techniques are used to create printed electronics: inkjet, screen printing, gravure, flexography, pad printing, offset gravure and offset printing. After printing, the electronics is treated with drying or sintering. The result of using conventional printing substrates and printing technologies is high volume production of low-cost electronics. This kind of electronics has also some disadvantages such as low level of integration, requires large surface of electronic components and slow switching compared to the production of conventional electronics (Starešinič and Muck, 2010).

Printed electronics are increasingly being used to make different kinds of sensors. Sensors are devices that respond to changes in the environment and give measurable responses.

Printed sensors have some significant advantages over their traditionally fabricated counterparts. Conventional electronics is made using the photolithographic process, which is expensive, mostly because of the high capital costs involved. On the other hand, it is cheap to fabricate printed electronics because of the simplified production process, lower capital costs and the high speed of production. Only rigid substrates can be used with the photolithographic process, but with printing technologies we can make printed electronics on flexible substrates. Photolithography is a high temperature process – unlike the press, which is a low temperature process. On top of this, all printed electronics bring several new application opportunities such as packaging integration (Pleša, 2017 and Kubersky, 2014).

Printed sensors have already started to make serious inroads into the market. By expanding the network of the Internet of Things, the market for printed sensors is also on the rise. The market requires high volume production and low costs, which is precisely what printed electronics offer.

Touch sensitive sensors are just one of the many sensors available. They are particularly interesting because they can be used as a switch. Touch sensors that operates on the principle of a change of capacitance are divided into three groups (Figure 1):

- zero-dimensional sensors, e.g. buttons – these sensors have only one touch point;
- one-dimensional sensors, e.g. sliders, wheels – these sensors detect the linear movement of a finger;
- two-dimensional sensors, e.g. touch screens – these sensors detect the movement of a finger on two axes (Atmel, 2015).

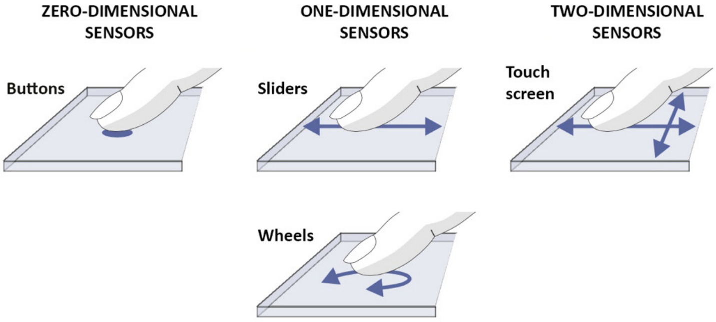

Figure 1. Three groups of touch sensors (Atmel, 2015).

Capacitive sensors has nominal capacitance in a normal inactive state. However, when the surface of the sensor is touched, the capacitance increases. The change in capacitance can only be measured using a chip (IC).

The aim of research is to fabricate a prototype of a printed capacitive slider based on a line sensor. That prototype is presenting a hybrid electronics that combine conventional elements (IC and programming) with printed conductive layers. The goal of the research was to:

- determine and optimize the process of making printed sliders
- fabricate a prototype of a printed slider

2 EXPERIMENTAL

2.1 Materials and methods

In this research printed circuit for sliders were screen printed on three different paper substrates: (1) recycled paper, (2) special paper for printed electronics and (3) synthetic paper. For printing circuits silver conductive ink CRSN 2442 (SunChemical) was used and for coating SG 70/15 (Coates Screen) was used. Regarding ink properties screen printing mesh 120 l/cm was used for printing. All the samples were dried for 225 s at 120°C.

2.2 Printing of test capacitors

In preliminary study 10 simple capacitor designs with various distances between electrodes from 0.1 to 1 mm were printed using screen printing (Figure 2). Capacitors have simple square electrodes dimensions 1 x 1 cm. From every electrode 0.5 mm line leads to round contact surface which was used for measuring the capacitance. Capacitor capacitance was measured with multimeter and the influence of the distance between the capacitors electrodes was studied.

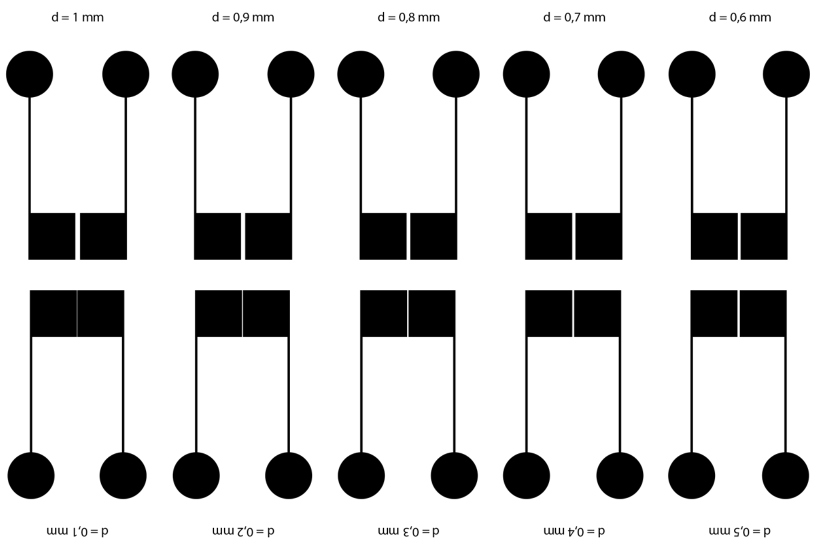

Figure 2. Test capacitors with various distances between electrodes.

2.3 Designing and printing of capacitive sliders

Based on preliminary research results 10 different designs of a printed circuit for sliders were designed: 8 designs for large capacitors and 2 designs for small capacitors (Figure 3). According to literature (Atmel, 2015) small sliders (between 21 and 26 mm long) should be designed with straight space between the electrodes. In this research two small slider designs were tested: one with three electrodes one by another (design 6 in Figure 3) and the other where highest channel electrode hugs the other two electrodes (design 5 in Figure 3). For large sliders (between 26 and 60 mm long) a zigzag space between the electrodes is recommended so there were made four modifications of "zigzag sliders": one with 0.5 mm distance between the lines (design 1B in Figure 3), other with 1 mm between the lines (design 2B in Figure 3), third where highest channel electrode hugs the other two electrodes and the distance between the electrodes is 0.5 mm (design 4B in Figure 3) and the fourth where all three electrodes are embraced with other conductive line (design 3B in Figure 3). All four modifications were made also on "straight line sliders" (designs 1A, 2A, 3A and 4A in Figure 3). The designs with highest channel electrode hugging the other two electrodes and the designs with all three electrodes are embraced with conductive line were made to improve the electric field which effects the slider accuracy. After printing circuit was coated and so protected from external influences and kept electrically isolated. Capacitance was measured on printed samples using LCR-300 Voltcraft multimeter with and without touching them with capacitive touch pen and different designs were compared.

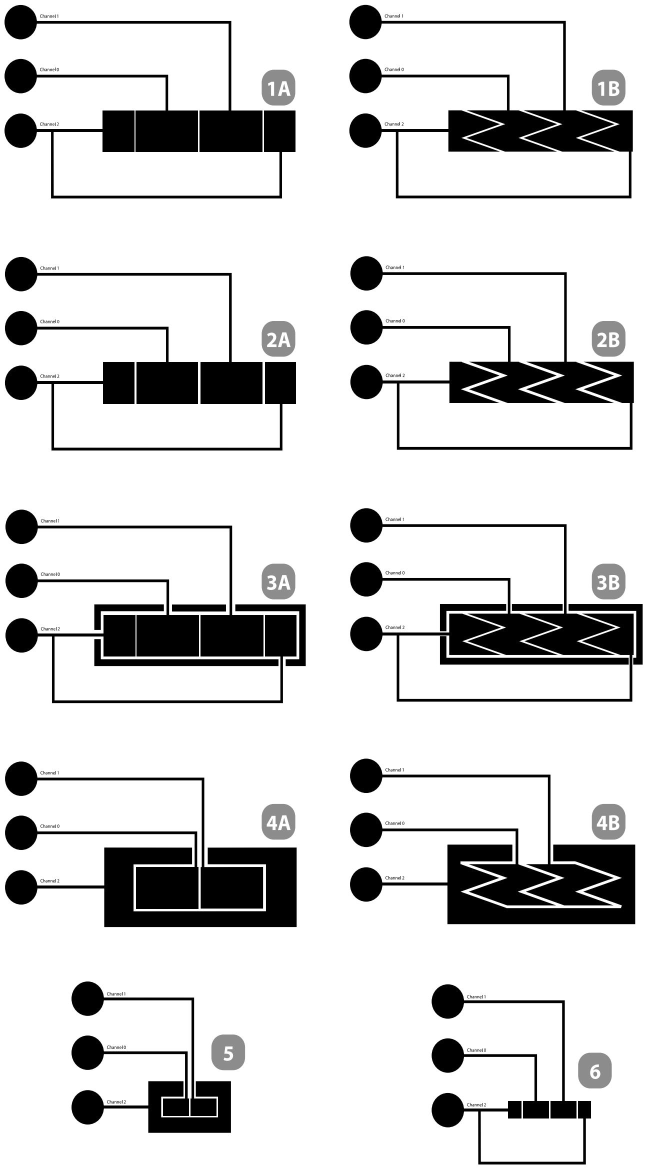

Figure 3. Different slider designs with labels.

3 RESULTS & DISCUSSION

Measurements of capacitance of capacitors show that the capacitance is higher when electrodes are closer together. Capacitor with the distance 0.2 mm between the electrodes has the highest capacitance and the capacitor with the distance between electrodes 1 mm has the lowest capacitance (Figure 5). The smallest distance between the electrodes that was tested (0.1 mm) is proven to be too small for good print quality with chosen ink and selected screen mesh. Comparing capacitance measured on capacitors printed on different printing material revealed that capacitance of the capacitors is lower when printed on special paper for printed electronics, but on the other hand almost the same when printed on recycled paper and synthetic paper.

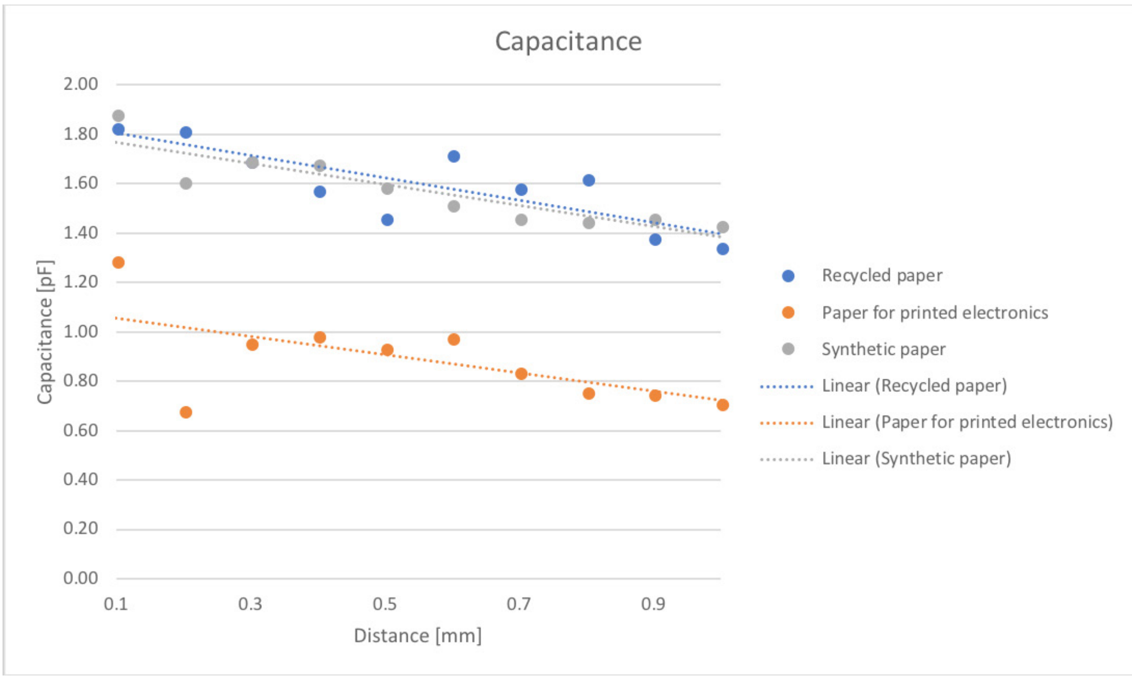

Figure 4. Capacitor capacitance printed on different substrates.

Nevertheless, special paper for printed electronics had the lowest capacitance the measurements of the change in capacitance when the slider is touched are comparable to recycled and synthetic paper. The chip is measuring the change in capacitance that is why low nominal capacitance is not an issue. When measuring the change in capacitance the influence of printing material is small and it is hard to determine a correlation between them. Differences between the materials can also be attributed to the measurement error.

When measuring the change of capacitance on printed sliders which is essential for slider functioning it was discovered that design 1B is the most responsive, right behind it there are 2B and 3B designs. All of these three designs have zigzag line between the electrodes. After that the same slider designs with different shaped spaces between the electrodes were compared: 1A vs. 1B, 2A vs. 2B, 3A vs. 3B, 4A vs. 4B. The zigzag space has proved better in all the cases except in 4A vs. 4B comparison, where A4 with straight line space had higher capacitance than 4B with zigzag space. That means the zigzag line on large slider design is more optimal. The same designs with different distances between the electrodes were also compared: 1A vs. 2A, 1B vs. 2B. The highest change in capacitance is on designs 1A and 1B where electrodes are closer together, the exception is a design with zigzag space on paper for printed electronics where the capacitance is lower where the electrodes are closer together. Designs 3A, 3B, 4A and 4B with highest channel electrode hugging the other two electrodes and the designs with all three electrodes are embraced with conductive line do not show improved slider response.

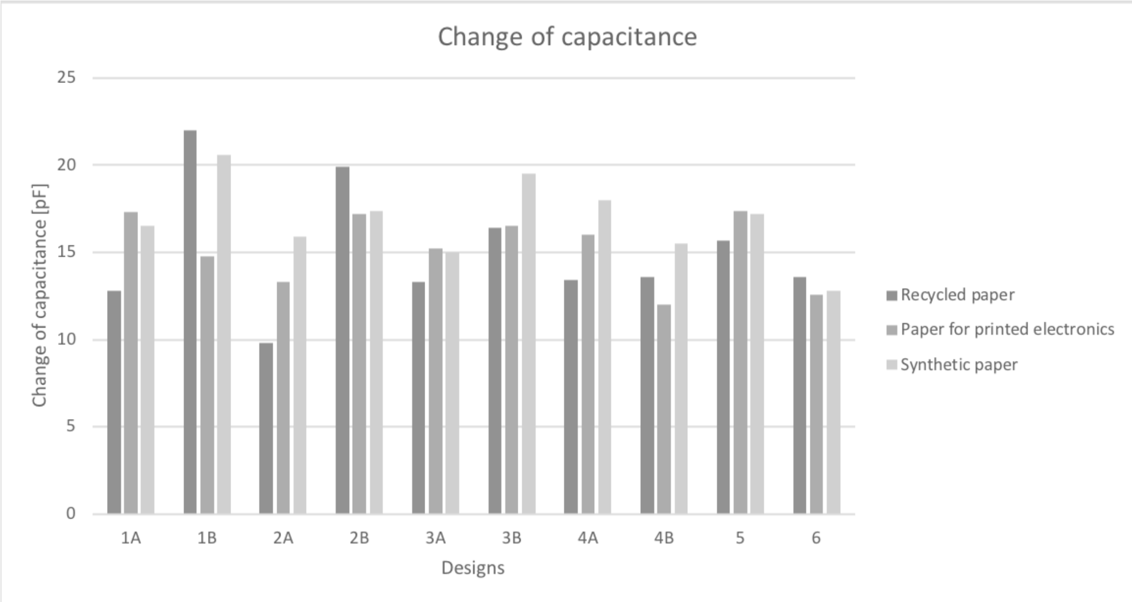

Figure 5. Change of capacitance on different slider designs.

4 CONCLUSIONS

Higher capacitance of a capacitor is achieved with smaller distance between the electrodes, but the question is how fine space can be achieved with printing conductive materials on various printing materials with different surface properties. For printing capacitors the smallest distance between the electrodes is recommended according to the substrate, ink and printing technique properties. The roughness of the substrate, the size of conductive ink particles and a printing technique influence the precision of print and should be considered when determining the distance between the electrodes.

The research proves that printed sliders can be made by printing conductive inks on different printing substrates. However, on sliders performance printing substrate, shape and size of the slider have affect. For small sliders, design with space between the electrodes in a shape of a thin line should be used. Better response of a small slider is achieved if the highest channel electrode hugs the other two electrodes – this increases the intensity of the electric field and higher capacitance is achieved. For large sliders, the design with zigzag space is more optimal. Sliders with smaller distance between the electrodes have better response than sliders with greater distance. Unlike small sliders, for large sliders it is not important if the highest channel electrode hugs the other two electrodes – the slider response is more or less the same.

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FORMATION AND CHARACTERIZATION OF SHELLAC FILMS

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ABSTRACT: *The aim of our research was to prepare and characterize properties of shellac as a potential packaging film. Advantages and disadvantages of prepared films have been discussed and presented.*
This research shows preparation and characterisation of biopolymer, using different amounts of plasticizers. Our research is focused on film properties that are important for packaging materials. The aim of this work is to investigate moisture barrier properties and tensile properties of de waxed shellac flakes, using 2 different amounts of glycerol and poly (ethylene) glycol as plasticizers, which could be used as packaging materials. The results of the research has shown that shellac has certain barrier properties that could be used as film in the packaging filed as replacement of plastic film barriers.

Keywords: shellac, barrier, properties, Kerria Lacca, packaging.

1 INTRODUCTION

These days, plastics are still widely used as packaging material, due to their ability to preserve the sensory properties and nutritional values in food products (Byun et al., 2012). On the other hand, there are high demands for the utilisation of natural polymer sources as food packaging materials (Byun et al., 2011). Natural polymers are conserved as an alternatives to synthetic plastics and many research has been done on the application on biopolymers in many fields (Vrabič Brodnjak, 2017). Since food packaging materials require non-toxicity, good moisture, water, mechanical and chemical properties, many biopolymers cannot conquer to plastic materials, such as polyethylene, polypropylene etc. Therefore a good selection, production and preparation of biopolymers should be performed and implemented as food packaging. As a natural polymer, which is already used in many fields (wood preservation, finishes, adhesives for wood, component in cosmetics such as nail polish and many more) as well as in packaging, is Shellac. It is a natural polymer, obtained from purified resinous secretion, by the insects Kerria Lacca (Kerr) Lindinger (Coccideae). This species is the most important lac insect, being a main source of lac, for the production of shellac. The insect is mostly cultivated on host trees in Thailand, India and Myanmar (Soradech et al., 2012). Shellac is one of the thermosetting resins of animal origin. It is a natural bioadhesive polymer and is chemically similar to synthetic polymers, and thus can be considered a natural form of plastic. It can be turned into a moulding compound when mixed with wood flour and moulded under heat and pressure methods, so it can also be classified as thermoplastic. Its chemical structure is composed of hard and soft resin of polyesters and single esters containing hydroxyl and carboxyl groups (Farang, 2009; The, 2008). Shellac has excellent film forming and barrier properties. It is soluble in alcohol and alkaline solutions (Soradech, et al., 2012). Therefore it has been widely used in the food and agro industries for gas, moisture, water and microbial protection of food products (Soradech et al., 2017). The goal of our research was to prepare shellac films, which could be used as packaging films. Different amounts of plasticizer have been used. Therefore, the research was focused on film properties (moisture barrier, tensile properties etc.), which change with the amount of plasticizer and are important for packaging films. The results has shown, that shellac has a potential as a packaging film, most of all it could be used as barrier and replacement of plastic film barriers.

2 EXPERIMENTAL

The shellac solution was prepared by dissolving 2 g of shellac flakes in 100 ml ethanol and PEG 200 was added as a plasticiser (2 and 4%). The solution was mixed room temperature for 30 minutes until flakes was not dispersed. After that, the film solution was filtered through a polyester screen (mesh no. 140 with mesh opening 160 μm) with aspiration to remove small lumps in the solution. After the aspiration and the treatment, the Shellac solution was casted onto petri dishes (50 ml), spread thinly, uniformly and dried at 55 °C for 10 hours. After the films were peeled off from the dishes, they were cooled at room temperature (23 °C; 55% RH).
When films were prepared thickness, water vapour permeability, tensile and surface properties, and thermal stability were determined and analysed.

The thickness of films was measured with a precision digital micrometre Mitutoyo Corporation, Japan, to the nearest 0.0001 mm at 5 random locations on each film.

To determine the WVP of films and moisture content, the ASTM E96 standard desiccant method was used (Srinivasa et al., 2004). The test cups were filled with silica gel (RH = 16% in the cup), where a sample was placed between the cup and the ring cover of each cup (Srinivasa et al., 2004). There was an air gap of 11 mm between the silica gel and the underside of the placed film. To ensure the best results of WVP, a silicone sealant was applied around the cup edge. The films with the exposed area of 50 cm2 were tested at 50 ± 2% RH and 40 ± 2°C for 24 hours. Two replicas per film were tested.

Thermal stability of shellac films was made using Mettler apparatus, with heating plate Hot stage FP 82 HT. Measurement conditions were: starting temperature 25°C, heating speed: 2°C/min and end temperature 150°C. For each sample 25 measurements have been done.

Tensile strength (TS) and elongation at break (E) of the films were determined on a tensile testing machine Instron 6022. The samples were analysed in standard atmosphere 23°C ± 1°C of temperature and 55% ± 2% of relative humidity. The cross speed head was 0.15 mm/s. The films of 6 cm in length and 0.7 cm in width were used, and a minimum of five probes for each sample was tested. During the sample stretching, several load and elongation data per second were recorded until a break of the sample occurred.

The SEM micrographs of film surfaces were taken with a scanning electron microscope (JSM -6060 LV). The instrument was operated at 10 kV, at the magnification 400×.

3 RESULTS & DISCUSSION

Shellac is one of the thermosetting resins of animal origin. The functional properties of films were investigated as function of thickness, water vapour permeability, tensile properties and plasticizer content (Table 1). The thickness of the films influences water vapour properties. For food packaging materials it is great importance to achieve water vapour permeability (WVP) as low as possible, where high WVP determines poor moisture and water barrier properties. In our research, the thickness (mean values) of analysed samples were used in the calculations for WVP.

Table 1. Thickness, moisture content, water vapour permeability (WVP) and thermal stability of Shellac films, with two different percentage of PEG in Shellac films.

Sample	Percentage of plasticizer PEG 200 (%)	Thickness (μm)	Moisture content (%)	WVP (g /m2·day)	Thermal stability (°C)
Shellac_4	4	233 ± 3.0a	7.13 ± 0.6a	4.78 ± 0.2b	149.5 ± 2.6c
Shellac_2	2	229 ± 1.5a	9.66 ± 0.5a	6.98 ± 0.7b	102.8 ± 3.7c

[a] Means of five replicas ± standard deviation; b Means of five replicas ± standard deviation
[c] Means of ten replicas ± standard deviation

As expected, the thickness of the sample with higher amount of plasticizer, was higher compared, to the other sample. The water vapour permeability of films for food packaging should be as low as possible, where high WVP determines poor barrier properties. The thickness of films influences water vapour properties. In our research, the thickness (mean values) of films was used in the calculations for water vapour properties. Table 1 shows a comparison of films with different ratio of added plasticizer, and it can be seen that film with 4% of PEG had lower WVP compared to sample with 2% PEG. From the obtained results, it can be seen that plasticizer improved water and moisture barrier properties.

Thermal stability of both samples has shown that over 100°C is the temperature at which films degrade. Film sample with 2% of PEG has melted at 102°C, but 4% of PEG shown improvement in thermal stability of Shellac. With higher amount the stability increased, which has proven, that it could be a good solution.

Great mechanical properties such as tensile strength are very important for packaging films, due to the handling and shipping of packaged products. At the same time, elongation at break – flexibility is also very important. For such products, high tensile strength is required, but deformation, elongation should be adjusted according to the characteristics required for certain film applications. Typical stress-strain profiles for each film formulations have been determined. Results from the shellac film demonstrated (Figure 1) that higher amount of plasticizer increased the elongation at break, but the tensile strength decreased. Nevertheless, the elongation at break was better because of the increase in solubility and homogeneity of all film solutions.

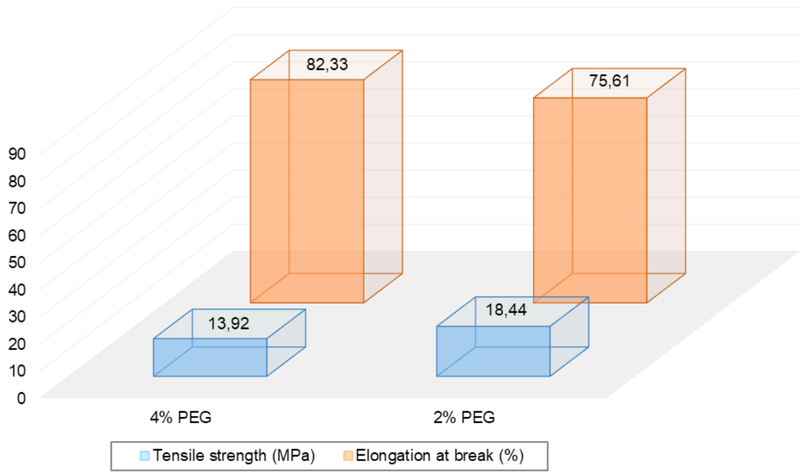

Figure 1. Tensile strength and elongation at break for both samples with 2% and 4% of PEG.

SEM micrographs of films are presented in Figure 2. The 10kV voltage was used since at higher voltage, film samples would get damaged very quickly and the determination of the surface would not be correct. The same was at 400× magnification, as higher magnifications degrade the surface of analysed films. Form the figures (a) and (b) it can be seen, that sample with 2% has not so even surface, compared to sample with higher amount of plasticizer. The surface micrographs revealed a smoother, even surface at this film sample. Lower concentration of plasticizer caused less uniform, smooth and dense structure

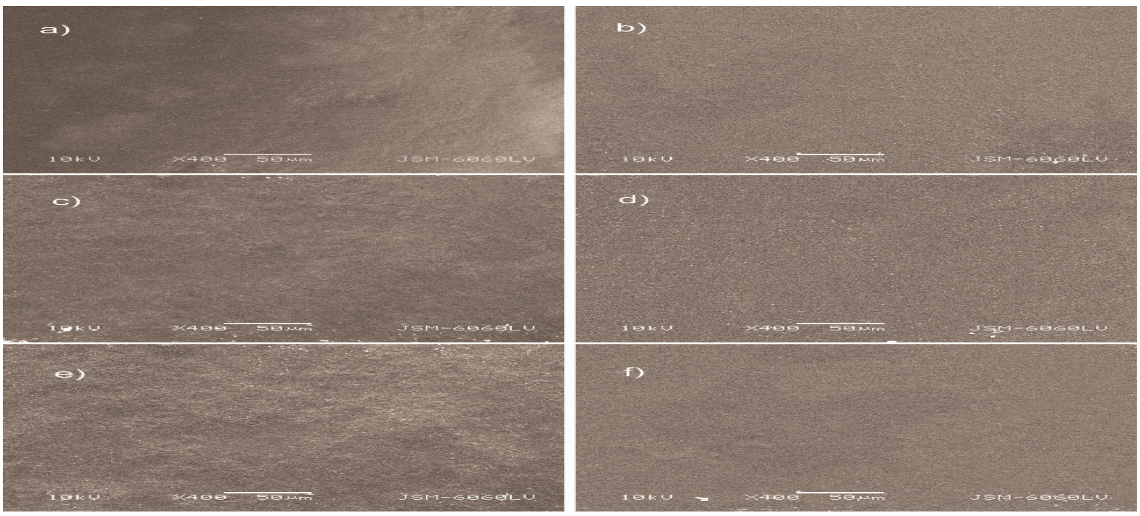

Figure 2. SEM micrographs of Shellac samples with (a) 2% and (b) 4% of PEG.

4 CONCLUSIONS

Shellac has an excellent film forming and barrier properties. It is soluble in alcohol and alkaline solutions. Therefore it has been widely used in the food and agro industries for gas, moisture, water and microbial protection of food products. The nature of films from biopolymers is mostly hydrophilic; therefore, the thickness influences water barrier and mechanical properties.
In our research, Shellac films were successfully prepared. The results have shown that PEG had good impact on film properties. With higher amount elongation increased, as well as thermal stability and moister barriers. In addition, in blend films, a decrease in water vapour permeability was detected and this could be explained with the addition of higher PEG content.

One of the issues to be taken into account in further research on enhancing water barriers and tensile properties of shellac films, to prepare bi-layer or laminated films with other bio polymer components, which ensure more effective barriers against water transfer and better mechanical properties.

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MONTE CARLO DENOISING OF COMPUTER GENERATED IMAGES BY NON-LOCAL MEANS FILTERING

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ABSTRACT: *In the present study Monte Carlo noise that had been introduced to various computer generated images was reduced by implementing the non-local means algorithm. Its performance, i.e. the degree of noise reduction, was assessed using three image quality metrics in addition to performing subjective visual evaluation of the denoised images.*

Keywords: computer generated imagery, rendering, Monte Carlo, denoising, non-local means filtering.

1 INTRODUCTION

In the computer graphics pipeline, rendering is the process of creating a photorealistic or stylised final image, where computations of objects and scene geometry, textures and shading algorithms, direct and indirect illumination, camera and specific effects are performed. Final visualisation result is typically a 2D bitmap image, in which pixels represent the complexity and correlation of all input parameters. Path tracing is a rendering method that includes Monte Carlo (MC) integration (Zwicker, 2015) and considers indirect and global illumination in their full potential. Integration implies the gathering of all possible light rays from different directions and interacting with the surface of the 3D object. In a computer simulated light transport, all possible solutions of light travelling cannot be computed, consequently with the equiprobability the random directions of the light are in the rendering workflow defined with samples. Here, two main interdependent problems arise. First, for the sake of rendering realism the number of samples has to be extremely high in order to generate a noise-free output image. Second, the amount of noise over the image is non-uniform, i.e. spatially-variant. In the past, the challenge of removing the MC noise from CG renderings by preserving the details of the image and sharp edges was approached by applying various filtering methods on bitmap images and adopted to the pipeline of CG imagery generation (Rousselle, 2013). Recently, the researchers introduced machine learning and artificial intelligence methods in MC rendering workflow. Kalantari et al. presented an intelligent system based on artificial neural networks and a nonlinear regression model (Kalantari, 2015). Chakravarty et al claimed that their novelty including the variation of deep convolutional networks could solve the challenges of MC integration for real-time rendering (Chakravarty, 2017).
The objective of our study was a reduction of MC noise in a number of computer generated (CG) images – only two will be shown – by implementing the non-local means (NLM) algorithm. Its performance was assessed through computing three image quality metrics, as discussed in the Materials and methods section.

2 EXPERIMENTAL

2.1 Non-local means filtering

Non-local means (NLM) algorithm (Buades, 2005) is one of the more successful recent attempts to reduce noise in an image while at the same time preserving important information, such as image structures, details and edges. Many of the traditional image denoising attempts – Gaussian-, anisotropic-, bilateral-, Wiener filtering, wavelet thresholding, total variation minimization and others – make several assumptions about the noisy image being processed (Evans, 2005) that can eventually result in its undesirable blurring. These methods try to separate the image into the smooth part – true image – and the part with the noise by removing the higher frequencies from the lower ones. But in practice images are rarely completely smooth since they also contain high-frequency fine details and structures. When high frequencies are removed, not only the noise will be eliminated, but the high-frequency content of the true image as well. In addition, low-frequency noise might still remain in the image.

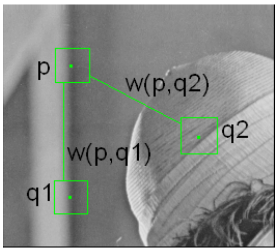

Figure 1. Self-similarity in an image: neighbourhoods of pixels p and q1 are similar, while those of p and q2 are not.

Unlike these methods, NLM is based on the concept of self-similarity appearing in an image. As shown in Fig. 1, neighbourhoods of pixels p and q1 are very similar, while neighbourhoods of pixels p and q2 are not. Consequently, pixel q1 will have a stronger effect on the denoised value of p compared to q2, i.e., the weight w(p,q1) will be much greater than w(p,q2). So instead of replacing the value of p by averaging locally within its neighbourhood only, the idea here is to look for pixels with similar neighbourhoods across the whole image and take average (mean) values of these regions in order to calculate a new value of p.

NLM algorithm can be controlled by three adjustable parameters (Python, 2018). Patch size (PS) is the radius of the neighbourhoods (patches) used to find the similarity between the pixel values. If this parameter is set too high, no similar neighborhoods will be found, if it is too low, too many similar neighborhoods will be detected. Patch distance (PD) is the radius of a search window, in other words, the maximum distance where to search for patches. The third parameter, H, is the weight-controlling parameter; a higher value results in a smoother image with less noise, but at the expense of blurring image features.

2.2 Image quality assessment

In the study several images (renderings) produced with Cycles, a path tracing Blender rendering engine were investigated. Renderings were prepared with noise (no. of samples = 50) and without it (no. of samples = 2000). Images differed in brightness, contrast, the number of salient structures and the amount of detail. Each of the three NLM parameters (factors) – PS, PD and H – was investigated at three levels: PS at 1, 6 and 11, PD at 2, 7 and 12 and H at 0.02, 0.06 and 0.1. These values were chosen empirically based on extensive experimentation with various CG images and settings.

In addition to a visual inspection of the resulting images containing reduced amounts of noise, three objective image quality metrics were computed: PSNR, SSIM (Wang, 2004) and PSNR-HVS-M (Ponomarenko, 2007). Unlike PSNR that compares the true, noise-free, and the resulting image pixelwise, SSIM and PSNR-HVS-M are based on the properties and limitations of the human visual system and should according to the literature correspond more closely to our visual experience and assessment of image quality. For each of the three metrics, the higher its value, the better the image quality, i.e., the higher the resemblance of the noise-reduced image to the ground truth (image without any noise) one.

The obtained results from a non-replicated 3 × 3 × 3 factorial design were interpreted using a three-way analysis of variance (ANOVA).

3 RESULTS & DISCUSSION

Grayscale versions of two ground truth images coded as '01' and '05' are, together with their noisy versions on which NLM algorithm was implemented, displayed in Fig. 2. The degree of elimination or reduction of noise artefacts using 27 combinations of three NLM parameters was measured by PSNR, SSIM and PSNR-HVS-M metrics (Fig. 3). While PSNR and PSNR-HVS-M trends are for most of the images quite similar, SSIM results for several parameter combinations show some striking differences compared to those obtained by the other two metrics. This is e.g. the case with the images PS1_PD12_Hxx_01 and PS1_PD7_Hxx_01. These denoised images (see Figs. 4a and b) that are obviously not at all affected by their actual level of the H parameter, are characterised by very low SSIM and at the same time extremely high PSNR values. One possible explanation for this unusual behaviour can be that the SSIM metric that tries to take into account some aspects of our visual system heavily penalizes severe blurring that is evident in these images. On the other hand, the fact that noise in these images was almost completely removed by the denoising algorithm was rewarded via a high mark by a simple pixel-by-pixel metric such as PSNR. Note also that SSIM values for all '05' denoised images were higher than those for '01' images, probably due to the fact that SSIM, unlike PSNR, takes into account image contrast, which is more pronounced in '05' images.

'01' and '05' denoised images with the highest SSIM values were PS11_PD2_H0.06_01 and PS11_PD2_H0.06_05, respectively (Figs 4c and d). It can be seen that the details (i.e. the sharpness) in these two images are preserved, while there is still a fair amount of noise present especially in the parts of the objects directly facing the camera (image '01') and in the shadows (image '05').

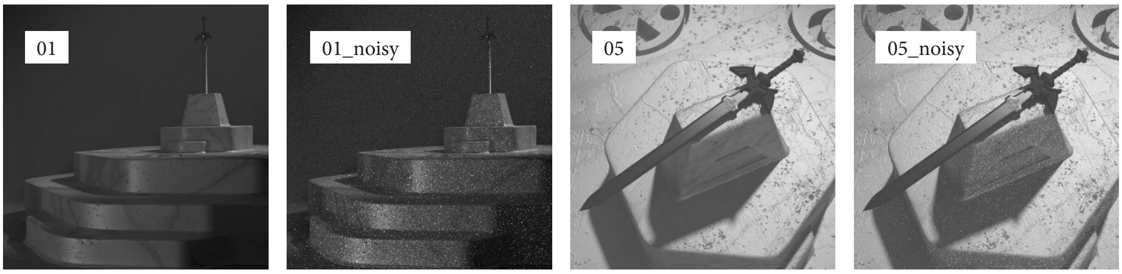

Figure 2. Two ground truth (noise-free) and noisy images investigated in the study.

Factor means plots (Fig. 5) summarize rather complex relationships between the three NLM parameters and their effect on image denoising performance. Results for PSNR-HVS-M are quite similar to those for PSNR and are not displayed in this paper. The plots on the diagonals show the overall level means, i.e. main factor effects, while the off-diagonal plots show the means for each pair of factor levels. These plots nicely reveal the two-way interactions as demonstrated in Fig. 5e where an interaction between PS and H (see the top-right plot of Fig. 5c) is shown once again, this time with actual factor settings and PSNR values. With PS = 1, PSNR is entirely independent of the level of the parameter H (PSNR = 31.2 = constant), while at the other two PS settings – PS = 6 and PS = 11 – the denoising performance (= PSNR value) is strongly influenced by the corresponding level of H, i.e. whether it is set to 0.02, 0.06 or 0.1. In general, significant interactions between two of the NLM parameters exist in all those cases (plots) where the three corresponding curves are not parallel to each other.

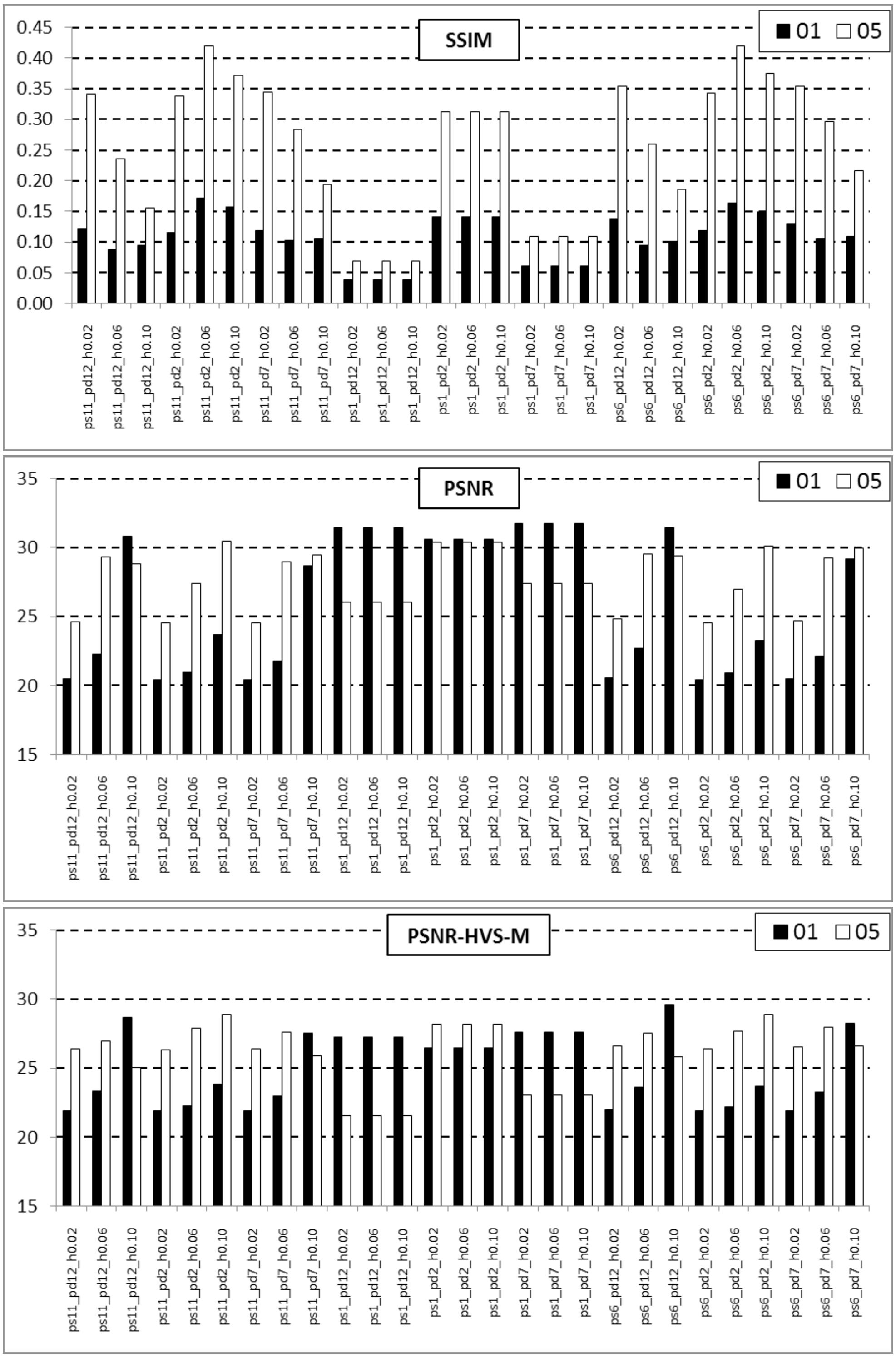

Figure 3. Image denoising results: SSIM (a), PSNR (b) and PSNR-HVS-M (c).

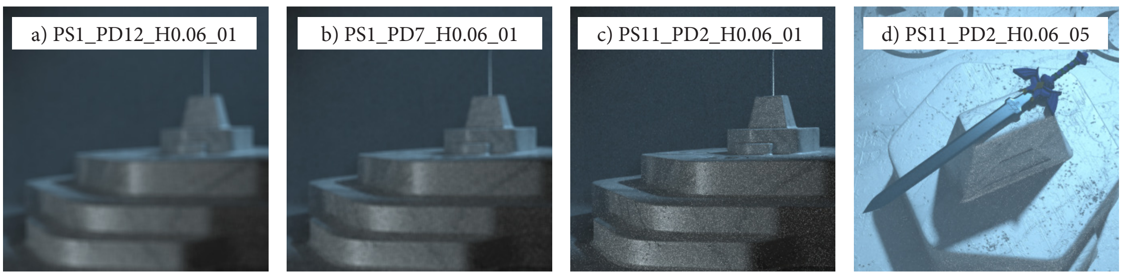

Figure 4. Four typical denoised images with extreme PSNR and SSIM values; see text for an explanation.

It should be noted that the SSIM factor means plots (Fig. 5a and b) are very similar for both investigated images while this cannot be said for the corresponding PSNR plots (Figs. 5c and d). This fact has to be somehow related to the intricate differences in both images, such as contrast, the number of edges and other important features, etc. but further work is clearly required to understand these discrepancies better.
ANOVA tables for SSIM and PSNR metrics are shown in Tables 1 and 2, respectively. They contain information about the magnitude of main effects and contributions of two-factor interactions (see F-Ratio). A contribution (effect) is statistically significant if its P-value is less than 0.05 at the 95% confidence level. Similarity in SSIM results (Table 1) for both images – significant effects of parameters PD and PS of similar strength, much lower importance of the remaining four contributions – corresponds to the above mentioned resemblance of Figs. 5a and b. With PSNR metric (Table 2), the situation is far more ambiguous: while for the image '01' the most significant effect is that of parameter PS, followed by H (their mutual interaction is also important – see Fig. 5e), denoising of image '05' seems to be most heavily influenced by the H settings, but PS-H and PS-PD interactions are also not negligible.

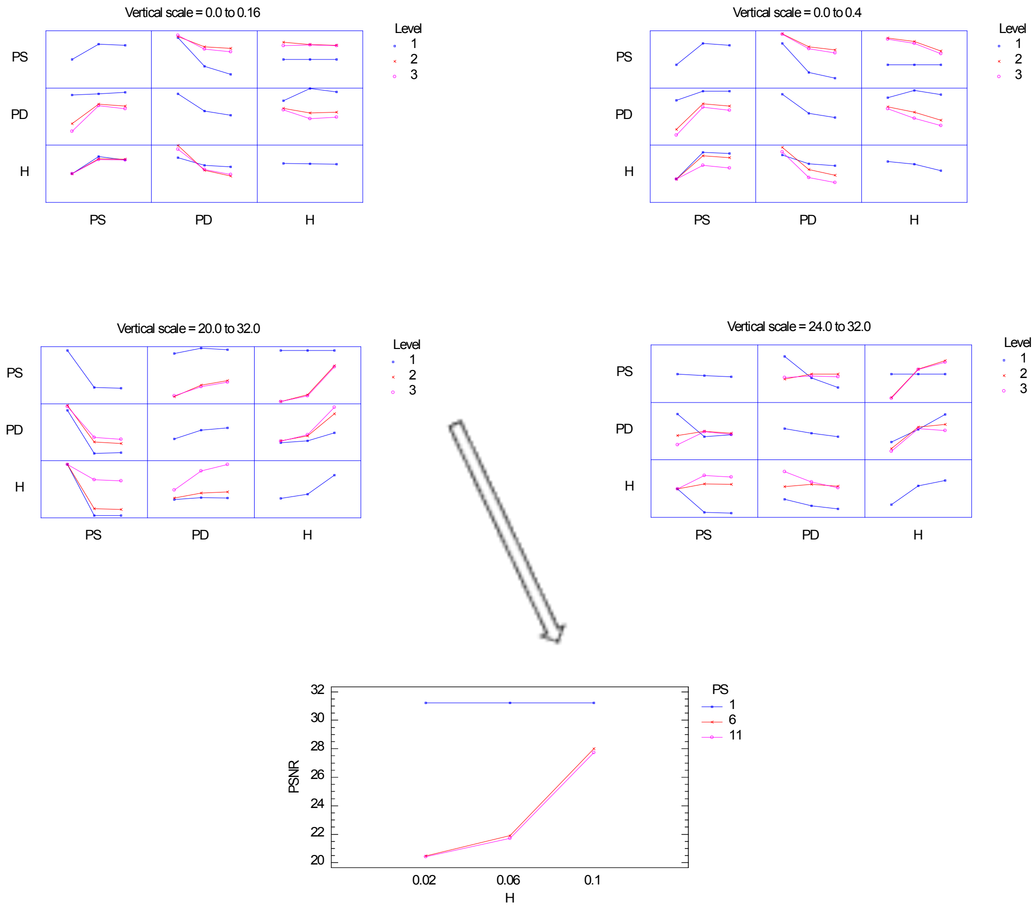

Figure 5. Factor means plots; SSIM results for images '01' (a) and '05' (b), and PSNR results for images '01' (c) and '05' (d).

Table 1. SSIM results: ANOVA table for images '01' (left) and '05' (right).

Source	*SS*	*Df*	*MS*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
PS	0.01037	2	0.00518	25.93	0.0003
PD	0.01855	2	0.00927	46.38	0.0000
H	0.00003	2	0.000016	0.08	0.9206
INTERACTIONS					
PS-PD	0.00436	4	0.00109	5.45	0.0204
PS-H	0.00009	4	0.000022	0.11	0.9753
PD-H	0.00319	4	0.00080	3.99	0.0454
RESIDUAL	0.00160	8	0.000200		
TOTAL (CORR.)	0.03819	26			

Source	*SS*	*Df*	*MS*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
PS	0.12090	2	0.06045	49.62	0.0000
PD	0.13471	2	0.06735	55.29	0.0000
H	0.01960	2	0.00980	8.05	0.0122
INTERACTIONS					
PS-PD	0.01782	4	0.00445	3.66	0.0560
PS-H	0.00987	4	0.00247	2.02	0.1836
PD-H	0.01936	4	0.00484	3.97	0.0460
RESIDUAL	0.00975	8	0.00122		
TOTAL (CORR.)	0.33200	26			

Table 2. PSNR results: ANOVA table for images '01' (left) and '05' (right).

Source	*SS*	*Df*	*MS*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
PS	370.907	2	185.454	128.41	0.0000
PD	26.9919	2	13.4959	9.34	0.0081
H	124.845	2	62.4226	43.22	0.0001
INTERACTIONS					
PS-PD	5.55259	4	1.38815	0.96	0.4783
PS-H	62.4659	4	15.6165	10.81	0.0026
PD-H	22.7815	4	5.69537	3.94	0.0469
RESIDUAL	11.5541	8	1.44426		
TOTAL (CORR.)	625.099	26			

Source	*SS*	*Df*	*MS*	*F-Ratio*	*P-Value*
MAIN EFFECTS					
PS	0.702963	2	0.3514	1.20	0.3507
PD	6.17852	2	3.08926	10.53	0.0057
H	56.8207	2	28.4104	96.82	0.0000
INTERACTIONS					
PS-PD	24.1126	4	6.02815	20.54	0.0003
PS-H	28.4237	4	7.10593	24.22	0.0002
PD-H	4.42148	4	1.10537	3.77	0.0523
RESIDUAL	2.34741	8	0.29342		
TOTAL (CORR.)	123.007	26			

4 CONCLUSIONS

Results show that the three NLM parameters affect the algorithm's noise removal capability to various degrees, depending on the characteristics of each investigated image. SSIM metric appears to correspond more closely to subjective visual perception of image quality compared to PSNR since it rewards sharp edges and object contours in the images. Further investigations are necessary to better understand the mutual interactions of the NLM parameters and their influence on image quality metrics, such as SSIM and PSNR.

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RECOGNITION OF WORDS WITH JUMBLED LETTERS

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ABSTRACT: *Visual word recognition reflects the efficiency of word interpretation. Numerous studies propose models to explain the underlying mechanisms of this phenomenon. Adding to this field of research are the findings of one particular study that have circulated the internet and occupied the scholars' interest for some time. These findings provided support for the notion that jumbled letters in a word (apart from the first and the last letter) provide no influence on reading speed, recognition speed, and reading comprehension. The findings have been labelled as a hoax by scholars. We decided to conduct a research with the aim to investigate the differences in reading performance between the words with non-jumbled and jumbled letters for two languages (Slovene and English) across two background colours (white and grey) through the analysis of eye movements. The findings of the study indicate that longer reading time is needed for the words with jumbled letters in both languages and that more complex words provide greater number of fixations.*

Keywords: reading comprehension, fixation frequency, reading speed, word recognition.

1 INTRODUCTION

Reading effectiveness is influenced by perceptual and cognitive processes such as visual word recognition. Cognitive psychologists suggest numerous models for visual word recognition: whole word recognition approach (Haber & Schindler, 1981; Reicher, 1969), serial letter recognition (Sperling, 1963), parallel letter recognition (McClelland & Rumelhart, 1981; Rayner, Pollatsek, Ashby, & Clifton Jr, 2012). The currently acknowledged model suggests that words are identified on the basis of their compositional elements–letters, where the letters are not identified sequentially but parallelly. Additionally, letter processing i.e. letter identification efficiency is interwoven with typeface design (Pušnik, Možina, & Podlesek, 2016) on the basis of its legibility through familiarity (Beier, 2009; Nedeljković, Novaković, & Pinćjer, 2017).
In connection with this topic, scholars have explored the visual word recognition when letters in words are transposed i.e. jumbled. These investigations were the result of a certain statement that circulated on the internet suggesting that the order of the letters in a word is not relevant to the recognition process as long as the first and last letter preserve the right place. An explanation of this phenomenon can be found in an online article called The "Cambridge Effect" (Wren, 2005). The author of the article explains that so-called "Cambridge Effect" is only partly true. Namely, it is easy to read and understand short words (e.g. hmuan; human) with jumbled letters. However, it would be far too complicated or impossible to read longer words in this way (e.g. recasreh; research). Even though the statement was later found to be a hoax, some researchers took an interest in the matter. For example, Rayner et al. (Rayner, White, & Liversedge, 2006; White, Johnson, Liversedge, & Rayner, 2008) report findings of their research on reading text with transposed letters and conclude that some variations of text in this regard are easier to read while others are not. Namely, their research shows that reading speed of the text where words have transposed letters declines as transposition moves from beginning letters, across final or ending letters, to internal letters. In comparison to the normal text, the text with transposed letters will always have a cost to reading time and it will significantly vary on the position of the letters. However, the choice of the typeface and text–background was not controlled in previous research. Therefore, the purpose of this article was to investigate the effect of letter transposition on reading performance in different languages and against different background colour through examination of eye movements.

2 EXPERIMENTAL

2.1 Participants

Eighty students from the University of Ljubljana participated in the experiment. Participants consisted of 50 women (62.5%) and 30 men (37.5%) with the average age of 22.1 years. All of them reported normal or corrected-to-normal vision (32 participants reported the use of either glasses or contact lenses).

2.2 Stimulus design

Eight tests were performed that were divided in two groups. Four tests were conducted in the English and four in the Slovene language. The tests in both languages had the same number of lines (12 for the English language; 10 for the Slovene language). The content was the same for all the tests and it showed an extract from the book The Little Prince. The only difference was in the length of the individual words that occupied paragraphs in different languages. The line length of the paragraphs for both languages was kept constant and was formulated as suggested by relevant sources, containing up to 75 characters (spaces included) (Bringhurst, 1992; Dyson, 2004; Ruder, 1981). All the tests were set in Georgia Bold typeface style with 29 px size (Arditi & Cho, 2005; Franken, Podlesek, & Možina, 2014; Lund, 1997). The colour of the text in paragraphs was set in black and the background colour in grey or white (Baetens, 2008; Dzulkifli & Mustafar, 2013; Hall & Hanna, 2004). Table 1 shows the setups of the performed tests.

Table 1. The setups of the performed tests.

Test	Typeface	Size [px]	Background colour	Typeface colour	Number of lines	Characters/line with spaces	Language
A	Georgia	29	grey	black	12	64.9	ENG
B			grey		12		
C			white		12		
D			white		12		
E			grey		10	67.7	SLO
F			grey		10		
G			white		10		
H			white		10		

2.3 Measures

The most common approach for measuring reading rate is tracking the eye movements (Rayner, 1998) due to its reliability over the linkage to shifts in attention (Deubel & Schneider, 1996; Wedel, 2013). For this study, two variables for measuring eye movements were chosen: number of fixations (critical parameter in determining search times) and total fixation duration (indicating cognitive effort), alongside the reading speed. The collection of data on eye movements was executed with Tobii X120 eye tracker device. Eye movements were assembled with 120Hz frequency and subsequently processed for calculation of eye fixation frequency and fixation duration.

2.4 Procedure

Participants were asked to read silently from the screen and afterwards to answer series of questions which were designed to verify if the text was actually read (Aberson & Bouwhuis, 1997; Beymer, Russell, & Orton, 2008; Weisenmiller, 1999). At the end of the experiment, there was a question which was a control question for the content of the text. The role of the question was to check for comprehension to see whether the participants silently read the text. The question referred to the word telescope in the sentence. All 80 participants reported having acknowledged the control word. Therefore, the comprehension check-up showed that all the participants understood the content of the text.

3 RESULTS & DISCUSSION

The investigation of the reading time of paragraphs of words with non-jumbled and jumbled letters revealed that the overall shortest reading time (40.43 s) was for the text in Slovene language in the test where the colour background was white (Table 2, Test H). The difference in reading speed between the words with non– jumbled and jumbled letters was from 13 to 25 seconds apart in the favour of the non–jumbled text. The lowest difference, 13.2 seconds, was for words in English language where black text was presented on the grey background. 14.93 seconds was the difference for Slovene text (black typeface on white background). Next difference was 15.4 second for Slovene text; black letters on white background. The highest difference was noticeable for English text where black letters were presented on the white background (24.2 seconds). Generally, texts with non–jumbled letters were read faster in both languages but were read with different pace across different

backgrounds (SLO grey = 47.70, SLO white = 40.43; ENG grey = 58.46, ENG white = 52.60). On the other hand, the data on reading rate for the texts with jumbled letters revealed a slightly different trend. The text in Slovene language was read faster when set against the white background (SLO grey = 63.10, SLO white = 55.36) whereas the text in English language was read faster when set against the grey background (ENG grey = 71.48, ENG white = 76.80). The difference in reading rate between words with jumbled and non–jumbled letters for both languages was expected due to the findings of previous studies. However, it was found that reading of jumbled letters was faster in Slovene language. These results are understandable since all the participants were Slovene native speakers and English language was their second language.
The analysis of reading speed revealed that the fastest reading rate was for the text in Slovene language with non–jumbled letters set against the white background. The number of fixations, however, was not the smallest in this case. Namely, the number of fixations was, expectedly, higher for words with jumbled letters. But the results also show that the number of fixations was higher for the text set against the white background for both languages (jumbled letters: SLO grey = 148, SLO white = 163; ENG grey = 173, ENG white = 250 / non–jumbled letters: SLO grey = 106, SLO white = 125; ENG grey = 135, ENG white = 193). Even though the reading rate was faster for texts set against the white background, the number of fixations was greater in this case in comparison to the number of fixations for the texts set against the grey background. This can be explained by the higher contrast in colour between the text and background. In this case eyes receive more input (more detail) and use more fixations to search through details of the stimuli.
When the results of the total fixation duration were analysed, it was observed that the shortest fixation durations were for the texts in Slovene language regardless of the background. In regards to reading comprehension, we could observe that comprehension was high for both languages regardless of the background colour and jumbling of the letters. All the participants answered correctly when asked about the content of the read text.

Table 2. An average number of fixations, reading speed and total fixation duration for each test.

Test	Language		Letter order		Colour		NF	RS	TFD
	ENG	SLO	Jumbled	Non-jumbled	Background	Typeface	N	[s]	[s]
A	•		•		grey	black	173	71.48	1.50
B	•			•	grey		135	58.46	1.08
C	•		•		white		250	76.80	1.14
D	•			•	white		193	52.60	0.70
E		•	•		grey		148	63.10	1.50
F		•		•	grey		106	47.70	0.80
G		•	•		white		163	55.36	0.90
H		•		•	white		125	40.43	0.50

* NF. – Number of fixations; RS. – Reading speed; TFD. – Total Fixation Duration

Additional analysis of variance was performed through the series of one–way ANOVA tests to compare the effect of letter transposition on reading performance in different languages and on different backgrounds. The outcome variables were found to be normally distributed and equal variances are assumed based upon results of Levene's test and robust test on the equality of means. Analysis of variance that was conducted to compare the effect of letter transposition on the number of fixations, in the case of English language and grey background, showed a statistical difference between condition means [$F(1,18) = 10.836$, $p = 0.004$], effect size $r = 0.37$. The main effect of the letter transposition on the number of fixations, in the case of Slovene language and grey background, was also found statistically significant [$F(1,18) = 17.332$, $p = 0.001$], effect size $r = 0.49$. There was no statistical difference in group means in the cases of English and Slovene on white background. The results indicate that letter search is significantly greater for the words with jumbled letters when they are presented on the gray background. This can be explained by the lack of contrast between the text–background colour where eyes use more fixations for the search of incongruent patters in comparison to when the same stimuli is presented against the white background.
Analysis of variance that was conducted to compare the effect of letter transposition on reading speed, in the case of English language and white background, showed a statistical difference between condition means [$F(1,18) = 36.275$, $p = 0.000$], effect size $r = 0.67$. The main effect of the letter transposition on the reading speed, in the case of Slovene language and white background, was also found statistically significant [$F(1,18) = 31.192$, $p = 0.000$], effect size $r = 0.63$. There was no statistical difference in group means in the cases of English and Slovene on grey background. These results can be explained by suggesting that greater contrast between the colour of the text and background influences faster pattern recognition i.e. eyes detect letter shapes faster.

Analysis of variance for the search of the effect of letter transposition on the third variable, total fixation duration, showed a statistical difference between group means in all four conditions ($p < .05$) with large effect size ($r > 0.2$). The results indicate that, nomatter the conditions, words with non–jumbled letters are processed faster. These results are consistent with previous findings (Rayner et al., 2006; White et al., 2008).
Further analysis of the data shifted the focus of the initial aim of the paper towards the analysis of the reading rate of longer words with jumbled letters (in comparison to those with non–jumbled letters). From all the data gathered on the number of fixations of all the participants, an average number of fixations was calculated. Specifically, all the fixations from each test were combined with the heat map of each test. In this way, it was possible to observe where the centres of the interest were and determine where in text participants had difficulties in reading (either they had to return to the same point, or the word was not easily recognizable because of the jumbled letters, or maybe the word was generally complicated even though it was presented with non–jumbled letters). Figures 1 to 4 present centres of fixations (on the left jumbled letters, on the right non–jumbled letters).

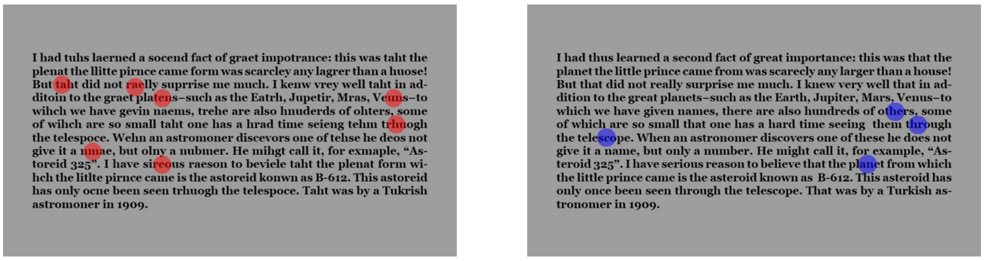

Figure 1. Main fixations in jumbled and non–jumbled letter order for English text set against the grey background.

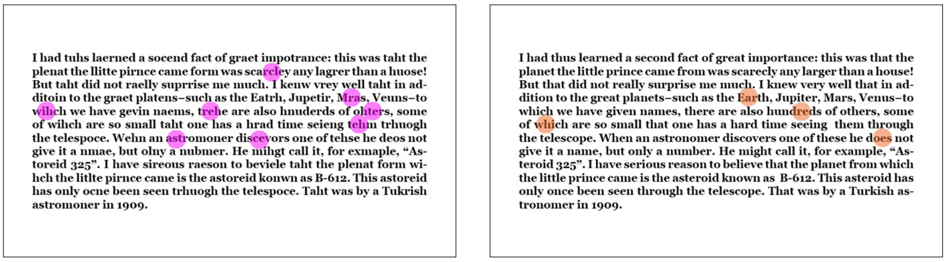

Figure 2. Main fixations in jumbled and non–jumbled letter order for English text set against the white background.

Figure 3. Main fixations in jumbled and non–jumbled letter order for Slovene text set against the grey background.

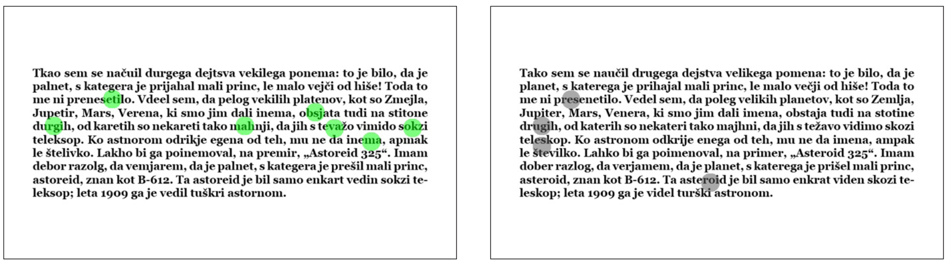

Figure 4. Main fixations in jumbled and non–jumbled latter order for Slovene text set against the white background.

In this way, the maximum number of important fixations from each test was gathered (Table 3). For tests with words set with jumbled letters, the number of average fixation points was 7 or greater and for tests with words set with non–jumbled letters the number of average fixation points was 5 or fewer. Table 3 presents all the words were the average fixation point in the test was.

Table 3. An average mean of the number of fixations in non–jumbled and jumbled letter order for all tests.

Test	Fix.	Word
A	7	taht, raelly, platens, Veuns, trhuogh, nmae, sireous
B	4	Others, telescope, throuhg, planet
C	8	scarcely, Mras, wihch, trehe, ohters, discevors, astromoner, tehm
D	4	Earth, hundreds, which, does
E	7	Verena, obsjata, durgih, mahnji, štelivko, inema, mali
F	5	Jupiter, teleskop, astronom, planet, asteroid
G	7	prenesetilo, pbsjata, durgih, mahnji, tevažo, sokzi, inema
H	4	Presenetilo, drugih, teleskop, asteroid

Table 3 shows were the word fixations were made. It can be observed that in the Test A participants had difficulties with words of different length–from four to seven letter words. Within the test where letters had non–jumbled order (Test B) words were longer, consisting of more letters–from six to nine. Both tests were performed with black typeface on the grey background. Test C shows the highest number of fixation centres. Fixated words had from four to ten letters. Again, it can be observed that there was no connection between the fixation centres and number of letters. The complexity of the word was found to be more important i.e. the sequence of the jumbled letters. A similar trend, as in Test B, was observed in the Test C. Four fixation centres appeared but this time the word length had greater range (from four to eight letters). Similar observations were noticeable for the text presented in Slovene language. Fewer fixation centres could be found in texts with non–jumbled letters while text with jumbled letters needed more fixation centres. On average, all the letters in Slovene language, where fixation centres appear, were longer compared to English words.

4 CONCLUSION

The goal of this study was to investigate the reading performance of the words with jumbled and non–jumbled letters, set in two different languages, against two different backgrounds by analysing the data gathered with an eye tracking device. The findings indicate that reading rate of the text when words have jumbled letters in both Slovene and English language is slower in comparison to the text when words have non–jumbled letters. Through this investigation, it was revealed that texts, regardless of the transposition of the letters, were faster read when set in Slovene and against the white background. Further investigation of the fixation centres within words showed that there was no connection between fixation centres and the number of letters and that the complexity of the word had a greater impact on reading rate.

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THE DEVELOPMENT OF THE GENERATIVE BRANDS' CATEGORIZATION

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ABSTRACT: *Modern computer programming is constantly progressing and some communication methods with computers are developing to such extent that it is easier also for non-programmers to understand them, learn them and create. More comprehensive syntax and semantic enable the designers exploring new approaches to present brand identities. One of these approaches is generative brand identity, a subgroup of dynamic brand identities. These generative brand identities are made with computer languages, and to present identity elements, an external variable is used. But they need at least an element that remains the same in order to be recognisable and coherent. Now the companies are encouraged to use brand identities and logos that are not limited to traditional graphic visual expression but aimed to promote the development of interactive performances of generative brand identity and logos. This study gathers and compares two categorizations of dynamic brand identities that are later used for creation of a new one, dedicated solely to generative brand identities.*

Keywords: Generative design, graphic design, programming, logo, brand identity.

1 INTRODUCTION

For the last several years generative design has created considerable excitement among professional designers. Through the interplay of complex information with graphic design and programming, new and fascinating visual worlds are emerging where the coincidental is shaped to help correlations become visible. The creator can discover new capabilities of the design itself, creates something unique and different with the code that cannot be achieved otherwise (Massingham, 2011). The possibilities of programming languages, mainly simplification of syntax and semantics, will change the role of the designer since computer art allows the audience or user to co-create the final product, which attracts and awakens interest in the work itself (Ish, 2013). We are expecting a paradigm shift in design that will lead to realms of visual imagery. Until now, designers have used tools that programmers have developed for them, which has forced designers to adjust to their systems (Bohnacker, Groß, Laub and Lazzeroni, 2012).

Generative logos use a generative way of presenting elements of identity, which means that they are constantly changing. Visual symbols as a business trademark can be visually changing and vibrant. Traditional forms of media are unable to stand out and attract the necessary attention of readers today. With the progress of digital media techniques, which change people's behavior in information collection and reading, corporations are encouraged to use brand identity and trademarks that are not limited to traditional graphic visual expression but aimed to promote the development of interactive performances of dynamic brand identity and trademarks (Hsu, 2013).

In the theory of generative design, we explore the programming and the various options offered by the programming languages. With the acquired knowledge, the designers became active in the production of programs and programming languages, and at the same time allow other designers easier access to the software.

Generative art, on the one hand, does not interfere with aesthetics, but rather it intends to deepen into the disciplinary approach to it. This includes a human factor that outlines the implementation process (Curralo, 2014). Algorithms produce interactive and generative logos, which find a variety of solutions based on the parameters that are set, which preserves the visual identity.

These brand identities should be adapted to more and more devices, and there are increasingly complex ideas for presenting businesses, products, individuals, etc., it is difficult to present a multi-layered overall image with just one logo. One solution to this problem are the generative logos and associated brand identities. With their logical and systematic design structure, generative logos vary according to different environments. Although they are more complex to design, the effect is stronger and more impressive. Generative logos are an established, but not quite common practice in graphic design, which has not yet been thoroughly researched and represent a new way of displaying the overall image.

The aim of the research was to review two existing generative brands' categorizations that could enable a more comprehensive understanding and use of these media and the proposal of one new approach. The experiment included the selection of generative brands' categorization, followed by analysing each one with the aim to identify the (predominant) input variables that define a category and the definition of the used methods for categorisation. Next, a new categorisation with six groups was preliminary introduced, based on analysis of generative logos collected from the web, books and articles and new observations about their dynamic and generative aspects.

2 OVERVIEW OF LITERATURE

Because of their relative recent introduction to the world of graphic design, the review of the references reveals that there have not been many in-depth research analyses aimed at the performances of generative brand identities and logos. There has been research made in the field of the use of a dynamic brand identity (Felsing, 2010) that has shown that they are preferred by the organizations of the public and cultural sector. They are attracted by the interaction between organization, content and visualization, which affects the quality of the overall image. Apart from this one and the general categorization (Lin, 2007; Williams, 2001; Liu, 2009; Krasner, 2008; Taylor, 2011; van Nes, 2012; Hsu, 2014), questions about the authorship of the final product (Cox, McLean, Ward, 2000, McCormack, 2014, Paul, 2016), the aesthetics of randomness (Schönleib, Schubert, 2009) and raising questions about copyright protection (Postigo, 2012; Birdy, 2012) more detailed studies of generative brand identities and logos were not found.

3 CATEGORIZATION OF DYNAMIC BRAND IDENTITIES

The main purpose of categorizing is to show the various ways how dynamic brand identity develops into the final product. Research provides examples that can also be used to solve problems in design and other areas. These can serve designers as inspiration for further work. New technologies allow to leap from paper to the screen, where the use of dynamic brand identities is the widest.

The review of the refferences shown that there are only two relevant categorisation of dynamic brand identities, i.e. Hsu's categorisation according to the time frame and Van Nes's categorisation by use of the dynamic identity.

3.1 Hsu's categorisation according to the time frame

In the scientific paper, Visual Expression and Design Principles for Dynamic Brand identities (2014) Hsu proposes that the expression forms are divided into four types based on four different timeframes of motion:

- **Limited timeframe:** Moving images are played within a limited timeframe such as films, animation, etc. This way of presenting a logo is mostly adopted by the industry companies of communication media. But, similar forms are gradually introduced to all industry companies due to the emerging technology.
- **Rotational timeframe motion:** Moving graphics are played rotationally. Only a small portion of companies are using this way of presenting their dynamic logos.
- **Non-fixed rotational timeframe motion:** Moving images are randomly generated and played rotationally. A non-fixed rotational motion graphic is a dynamic trademark that generates no fixed form, found randomly under mobile carriers.
- **Motionless logos:** Trademarks present motionless static and dynamic images both. These logos contain no limited timeframe animations or moving images with both static and dynamic trademarks that are versatile and widely distributed in different industries.

This categorization aimed to analyse the visual expression forms of dynamic brand identities and their design concept. Forty-four international dynamic brand identities were analysed using a case study method; in addition, the types of dynamic brand identities, visual expression forms, and design concepts were established through discussion forums held three times by focus groups with five to seven participants per discussion. Collected data was then analysed and put into categories.

The only criterion for this categorization of logos is the time, therefore, this categorization considers all the dynamic brand identities, and there are no specific categories for generative logos. Rotational and linearly developing logos between the generative ones cannot be traced because these logos are managed by the algorithm. In this case, generative logos would fall only in the non-linear or static category.

3.2 Van Nes's categorisation by use of the dynamic identity

Van Nes divides them into six types in her book Dynamic Identities: How to create a living brand (2012), where she named them based on their behaviour:

- **Container:** a most obvious way of creating a dynamic identity, where with only one changeable variable (colour, image ...) a great recognisable variety of logos can be created.
- Wallpaper: a common example of dynamic identities where a variable is placed behind the constant logo. The shape can vary, but impression is still a single identity.
- **DNA:** the brand identity has several key elements that are interchangeable, thus creating a new image every time.
- **Customised:** this allows the client to interact, be a part of the brand and customize its logo. This is the first step towards letting identity reflect a certain sense of community, creating an emotional bond.
- **Formula:** where the whole system is a constant, whether this is a grid or a set of rules it forms a system that brings everything together.
- **Generative:** lets the identity be influenced by external data (weather, news, tweets, number of visitors…) and puts it in real time. The identity can adapt in response to its input.

For this categorization van Nes dissected the identity into six components: a logo, colour, typography, graphic elements, imagery and language. Together they form a system that builds the identity of the brand and each component helps sharpen the identity of the brand it represents. She researched nighty-three dynamic brand identities and put them into six categories based on the analysis of visual behaviour of their components and case studies of the identities. Within van Nes' explanation, the functionality of the flexible elements receives more attention than the actual strategic foundation of the visual identity.

This system allows a simple categorization of most the dynamic brand identities and gives designers new ideas in finding solutions. However, it does not go into enough detail, especially for more technologically-supported identities that are influenced by data or are completely automatic. Some categories, in a simple and obvious way, change static visual image into dynamic ones. It is precisely this category of generative brand identities that gives the need for categorization, as it mentions and does not define all the ways in which companies can represent their employees or use a more personal way or get in touch with users.

In Figure 1 the procedure for identification of a new brand identity categorisation is shown.

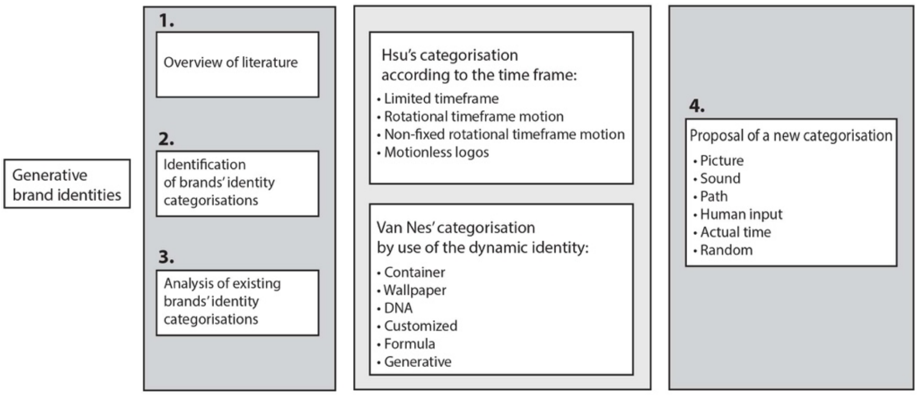

Figure 1. The procedure for identification of a new brand identity categorisation.

4 RESEARCH METHODS AND CATEGORIZATION OF GENERATIVE BRAND IDENTITIES

In this study, we want to analyse and categorize generative logos and their conceptual background based on the type of input variable that affects the change of the logo. The purpose of the study, based on thirty-six generative logos collected from web, books and articles (van Nes, 2013; Bohnacker, Groß, Laub, Lazzeroni, 2012; Jochum, 2013; Hsu, 2014), is to present the importance of these logos in contemporary graphic design. A case study of each logo was made then by the help of a discussion group consisting of four participants: three professional designers and one linguist, aged 30-40, three men and one female, and a citation analysis. Analytically presented research and development in this field, as well as the introduction of before mentioned methodologies the collected data was analysed depending on the structure of the code and the input variable, contributing to the new categorization of generative logos in this research field, which provides a thorough understanding of this development field of generative art.

The acquired data has been put into six groups:

- **Picture**
  Logos draw sources from colours and shapes found in provided images.
- **Sound**
  Logos are responsive to music or voice and the changes occur according to the given parameters.
- **Path**
  The solutions include the tracking devices and tracking movement of people or animals, and thus create a logo with the route in given area.
- **Human input**
  This topic is the most diverse, as the ways of entering information for the creation of logos vary, including also instances of interactive logos where the person directly influences the change.
- **Actual time**
  The logos of this group share the property that everything is happening in real time.
- **Random**
  Here, the logos are randomly generated and have no input variable.

Some of the logos are multi-modular, especially in the case of human input where some logos have an additional variable. In these cases, the dominant variable was considered which determined into what category the logo was put into.

The demonstrated results present many ways of influencing the final image and reveal various ways in which the computer affects the final product. The presented categorization can serve to designers and programmers as an inspiration for their work and facilitate communication between the designers and the users. Moreover, the result of this analytical approach facilitates the users' understanding of the impact of programming languages on the ultimate look of the product.

5 CONCLUSION

Today, generative logos are more accessible than ever because of less demanding software tools for their production. They are widely used in television and internet adverts, where their ability to express uniqueness, the involvement of users in the creative process and the ability to attract the viewer's attention is used. Web standards are evolving and becoming more and more powerful and advanced, and the capabilities of even the most basic knowledge of programming languages are becoming incomparable with those five years ago. In the research the review of three dynamic brand identities' categorisations are presented. Hsu's categorisation according to the time frame and Van Nes's categorisation by use of the dynamic identity were presented and discussed. Based on some critical observation about the existing approaches, a categorisation specifically for generative brand identity was proposed. The use of categorisation form (type) is not unambiguous, yet according to their release in the research and professional publication, they certainly present researchers' observation according to methodology used and presumably also the evolving trends of generative art.

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THE EFFECTS OF TYPEFACE AND IMAGE COMPLEXITY ON CONSUMER' VISUAL ATTENTION AND ATTITUDINAL RESPONSES IN ADVERTISING

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ABSTRACT: *The effects of semantic typeface design properties have been a subject of research mainly found in the field of advertising. Unlike the functional properties, the semantic properties of typefaces can t: rigger a cognitive and emotional reaction. These properties are often correlated with the complexity of the form. When put in the context of print advertisements, the complex forms of typefaces are paired with different levels of image complexity. Previous findings provide insufficient guidelines on this matter. Therefore, the aim of this paper is to test the effects of typeface vs image complexity in print advertisements by analysing eye movements and attitudinal responses. An experiment 2 × 2 between subjects' factorial design was conducted. The results indicate that the relationship between low image complexity and high typeface complexity can positively influence consumer's visual attention and attitude.*

Keywords: typeface complexity, eye tracking, advertising, visual attention, visual complexity.

1 INTRODUCTION

Typefaces are determined by their functional and semantic properties (Henderson, Giese, & Cote, 2004). The functional properties of typefaces relate to the attributes of the form that are universal i.e. the properties that help distinguish one letterform from another (see Pušnik, Podlesek, & Možina, 2016). The effects of the functional properties of typefaces have been extensively explored through the studies on the legibility of type forms (Beier, 2009; Nedeljković, Novaković, & Pinćjer, 2017; Rayner, 1998). On the other side, the semantic properties of typefaces relate to graphic descriptions which trigger cognitive and emotional reactions (G. R. Morrison, 1986). In such instances, the formal attributes of a typeface establish semantic associations which are often correlated with the complexity of the form (see Beier, Sand, & Starrfelt, 2017). The effects of such typeface properties that are more elaborative and complex have been the interest of research in the field of advertising effectiveness (Childers & Jass, 2002; Doyle & Bottomley, 2006). Still, a vast body of research in this field focuses on the effects of the image i.e. pictorial part of the print advertisement (which has proven to be the most frequently used medium in the print commercial propaganda). Particularly, existing studies have addressed the effect of visual rhetoric of images in advertising on comprehension and elaboration (Gkiouzepas & Hogg, 2011; McQuarrie & Mick, 2003; Scott, 1994), as well as originality and familiarity on visual attention (Pieters, Warlop, & Wedel, 2002). However, the effects of the semantic properties of typefaces in relation to the pictorial part of an advertisement have not yet been fully explored.

A particular feature of the form–that of visual complexity, embodies a range of implications that invite researchers to investigate effects of visual complexity on consumer reactions (B. J. Morrison & Dainoff, 1972). Namely, advertisements that contain more detail are considered more visually complex. Pieters et al. (2010) propose the concept of feature complexity in advertisements which suggests that the image is more complex when there are more detail and variations in the basic visual features such as colour, luminance and edges. Their findings indicate that higher feature complexity may hurt visual attention. However, their inferences are based on the sample of tested advertisements that were not controlled for typeface design. Therefore, their research lacks concrete implications for typeface application in relation to image complexity.

Considering that findings of previous studies indicate that the effect of print advertisements depends on the semantic properties of typefaces, which is defined by the complexity of visual elements (McCarthy & Mothersbaugh, 2002; Puškarević, Nedeljković, Dimovski, & Možina, 2016), as well as feature complexity of images (Pieters et al., 2010), the purpose of this paper is application of eye tracking methodology and attitudinal responses to identify the effects of typeface vs image complexity in print advertisements.

2 EXPERIMENTAL

An experiment 2 (typeface complexity: low vs high) × 2 (image complexity: low vs high) between subjects' factorial design was conducted. In total, 120 students from the University in Ljubljana took part in the study.

2.1 Independent variables

According to visual complexity theory (Donderi, 2006) and methodology of Pieters et al. (2010), measurements of image complexity were collected. The starting point was the assumption that more detail and variations of basic elements will need more computer memory to store the image. DSLR camera Canon EOS 5D Mark III was used to make 20 images of various content. Images were shot in RAW, unstructured format. In the Camera Raw Conversion software Adobe RGB 98 colour profile and 8 bits per channel were chosen. After this step, images were saved as TIFF file. The JPEG algorithm is considered a standard for image compression (Wallace, 1992) and it was used as the measure of feature complexity in the study. In order for JPEG algorithm to provide relevant results, all the images in the sample needed to be of the same pixel dimension (e.g. 1920x1280). Image compression resulted in image complexity scale with two endpoints: low feature complexity (656kb) and high feature complexity (2255kb). Once the scale was determined, target images i.e. images to be used in target ads (see Puškarević et al., 2016; Voss, Spangenberg, & Grohmann, 2003) were composed following above–mentioned procedure. The target images depicting realistic visual structure across two levels of feature complexity are shown in Figure 1.

According to Frutiger's (1989) common skeleton (i.e. letter matrix) and Dixon's (2008) description framework for typeface classification, samples of typeface stimuli were created. The starting point was the letter matrix which was found in the surface area of overlapped typefaces (Garamond, Baskerville, Bodoni, Excelsior, Times, Palatino, Optima, Helvetica). Graphic application Adobe Illustrator was used in this process. Once the common skeleton was determined, components under the label »formal attributes« in Dixon's description framework were used to make the typeface complexity scale. Eight formal attributes were superimposed on the letter matrix in succession in the following order: weight, modelling, proportion, key characters, terminals, construction, shape and decoration. This method provided subjective typeface complexity scale that was correlated with measurements from ImageJ software. Results from both methods aligned. Subsequently, combinations of several formal attributes were used for typography design for the target advertisements. The target typography, depicting low typeface complexity and high typeface complexity, is shown in Figure 1.

Figure 1. Target images.

The design of the target advertisements which is based on the objective measures of visual complexity i.e. the image feature complexity and typeface complexity is shown in Figure 2.

Figure 2. Stimulus design–target advertisements. From left to right depiction of realistic visual structure with: low image feature complexity and low typeface complexity; low image feature complexity and high typeface complexity; high image feature complexity and low typeface complexity; high image feature complexity and high typeface complexity.

2.2 Measures

Since eye movements (fixations) are considered indicators of visual attention (Deubel & Schneider, 1996), information on individual fixations was obtained through fixation frequency (spatial distribution of fixations) and total fixation duration. For collecting data on eye movements Tobii X120 eye tracker device was used. Ad (items: likable, favourable, interesting) and brand (items: good, favourable) attitude, as well as conative (items: probably, possibly) attitude, were measured with a five-point Likert scale (Mackenzie, Lutz, & Belch, 1986).

2.3 Procedure

Participants were randomly assigned to each of the experimental conditions. There were four groups of participants of which the two were the control group (observed low typeface complexity) and the two were the experimental group (observed high typeface complexity). Before the start of the experiment, each participant adjusted to the lighting conditions in the room after which he/she was exposed to 9-point calibration on the screen. Introduction pages were then presented containing the test ad. After the participants confirmed that he/she understood the procedure, a collection of four advertisements (one target ad and three filler ads) followed. After each advertisement, Likert scales were displayed and participants were asked to mark their responses. The participants viewed the collection of advertisements at their own pace.

3 RESULTS & DISCUSSION

To analyse data gathered through Likert scales (effects of typeface complexity on attitude), Mann-Whitney U test was used. First, data on advertisements with low image feature complexity will be presented. The control group rated advertisements lower on the likable dimension for the attitude toward the ad scale ($Mdn = 4$; Mean rank = 27.07) than participants in the experimental group ($Mdn = 4$; Mean rank = 35.66), and Mann- Whitney U value was found to be statistically significant $U = 347$ $z = -1.976$, $p = 0.048$. Also, on the favourable dimension the control group rated advertisements lower in the control group ($Mdn = 4$; Mean rank = 26.35) than in the experimental group ($Mdn = 4$; Mean rank = 36.33). Mann- Whitney U value was found to be statistically significant $U = 325$ $z = -2.362$, $p = 0.018$. The attitude toward the brand on the good dimension also showed statistically significant result: control group $Mdn = 3$; Mean rank = 26.20; experimental group $Mdn = 4$; Mean rank = 36.47; $U = 321$, $z = -2.386$, $p = 0.017$. Additionally, the purchase intention on the probability dimension was found to be statistically significant: control group $Mdn = 4$; Mean rank = 38.36; experimental group $Mdn = 3$; Mean rank = 27.80; $U = 356$, $z = -2.321$, $p = 0.02$. Main effects for other dimensions are not interpretable and will not be discussed. The data of attitude ratings towards typeface complexity on advertisements with high image feature complexity reveal no statistical significance. Descriptive statistics of the ratings on attitudinal scales of all groups are shown in Table 1.

Table 1. Means (M) and Standard Deviation (SD) for Attitude Dimensions for advertisements in both control (low typeface complexity) and experimental (high typeface complexity) groups across levels of image complexity (low vs. high image feature complexity).

		Image L				Image H			
		Typeface L		Typeface H		Typeface L		Typeface H	
		M	SD	M	SD	M	SD	M	SD
A_{ad}	Likable	3.67	0.88	4.13	0.83	3.69	1.01	3.72	1.07
	Favourable	3.73	0.82	4.22	0.66	3.79	0.98	3.76	0.95
	Interesting	3.37	1.16	3.63	1.04	3.48	1.02	3.45	1.12
A_b	Favourable	3.93	0.78	3.91	0.73	3.76	0.91	3.66	0.89
	Good	3.53	0.82	4.03	0.74	3.62	0.82	3.66	0.81
P_i	Probable	3.40	1.07	3.97	0.82	3.14	1.16	3.24	1.27
	Possible	3.50	1.01	3.63	0.94	3.31	1.20	3.38	1.17

Image L – Low image feature complexity; Image H – High image feature complexity; Typeface L – Low typeface complexity; Typeface H – High typeface complexity.

Series of One–way ANOVAs were executed for the analysis of the effect of typeface complexity on visual attention. In the case of the advertisements with low image feature complexity, the main effect of typeface complexity was found on both fixation frequency ($F(1,55) = 8.678$, $p = 0.005$)) and total fixation duration ($F(1,50) = 63.549$, $p = 0.000$)). In the case of the advertisements with high image complexity, the effect of typeface complexity was found not to be statistically significant. Descriptive statistics of the eye movements through measures of fixation frequency and total fixation duration of all groups are shown in Table 2.

Table 2. Means (M) and Standard Deviation (SD) of Attention Measures for ROI typography.

		FF		TFD				FF		TFD	
		M	SD	M	SD			M	SD	M	SD
Image L	control	11.68	6.63	2.79	1.63	Image H	control	16.86	10.89	4.70	3.35
	experimental	18.00	9.30	8.48	3.25		experimental	19.58	10.93	5.58	3.23

FF–Fixation frequency (Number of Fixations); TFD–Total Fixation Duration (Total Looking Time in Seconds)

These results indicate that viewers pay more attention to advertisements that are composed of less complex images and more complex typography. This relationship has proven to be beneficial for forming the positive attitude toward the ad and brand, as well as the purchase intention. These findings are in line with the existing research on the effects of image complexity and typeface semantics in advertising. Also, the current findings contribute to the existing pool of research. Namely, previous findings of Pieters et al. (2010) indicate that image feature complexity can hurt visual attention, implying that low image feature complexity can help visual attention. However, detailed guidelines on how to effectively pair the image and typography, as the two decisive executional elements of every advertisement, have yet to be updated. The results from this study contribute to these guidelines to a certain extent. The heat map analysis (Figure 3) shows a slight indication that advertisements with high image complexity might also benefit from the more complex typography. To pursue this further, an experiment with different levels of typeface complexity and a larger number of participants would be needed.

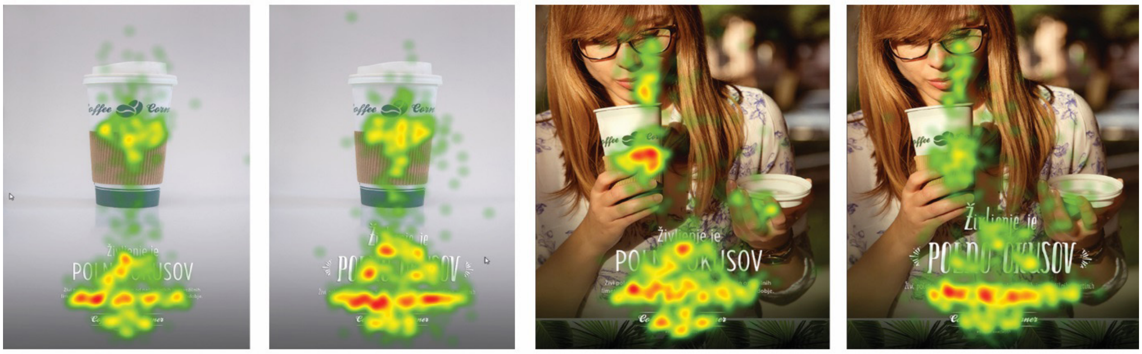

Figure 3. Heat maps comparing the eye movements of the control and experimental groups.

4 CONCLUSION

The goal of this study was to examine the effect of typeface complexity in relation to image complexity in print advertisements on visual attention and attitudinal scales. These effects were evaluated based on eye movements, attitudes and intentions of the viewers under incidental exposure to an advertisement. According to the findings, we can infer that typeface complexity has a significant effect on visual attention and attitude of consumers in certain conditions. When paired with an image that is low in feature complexity i.e. contains fewer detail and variations of basic elements, typeface complexity can influence consumer's visual attention and positively shape attitudinal responses. However, when paired with an image that is objectively complex i.e. contains more objects and details, typeface complexity will not have any influence due to the extensive visual "clutter". Future research might consider testing the effects of typeface complexity when different types of products are advertised or when an image in advertisement depicts unrealistic visual structure.

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THE INFLUENCE OF BACTERIAL NANOCELLULOSE ADDITION ON MECHANICAL PROPERTIES OF PAPER

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ABSTRACT: *Nanocellulose is in last period increasingly present in papermaking, mainly due to its positive effects on the different properties of various products. In this research, the influence of bacterial nanocellulose (which is less presented in papermaking) on mechanical properties of paper was analyzed. Nanocellulose was firstly chemically and mechanically processed and then added into the laboratory paper sheets together with a cationic starch as a retention agent. Nanocellulose has a positive effect on the tensile index of the samples. The add-in has improved tear index up to 35% and had no significant impact on burst index and elongation at break of samples.*

Keywords: nanocellulose, bacterial nanocellulose, papermaking, paper properties.

1 INTRODUCTION

Nanocellulose is the novel form of the most ancient and natural based polymer on earth: cellulose (Manikkam, 2018). It has exceptional strength characteristics on a par with Kevlar, a lightweight material used to manufacture high-strength, durable composites. However, in contrast to Kevlar and other materials based on fossil fuels, nanocellulose is completely renewable.

Especially because of its properties it is a topic of numerous researches in different fields. In last period it is also increasingly used in the pulp and paper industry, where it is incorporated in various types of papers and coatings in order to improve mechanical and other properties of products (Seppänen, 2014). Nanocellulose can be obtained in many different ways. With chemical procedures (Saito et al., 2009), mechanical procedures (Correia et al., 2016) or with the use of appropriate microorganisms (Jozala et al., 2016). Nanocellulose obtained with the use of microorganisms is environmentally friendlier since it does not require large quantities of chemicals or energy to be produced.

Bacterial nanocellulose is a nanofibrillar polymer produced by certain bacteria such as Gluconacetobacter xylinus, as a bottom-up process of polymerization of glucose into cellulose. The bacteria excrete the formed thick cellulose polymer gel consisting of fine-structured cellulose fibrils outside its cell wall. The width of the bacterial cellulose fibrils is around 20 - 100 nm and they consist of even finer cellulose nanofibrils with width around 2 - 4 nm. The purity of bacterial nanocellulose, its molar mass, the degree of polymerization and crystallinity are high. The mechanical strength is typically very high, but at the same time, it is very elastic and formable. Compared to cellulose nanomaterials originating from plants the water retaining of bacterial cellulose is excellent, due to its highly porous structure and large specific surface area (Gama et al. 2016).

As far as the influence of bacterial nanocellulose on the mechanical properties of papers is concerned, the literature review showed that there are not many articles related to this topic. Basta and El-Saied (2009) studied the efficiency of bacterial nanocellulose as a flame retardant and evaluating its behavior in paper production. They found that adding bacterial nanocellulose leads to an improvement in the breaking length and burst index of the paper. The research of Gao et al. in 2011 showed that with the increase of bacterial nanocellulose dosage, the properties of the tensile index, tear index, burst index, and stiffness greatly improve, while the porosity and the relative water absorption decrease. These promising results were the reason that we studied this area in more detail.

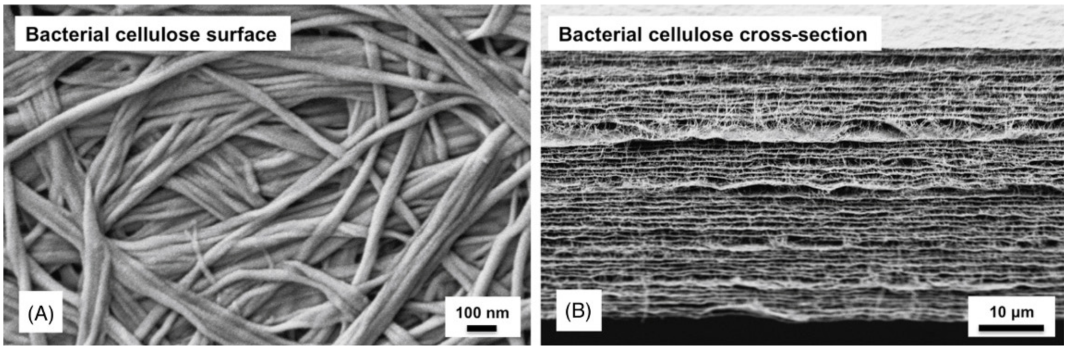

Figure 1. (A) Surface scanning electron micrograph of bacterial cellulose and (B) corresponding cross-section (Gama et al. 2016).

2 EXPERIMENTAL

In the first part of our study, bacterial nanocellulose was chemically and mechanically processed in order to be integrated into the paper. Initially, it was thermally treated in various media in order to remove impurities and extractives. Later mechanical treatment with a homogenizer and an ultrasonic probe was performed. All samples were prepared with the same procedure. Only the homogenization time was varied (sample BC 4; 4 min., BC 6; 6 min., BC 8; 8 min).

Laboratory paper sheets were produced on Rapid - Köthen apparatus, in accordance with ISO 5269-2:2004. For the laboratory paper sheets production commercially available bleached, eucalyptus fibers obtained by sulfate procedure were used. Fibers were refined in accordance with ISO 5264-2:2002 in laboratory PFI mill (1500 revolutions). Cationic starch as retention agent was added to the pulp in an amount of 0.5 % by weight of absolutely dry mass of basic fibers.

Paper sheets without bacterial nanocellulose were produced as a reference (sample V1). Other sheets contained 20% of bacterial nanocellulose by weight of dry matter of basic fibers (samples BC 4, BC 6 and BC 8). All paper samples were conditioned according to ISO 187:1990 before testing. All tests were carried out under 50% relative humidity at a temperature of 23 °C. In accordance with the standards we determined the following characteristics: grammage (ISO 536:2012), thickness (ISO 534:2011), density (ISO 534:2011), tear index (ISO 1974:2012), burst index (ISO 2758:2014), elongation at break (ISO 1924-2:2008) and tensile index (ISO 1924-2:2008).

3 RESULTS & DISCUSSION

As it can be seen from Table 1, which shows the basic properties of laboratory-produced paper, the reference sample V1, which had no added bacterial nanocellulose, reached the lowest values of grammage and density among samples. The values of sample thickness do not differ significantly all deviations are within the tolerance of the methods. With bacterial nanocellulose addition, grammage and density of samples were understandably increased. The highest increase was observed in the BC 4 sample, to which the least mechanically treated nanocellulose was added. Larger, less-treated particles were largely retained in the paper sheet and consequently increased these two parameters.

Table 1. Basic properties of laboratory-produced papers.

Sample	grammage [g/m^2]	thickness [mm]	density [kg/m^3]
V1	66.7	0.133	501
BC 4	79.0	0.128	616
BC 6	77.1	0.126	609
BC 8	77.8	0.134	579

From the Figure 2, it can be seen the addition of bacterial nanocellulose has a positive effect on the tensile index of the samples. The add-in has improved fiber links and increased this value in the case of the BC 6 sample by approximately 17%.

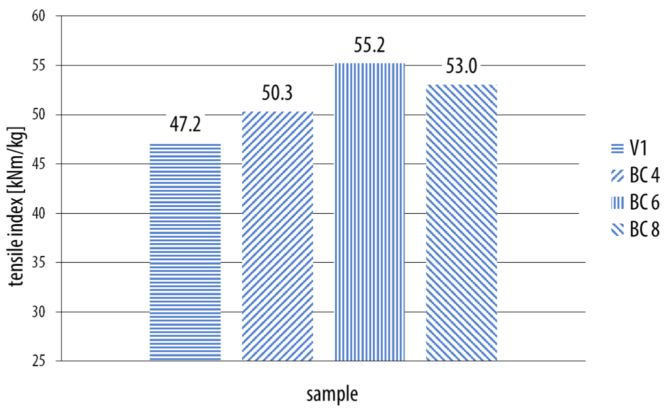

Figure 2. Tensile index of samples.

A similar trend can also be observed in the case of tear index of samples shown in Figure 3. Bacterial nanocellulose has improved fiber links and increased sheets density. This led to higher values of the tensile index, in the case of BC 8 sample for approximately 35%. It is clear from the picture that the mechanically more processed nanocellulose has improved the tear index to a greater extent.

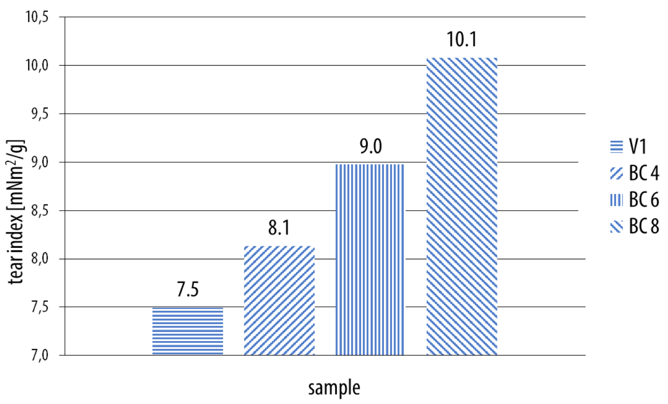

Figure 3. Tear index of samples.

The bacterial nanocelluloses addition did not have a drastic effect on the burst index of the samples. This is evident from Figure 4.

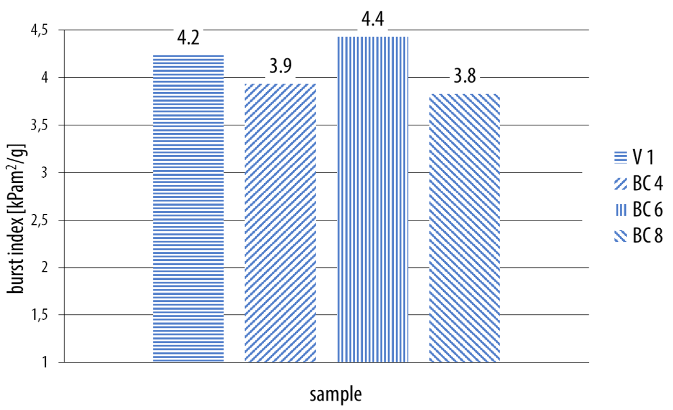

Figure 4. Burst index of samples.

Bacterial nanocellulose addition has slightly decreased only the values of elongation at break, as it can be seen from Figure 5. Due to stronger connections between short eucalyptus fibers, the stiffness of the paper most likely increased slightly. This is the reason for slightly lower values especially at samples BC 4 and BC 8.

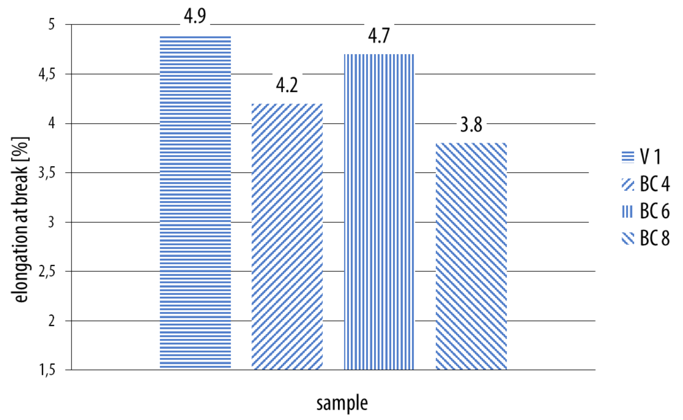

Figure 5. Elongation at break of samples.

4 CONCLUSIONS

Based on the results of the research it can be concluded that bacterial nanocellulose can improve characteristics of the paper, since it had a positive effect on practically all the measured mechanical properties, except elongation at break. It was found that the mechanical properties of the paper in which bacterial nanocellulose is added are enhanced with more intensive mechanical treatment. While retention of nanocellulose in the paper sheet is one of the key parameters, which effect on its function. For this reason, a relatively large amount of nanocellulose was added during this research. With the use of a more efficient and tailored retention agent, this percentage could be reduced, and it is expected that similar results would be achieved.

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THE POSSIBILITY OF USING ARDUINO BASED WATER LEVEL SENSOR FOR TISSUE PAPER ABSORPTION RATE AND CAPACITY MEASUREMENT

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ABSTRACT: The absorption rate and absorption capacity are one of the most important properties of the tissue paper. The interaction between the liquids and the tissue paper structure is determined by the surface angle and the rate of absorption which is defined by the porous structure of the paper. For some time there are several published studies, standards and methods like the ISO 12625-8:2010, ASTM D-4250, INDA Test Method IST 10.1. which are used by the industry besides pure experimental studies. In our research, we have assembled an Arduino based water level sensing device, which responses were calibrated with a specific amount of water. We have tested two 2 and one 3 ply tissue papers where we acquired the dynamics time and absorption weight and compared them with results obtained by the ISO 12625-8:2010 Part 8: Water-absorption time and water-absorption capacity, basket-immersion test method and the PDA – Penetration Dynamics Analyzer – ultrasound method.

Keywords: tissue paper, absorption, penetration dynamics analysis, Arduino.

1 INTRODUCTION

The absorption rate and absorption capacity are one of the most important properties of the tissue paper. As a speciality paper for wiping off liquids, it has to have high absorbance and bulk structure to pick up a large quantity of water or other liquid. The interaction between the liquids and the tissue paper (towel or wipes) are defined by the surface angle and the rate of absorption which is defined by the porous structure of the paper. In absence of external pressure, the absorption rate is mainly determined by the capillary pressure, liquid viscosity and density. The capillary pressure, in turn, depends on wettability, liquid surface tension and pore structure (Thorman et. al, 2012). An ideal tissue is a compromise between a large pore structure with high porosity to take in a large volume of liquid rapidly and a micro-fine pore structure that can lift liquids to a large height and retain it against opposing forces. The largest source of porosity in a tissue is from the volume between the tissue and a surface to be wiped, or between plies of a multi-ply tissue. An extensive study of the characterization of absorbent flow rate in towel and tissue was researched by (Beuther et. al, 2010). In their study, they used Sherwood ATS radial absorbency tester and X-ray unit to find absorption rates and direction. and their results indicate that the X-ray data confirms the validity of the radial test method, and demonstrates that by defining an experimental procedure, accurate and repeatable data can be measured by the more simple radial test method. Another testing method was proposed by a group of authors which used horizontal gravimetric method (Loebker and Sheenan, 2011). A Capacity and Rate Tester (radial orifice wicking instrument) was constructed where the sample is placed over a monofilament and centred over water supply tube. Water is applied and the sample weight is recorded in the function of time. The results obtained in this experiment had better repeatability that the rate and capacity measurement proposed by ATS and CGATS methods. The apparatus was able to detect differences in plyes, but the basis weight influence had to be improved. In a PhD thesis by Fabritius (2007) he developed develop an optical method for measuring liquid penetration into the paper in all three directions. Underlying the optical approach was the idea that the scattering properties of wetted and dry paper differ strongly, and optical measurement methods enable the detection of dynamical changes in scattering properties. Two different optical devices were used streak-camera and optical coherence tomography and the obtained measurements showed that the effect of three different coexistent subprocesses related to paper wetting can be detected. Only the effect of liquid migration along fibres could not be distinguished by the used methods. In his master thesis Hedberg (2015) developed a new method for measuring the dynamic absorption properties in the thickness direction of a single sheet of tissue paper which uses a camera to record the position of the front of a water flow passing on one side of the sample and when it is absorbed through the paper sample. The absorption rate is estimated by determining the time difference when the water passes the same position on both sides of the sample. Gabrielsson et al (2014) used yet another method to investigate the dynamic liquid absorption in kitchen towels. Their method has the basis in thermography where they have determined the absorption rate and the speed of absorption for different ply and embossed towel kitchens. Their results indicate that the embossing structures had clear effects, as well the sample compression. The spreading type of the conventional samples was oval shaped. For some time there are several published studies, standards and methods like the ISO 12625-8:2010, ASTM D-4250, INDA Test Method IST 10.1 which are used by the part of the industry. Some of the proposed methods were changed due to measurement uncertainty. As a new low-cost approach, we have tried using Arduino based water level sensing module to acquire paper penetration dynamics and absorption rate. The water level sensing can be done by several methods like the float sensor method or by using capacitance or conductivity sensors or probes. There are also other methods like ultrasound, optical method for the continuous measurement of liquid level. In our research, we have used a contact current amplification method as a low-cost alternative which can easily be assembled and used for quick water absorption determination.

2 EXPERIMENTAL

To test the different water (liquid) absorption measurement we have measured three different tissue paper towels which are commercially available. Two towels were made from 2 ply materials and out of pure cellulose, while the third sample was a 3 ply mixture tissue paper which contained 20% of recycled fibres. All of the samples had different embossing and creeping which was taken as an intrinsic value between different measurement methods and procedures. For the ultrasound method, we have used the Emtec PDA device which has a built-in module for tissue paper absorption evaluation. The method is based on the ultrasound signal intensity reading which is put through the water which is immersed in demineralized water.We have used a 2Mhz signal and the value T (impregnation time) was evaluated. Also, the dynamics of the impregnation for a 30s period of time was calculated to gain the dynamics curve. For the second method, we have used the ISO 12625-8:2010 Water absorption time and water absorption capacity basket-immersion test method. In this method, a 5,0±0,2 g test piece with a width of 76±1mm is put in a cylindrical basket with the weight of 3,0±0,1g made of stainless steel wired. The basket with the sample is submerged into water container and the absorption time is evaluated visually with a stopwatch (results in seconds), while the water absorption capacity Wa is calculated in grams of water per gram of each test piece (basically difference before and after of limited time water absorption). For the third method, we have used a water level sensor which was connected to Arduino Mega 2560 R3 board. This module uses current amplification by a transistor. When the liquid level is high enough to conduct the current between the base and the positive power supply, a certain amount of current is generated between the base and the emitter. And in a meanwhile, an electric current is produced in a certain amplification factor between the collector and the emitter and applied to the resistant in the emitter to produce a voltage. Then, this voltage will be collected by an AD converter. The operating voltage is 2.0-5.0V (we have used 5.0V) and the detectable depth is 40 mm. To get the amount of water absorbed we have calibrated the sensor response signal of Arduino with the amount of water which was added in precisely defined dosage. After calibration, we have immersed the tissue paper samples with 5 g for 30 seconds into the water tank in which the sensor was deposited and the readings were memorized. From the difference in start and stop signal values the amount in ml/grammes was calculated. From the individual readings, the absorption dynamics curve was constructed. For all tests, 10 samples were used and the mean value and standard deviation was calculated.

3 RESULTS & DISCUSSION

The immersion time value T for the sample measured with the ultrasound method are presented in Table 1. while the absorbtion curves are presented in Figure 1.

Table 1. T (immersion time) values for the samples.

Sample name	Ply	Material	T mean	T δ
Happy Casa	2	100% cellulose	0,213	0,078
W5	2	100% cellulose	0,212	0,068
Floralys	3	Cellulose +20% recycled fibres	0,179	0,073

As we can observe the T mean value is very similar for the 2 ply samples even if they have different creeping and embossing pattern, while the sample with 3 plys had the smallest T values.

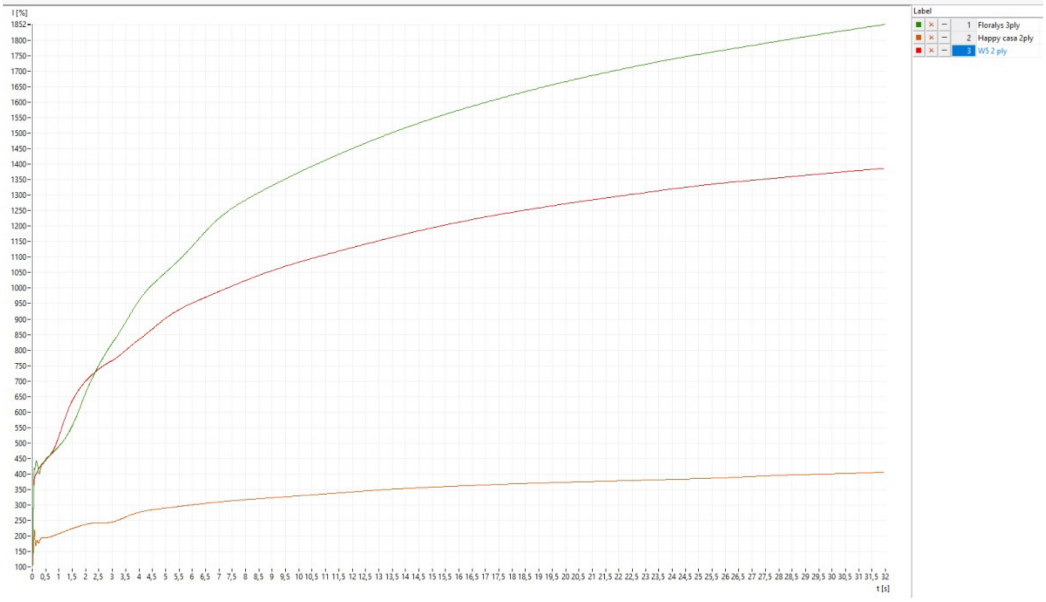

Figure 1. Dynamics of the paper towels absorption measured by ultrasound.

From Figure 1. we can observe that the Floralys 3 ply sample had intensity curve values during the time of absorption while the Happy casa 2 ply sample had the lowest intensity values and the sample W5 2ply has a similar absorption like the 3 ply sample for the first 2,5 seconds after which the 2 ply sample has lower intensity value from the 3 ply sample. This indicates that the Happy Casa sample absorbs very quickly the liquid in comparison with other samples.

For the ISO method, we have used the prescribed procedure and the water absorption capacity and absorption time is presented in Table 2.

Table 2. Water absorption capacity and absorption time determined by ISO 12625-8:2010.

Sample name	Ply	Material	Wa mean (g)	Wa δ (g)	At mean (s)	At δ (g)
Happy Casa	2	100% cellulose	10,37	0,32	10,64	3,67
W5	2	100% cellulose	6,04	0,39	19,80	2,21
Floralys	3	Cellulose +20% recycled fibres	8,014	0,4	21,37	3,29

From Table 2 we can see that there is a big difference in water absorption capacity and absorption time between samples. The quickest absorption time had the 2 ply Happy Casa sample (twice quicker from other samples) while it also had the largest water absorption capacity with a value of 10,37. As we can notice one operator measured the time, but still large variations occur as a visual and stopwatch method is prescribed by the ISO standard. No possibilities of the dynamics are possible as there is no way of collecting data without sensing device.

To come around this problem we have tried and approach of modifying the ISO method with water level sensing device. We have used the same grammage of paper to have reference value regarding the number of paper sheets which absorb the water and have used the same time of immersing (the 30s) but without the draining. We focused on as in real life application to the quantity of water which is taken off/from the surface as it is what really counts. The dynamics of the absorption were determined from the sensor reading till it visually was fully wetted and the amount of taken up water was calculated from the difference between the initial water level sensed by the module and the level after lifting out the soaked sample. The dynamics of the paper absorption is presented in Figure 2. while the calculated value of water uptake is presented in Table 3.

Table 3. Water absorption capacity and absorption time measured by water level sensor.

Sample name	Ply	Material	Mean Δ of sensing level	Calculated Wa mean (g/ml)	Wa δ (g/ml)	At mean (s)	At δ (g)
Happy Casa	2	100% cellulose	36	4,22±0.86	0,32	6.22	0.66
W5	2	100% cellulose	22.5	2,64±0,42	0,39	7.44	0.52
Floralys	3	Cellulose +20% recycled fibres	32	3.73±1.13	0,4	4.1	0.99

We can see that the mean time of full absorption (determined by hand feel) the Floralys 3 ply sample had the quickest time and W5 2 ply had the slowest time. We have made a comparison with the ISO test method values and as we can observe there is a very good correlation between the samples regarding absorption capacity as the W5 had the smallest amount of absorbed water in ISO method and the other samples also matched regarding ratios (higher/lower) with high R2 value of 0,93. With this, we can calculate with good accuracy the amount acquired by the ISO basket immersion technique even that there is a difference in our method as the samples are not dried off for 60 s, but just taken out of the water. For times comparison there are differences for the Floralys sample which could be most probably due to the immersion technique. For the ISO method, there was the free fall method in a horizontal position (length of the basket) while we pushed the tissue paper from the bottom side to certain water level in our glass and applied forced immersion. The dynamics of the absorption is presented in Figure 2.

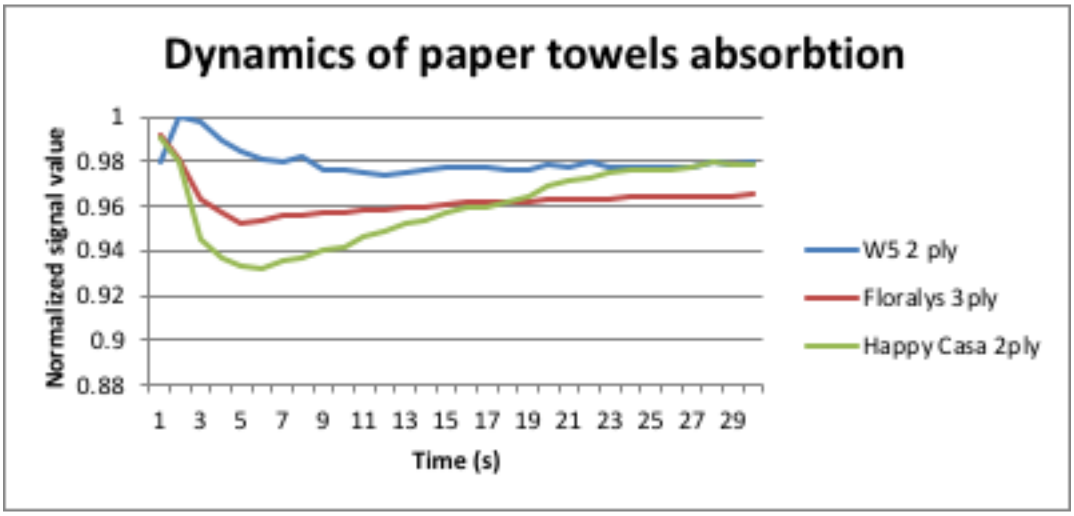

Figure 2. Dynamics of the paper towels absorption.

From Figure 2., we can see that the W5 2ply sample had a slight rise due to immersion and almost linear curve of absorption. The 2ply (Happy Casa) and 3 plies (Floralys) samples had a sharp drop after the first two seconds with lowest values around 5 seconds after which the dynamics of paper absorption was rising for both samples. The 2 ply Happy Casa sample had the sharpest drop from all the samples and in the 30th second had almost the same value as the W5 2 ply sample. There is a difference between the time of full wetting (3 ply casa had the quickest time) and lowest sensor value (2 ply Happy Casa) which is due to the amount of water taken and needed to reach full wetting of the sample.

4 CONCLUSION

From the presented results regarding water absorption dynamics and capacity measurement, the proposed method with the water level sensing using Arduino based platform is very useful and viable solution. There is a high correlation with the basket immersion method regarding quantity and additional information regarding dynamics is obtained which is not possible in the ISO method. The ultrasound method, on the other hand, does not give absorption capacity information. Regarding the low cost of the proposed system, we see it very useful for quick laboratory checks, as other proposed methods are either expensive regarding needed equipment, or are not very useful except in laboratory conditions.

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USE OF IMAGE SEGMENTATION FOR WOVEN FABRICS' POROSITY AND ALPHA MAP DETERMINATION

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ABSTRACT: *Correct visualisation of porous material in 3D computer renderings is important while it can reveal a material positioned underneath and thus significantly affects the rendered model's appearance. Besides complex models, accurate cloth appearance can be visualised with simple techniques including maps (normal, bump, alpha, specular). Textile porosity and pore parameters can be defined with image segmentation and measured with image analysis. The aim of the research was the definition of most suitable method of image acquisition and segmentation for creation of the alpha map for 3D visualisation of porous woven textile structure. In the results it is demonstrated that all tested factors (weave type, threads' density, illumination and threshold algorithm) influence open area and pore´s size of investigated woven fabrics, i.e. segmentation data in thresholded images and consequently textile visualisations. Statistical analysis also proved significant interactions between tested parameters (factors) and their influence on renderings.*

Keywords: transmitted illumination, reflective illumination, porosity, image analysis, alpha map, 3D visualisation.

1 INTRODUCTION

Realistic 3D visualisation of textiles plays important role in many industries, such as fashion, interior design, entertainment, etc. One of the visualisation methods is the record of cloth's appearance and its representation with various 2D maps. Alpha map pictures the porous structure of the model. In textiles, all spaces filled with air are considered as pores. Fabric porosity is in general defined as physical characteristic of fabrics which shows the portion of air in the total volume of fabrics (Zupin, 2012). According to mathematical definition and the theory of porosity, 2D and 3D models describing porous structures, can be applied. The simplest 2D model of representation for horizontal porosity is pure geometry of the projection of yarns diameter and yarn density and is calculated from the cover factor. The third dimension also called vertical porosity is defined with vertical pores, which are formed in places of longer, floating parts, i.e. non-interlaced segments of warp and weft yarns. The calculation of three-dimensional pores includes yarns diameters, distance between warp and weft yarns and length of floating yarns, fabrics thickness (Dubrovski, 2000).
Textile porosity can also be measured with image analysis, where with the implementation of appropriate algorithms on digitised images, the data about the area covered by pores and other pore parameters (i.e. perimeter, shape) can be calculated. These procedures are relatively demanding due to the fabric deformability. Nevertheless, with the use of corresponding equipment and image acquisition procedures (illumination with reflection and transmission), and with the development of a suitable thresholding algorithm, the methods can be automated, and satisfactory results can be obtained (Kang, 2001; Cardamone, 2002; Tàpias, 2010; Aydilek, 2002).

1.1 Modelling the appearance of textiles

Properties that are important for textiles' visual appearance and that are included in appearance-modelling are: optical properties (reflection, scattering, transmission and absorption); porosity; colour (optical properties of fibres and yarns and constructional parameters); texture and relief (type of weave, fibre and yarn construction parameters, finishing); and specific properties (anisotropy, yarns and fibres with special effects and higher translucency). The different types of properties are correlating and do not influence the final appearance in isolation. The review of literature shows that there are many different approaches that can be used for modelling the appearance of textiles. The most complex are
mathematical appearance models that were extensively studied and reviewed by Schröder et al. (Schröder, 2012). These physically-based appearance models are divided into three main types of approaches: surface-based, volumetric and explicit models. The cues that were defined and analysed in the study were translucency, silhouette, light diffusion, the possibility of real-time rendering, scalability, integration scale and viewing distance. On the other hand, in game, web, augmented (AR) and virtual (VR) reality solutions of textiles' and

cloths' performance, less expensive techniques are usually applicable, i.e. maps. These techniques are firmly established in 3D animation workflow and in the production of static visualisations that include many objects on the scene, which can be viewed by close, medium and far distance (Kočevar, 2017).
The aim of the research was to define the influence of defined parameters (weave type, threads' density, illumination during acquisition and threshold algorithm) on alpha map preparation and the definition of most suitable method of image acquisition and segmentation for creation of the alpha map for 3D visualisation of porous woven textile structure. Methods of transmitted and reflected light microscopy were used and compared for image acquisition and three different algorithms for image thresholding were applied. The results were analysed with multifactor statistical methods.

2 EXPERIMENTAL

For the research purpose, 8 different woven fabric samples were produced. Cotton warp and weft yarns were of the same linear density for all fabrics 17 × 2 tex. Four different densities of warp and weft were chosen, warp densities 22 and 29.3 ends/cm, and weft densities 15 and 20 picks/cm, which resulted in four different groups of woven fabrics with densities 22/15 (samples d1), 22/20 (samples d2), 29.3/15 (samples d3) and 29.3/20 (samples d4) threads/cm. Two different weave types were chosen, plain weave (PL) and twill 1/3 (T). All samples were woven with two threads in reed dent.
Fabrics' images were acquired with optical microscope (Nikon SMZ800 with the limits of magnification of 1–8x and ratio of magnification 8 : 1) and photo camera (Nikon D600, with settings 1/25 and ISO whiteness value 200). Images were acquired with software digiCamControl. Two different illumination techniques were implemented, i.e. under and above the sample, consequently image data were captured with transmitted and reflected illumination. Number of image samples for each technique and for each density of chosen weave type was 10. Workflow of image segmentation and analysis was performed in ImageJ, where image processing included scale setting, histogram equilibration and thresholding. Three different threshold algorithms were used for image segmentation, i.e. Minimum, Otsu and Yen. These three algorithms were selected due to their optimal performance in preliminary testing among all the proposed algorithms of the ImageJ software. With image analysis pore size and the area covered with pores were calculated. Open area of used samples was analysed. The experimental results were statistically processed by multifactor ANOVA at 0.05 significance level. For the statistical analysis of image analysis of woven fabrics five independent variables – factors – were chosen as displayed in Table 1. Each factor has two or three levels.

Table 1. Experimental design diagram.

Influencing parameter	Factor	Level
Weave	W	Plain weave (PL)
		Twill weave (T)
Warp density	D1	22
		29
Weft density	D2	15
		20
Illumination	L	Transmitted (T)
		Reflected (R)
Threshold algorithms	Alg	Minimum (MIN)
		Otsu (OTSU)
		Yen (YEN)

3 RESULTS & DISCUSION

In Table 2 the results of statistical analysis by multifactor ANOVA are presented for open area and average pore's size.

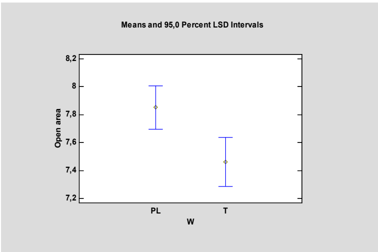
Table 2. Impact of factors on open area and on pore size of woven fabrics.

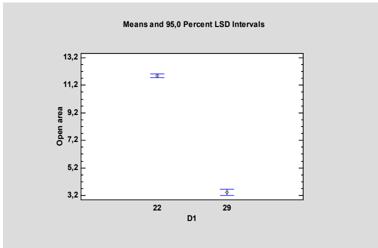
Open area						Pore´s size			
Source	SS	Df	MS	F-Ratio	P-Value	SS	MS	F-Ratio	P-Value
MAIN EFFECTS									
A:W	10,77	1	10,77	6,44	0,012	4,6E-05	4,6E-05	54,25	0,000
B:D1	3553,02	1	3553,02	2126,4	0,000	1,0E-03	1,0E-03	1220,06	0,000
C:D2	1081,57	1	1081,57	647,29	0,000	4,1E-04	4,1E-04	477,05	0,000
D:L	1065,50	1	1065,50	637,67	0,000	2,1E-05	2,1E-05	24,64	0,000
E:Alg	698,52	2	349,26	209,03	0,000	2,1E-04	1,0E-04	122,48	0,000
INTERACTIONS									
AB	19,22	1	19,22	11,5	0,001	1,4E-05	1,4E-05	16,55	0,000
AC	2,45	1	2,45	1,47	0,227	2,8E-08	2,8E-08	0,03	0,857
AD	0,01	1	0,01	0,01	0,926	9,1E-08	9,1E-08	0,11	0,744
AE	12,02	2	6,01	3,6	0,029	1,5E-05	7,5E-06	8,85	0,000
BC	96,76	1	96,76	57,91	0,000	6,8E-06	6,8E-06	8	0,005
BD	310,77	1	310,77	185,99	0,000	5,8E-05	5,8E-05	68,67	0,000
BE	195,67	2	97,84	58,55	0,000	2,9E-05	1,5E-05	17,07	0,000
CD	12,58	1	12,58	7,53	0,006	4,1E-10	4,1E-10	0	0,983
CE	47,71	2	23,85	14,28	0,000	1,3E-05	6,5E-06	7,66	0,001
DE	143,74	2	71,87	43,01	0,000	4,3E-05	2,2E-05	25,31	0,000
ABC	10,99	1	10,99	6,57	0,011	1,2E-05	1,2E-05	13,89	0,000
ABD	0,45	1	0,45	0,27	0,606	6,7E-08	6,7E-08	0,08	0,780
ABE	0,58	2	0,29	0,17	0,840	2,4E-06	1,2E-06	1,39	0,250
ACD	0,08	1	0,08	0,05	0,825	4,2E-06	4,2E-06	4,88	0,028
ACE	27,42	2	13,71	8,2	0,000	9,0E-06	4,5E-06	5,29	0,006
ADE	7,30	2	3,65	2,18	0,114	1,0E-05	5,1E-06	5,99	0,003
BCD	29,44	1	29,44	17,62	0,000	1,7E-05	1,7E-05	19,59	0,000
BCE	2,72	2	1,36	0,82	0,443	5,2E-06	2,6E-06	3,04	0,049
BDE	42,17	2	21,09	12,62	0,000	3,7E-05	1,8E-05	21,7	0,000
CDE	47,22	2	23,61	14,13	0,000	2,9E-05	1,5E-05	17,21	0,000
RESIDUAL	548,06	328	1,67			2,8E-04	8,5E-07		
TOTAL	13797,50	364				3,3E-03			

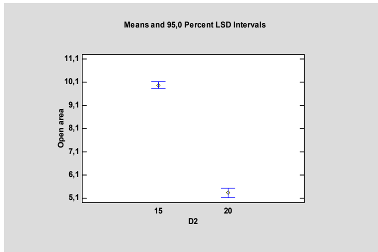
In Table 2 statistical analysis multifactor ANOVA shows that all five tested parameters (weave (W), warp (D1) and weft density (D2), illumination (L) and thresholding algorithm (Alg)) are significant factors and that they actually influence open area of woven fabrics. The factors by statistically importance are warp density (D1), weft density (D2) and illumination (L), algorithm (Alg) and at least important weave (W). Factors weft density (D2) and illumination during image acquisition are a little more than 3-times less important factors than warp density (D1), while thresholding algorithms are 10-times less important than the most important factor D1 and factor weave is 330 times less important than warp density.
Besides, statistical analysis demonstrates that many interactions between and among factors influence open area of analysed samples. The most evident is the statistical significance between results of warp threads density (D1) and illumination (L), between warp and weft density (D1 and D2) and between thread's density

(warp and weft) and threshold algorithms (Min, Otsu and Yen). Namely, the statistical results show that all three algorithms impact the open area and there are statistically significant differences between them. Pore's size is also influenced by all five factors that were analysed in the experimental. The most prominent factor is warp density (D1) followed by weft density (D2), then all three thresholding algorithms (Alg) and the type of illumination during image acquisition (L). The weakest influence on the pore's size is manifested by the two weaves (W), i.e. plain weave and twill, the same as with open area. The analysis of the interactions between and among the factors show that many of them are statistically relevant, however their significance is much lower than the significance of the main influential factors.

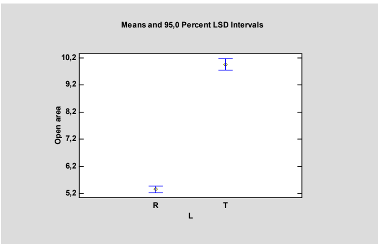
In Figure 1 the statistical significance of differences between levels of the factors and their influences is presented for open area: a.) weave (W); b) warp density (D1); c.) weft density (D2); d.) illumination (L) during acquisition and e.) threshold algorithm (Alg).

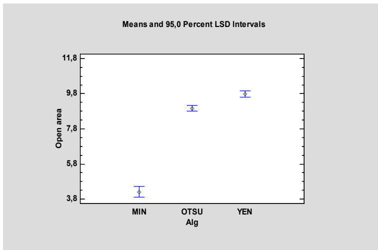






a) b) c)

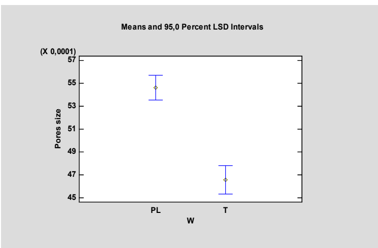


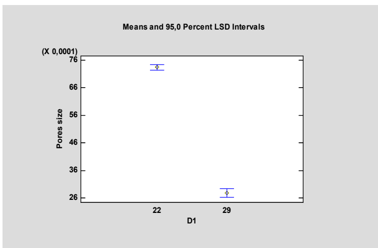


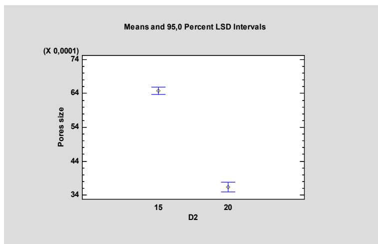
d) e)

Figure 1. Five influencing factors on Open area of woven fabrics.

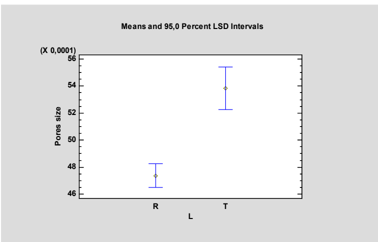
In Figure 2 the statistical significance of differences between levels of the factors and their influences is presented for average pore's size: a.) weave (W); b) warp density (D1); c.) weft density (D2); d.) illumination (L) during acquisition and e.) threshold algorithm (Alg).

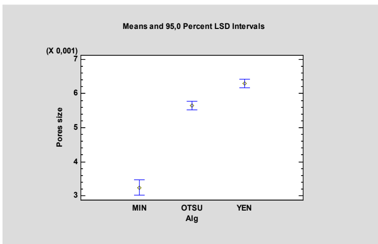






a) b) c)



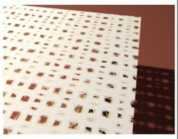
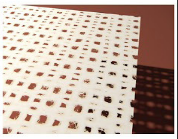
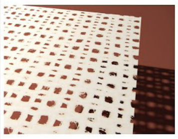
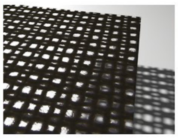
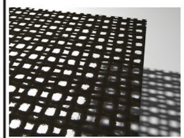
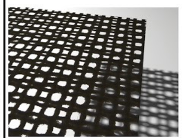
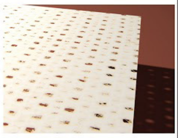
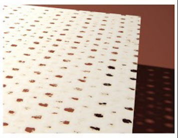
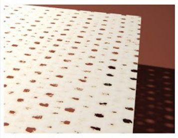
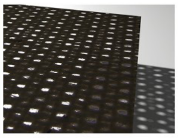
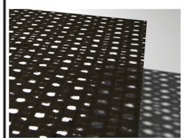
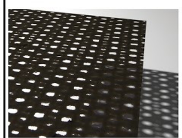
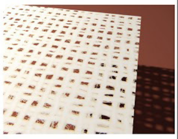
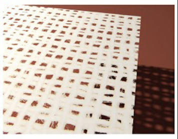
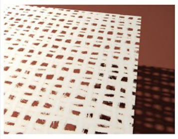
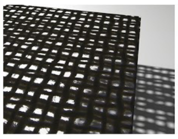
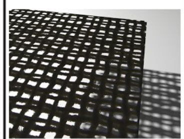
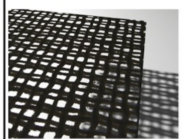
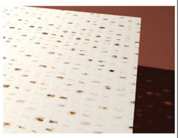
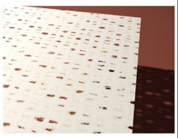
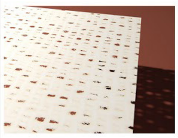
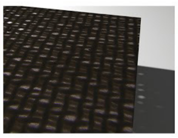
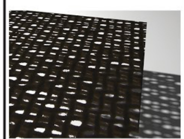
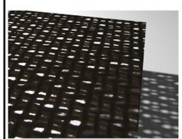


d) e)

Figure 2. Five influencing factors on average pore´s size of woven fabrics.

Analysing 3D visualisations of woven samples using alpha maps generated with image segmentation process, the influence of all five factors (illumination, weave, warp and weft density and use of various algorithms for their creation) is identifiable. The visualisations are shown in Table 3. The influence of illumination can be recognised through revelation of details. Small details, such as interlaced fibres in the void spaces of pores are more emphasized on thresholded images, consequently on visualisations, recorded using reflected illumination. Differences between plain weave and twill are shown through distribution of pores on the visualised surface. The "grid" of plain weave pores and the shape of pores on the plain weave fabric are more even than in the case of twill samples, due to longer floating threads and different types of pores present on the surface of twill. The influence of varied densities of warp and weft threads is also very noticeable; pores' sizes are always larger when density is smaller, regardless weave, illumination and algorithm used were captured for thresholding images. Considering the influence of algorithms used for alpha maps preparation, the variances between sizes of pores and their shape are perceptible and the level of visible details as well. Pores are the smallest when algorithm Min is used, and the largest when algorithm Yen is used.

Table 3. 3D visualisations of plain weave and twill 1/3 samples with various warp and weft densities (d1, d3), where reflected and transmitted light illuminations for image acquisition were used and three different threshold algorithms were applied for creation of the alpha maps.

Illumination		Reflected			Transmitted		
Algorithm		MIN	OTSU	YEN	MIN	OTSU	YEN
Plain weave	d 1						
	d3						
Twill 1/3	d1						
	d3						

4 CONCLUSION

In the presented research we confirmed the influence of the weave and the density of warp and weft threads on porosity of the fabric respectively on pore's size and on open area. We also established the importance of illumination technique for the optical image acquisition and the use of chosen algorithm for image segmentation for alpha maps preparation. Firstly, statistical analysis showed that all five investigated factors influence open area and pore´s size of studied woven fabrics, i.e. segmentation data in thresholded images (open area and pore's size). Secondly, it was proven there are statistically significant interactions between factors. The findings were correspondingly evaluated on 3D visualisations that confirmed evident differences in the computer generated formations of textile structure. Further, the conclusions can also be summarised with the next findings:

- The most important factor when analysing open area and pore´s size is warp density (D1).
- The weakest influence on open area and pore´s size has weave.
- All three threshold algorithms impact the open area and pore's size and there is statistically significant difference between all three algorithms (Min, Yen and Otsu).

- Between the two different illumination techniques used for image acquisition (transmitted and reflected light microscopy) there is also statistically significant difference when analysing open area and pore´s size of woven fabrics.
- Particularly at images visualised using alpha maps generated with images recorded with reflected illumination method and thresholded with algorithm Min, the level of details revealed is significantly higher than at algorithms Otsu and Yen.

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USER EXPERIENCE OF WAIT-ANIMATION PROGRESS INDICATORS

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ABSTRACT: *The research aim is to determine design parameters of animated progress indicators and present a user study on how they are perceived in the context of mobile application. Users' experiences of loader animation are generally more satisfactory when more real feedback is given. Informing users of the current working state makes the process more tolerable to the user by reducing uncertainty. User's perceived duration of time passing can be manipulated by altering a speed and acceleration of the progress animation, altering display of accuracy of status, altering perception with the application / brand design, using humour to alleviate anxiety, using text to explain the process, etc.. . This paper research questions are: (1) Does providing feedback during the wait prolong users' tolerable waiting time in the context of shopping app? (2) How is user's perception of time correlated to the design and speed of the progress indicator?*

Keywords: Progress bar, Animation, User Experience, Waiting Time.

1 INTRODUCTION

Animated progress indicators functions are: to reassure the user that the system is working and reduce the user's uncertainty, give the user something to look at while waiting, offer a reason to wait for the system to finish and reducing users' perception of time (Head, 2016). A user's willingness to wait for a system to complete an action depends on several factors, including: the urgency and complexity of the goal or task in mind; the context of use, be it spending time in line on a mobile phone, or hurrying to get an important project uploaded and users' expectations based on prior experience with the app or similar processes (Scherwin, 2014).

Users' experiences of loader animation are generally more satisfactory when more real feedback is given. Informing users of the current working state makes the process more tolerable to the user by reducing uncertainty. Informative loader can convey one or more messages that make waiting period much more pleasant, especially when it fosters the sense of anticipation. If loader's animation and design are customized and intended to metaphorically provoke a meaning, those meanings usually indicate future actions, product's function or brand identification. Viget's experiment confirmed that branded loading experiences hold participants' on the loading page for longer, and have lower abandon rates than the non-branded, generic experiences (Tate, 2015).

User's experience of the wait animation is also influenced by the mobile app micro-animation design, namely the animation of the transition between previous and the next screen. The previous research results show that in the transition between two images, bringing up the next image earlier dominates the perception of a fast transition over other variables examined in the study (Huhtala at al, 2010). New content should be brought up rather earlier than later despite of the effects of transition or overall duration.

User's perceived duration of time passing can be manipulated by altering a speed and acceleration of the progress animation, altering display of accuracy of status, altering perception with the application / brand design, using humour to alleviate anxiety, using text to explain the process, etc. By making a loading screen less generic and more novel, designer might be able to make time seem to pass more quickly or even make the wait more pleasant. This paper research questions are: (1) Does providing feedback during the wait prolong users' tolerable waiting time in the context of shopping app? (2) How is user's perception of time correlated to the design and speed of the progress indicator?

2 EXPERIMENTAL

The research was done at Faculty of Graphic Arts University of Zagreb as part of master's theses (Stanić, 2017). On-line survey of 37 smartphone users, out of whom 63,2% women and 37,8% male, was used as user research and user testing tool. 8,1% of participants fit into the category of age less than 20; 56,8% of participants fit into the category of age 21 to 25 and 35,1% fit into the category of age 26 to 30.

Animated design of determinate and indeterminate loaders with different style and speed were created and uploaded in video formats. The aim was to create animations that were comparable to the common generic animation which populate the applications, like the spinning pinwheel or loading bar. Based on the previous research, the animation's duration was set to five seconds (Nah, 2004). The research was divided in four sections. Collected feedback was analysed to prove research hypotheses.

Section one of the experimental was set to determine whether the speed of loading animation has an influence on perceived wait time. Participants were presented with five loading animations of the same design and duration (five seconds) but different speed. They were not aware that the animation's duration was the same and they had to rank animations according to the perceived time of duration.

In section two of the experimental, participants were presented with five animations of the same duration (five seconds) but different speed and different design (Figure 1). The task remained the same: they had to rank animations according to the perceived time of duration (Table 1.). Participants were also asked to rank animations according to the aesthetic appeal and visual interest. Animation D was ranked as the most appealing and visually interesting.

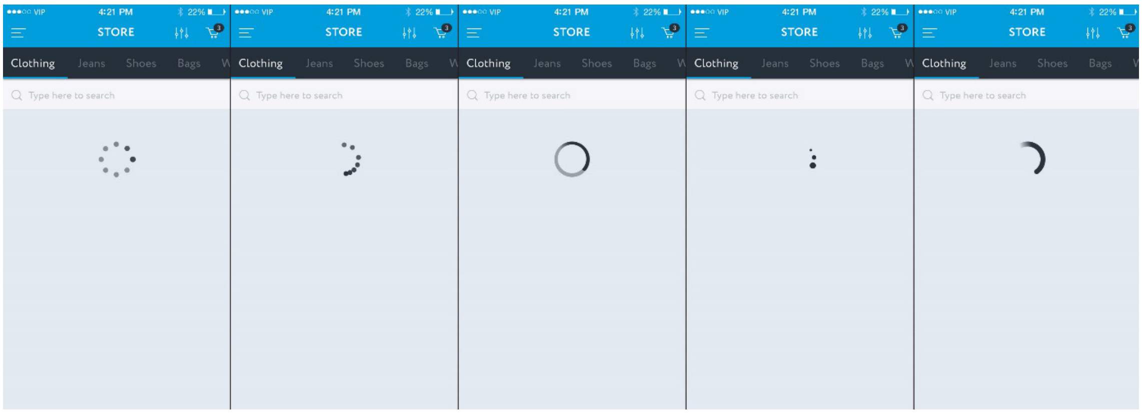

Figure 1. Loader animation stimuli from the section 2 of the research.
From left to right: Animation A, Animation B, Animation C, Animation D, Animation E.

Table 1. Section 2 research question: Rank the animations according to the perceived duration.

speed		longest duration 1	2	3	4	shortest duration 5
⇧	Animation A	24,3%	13,5%	21,6%	27,0%	13,5%
	Animation B	5,4%	21,6%	43,2%	10,8%	18,9%
	Animation C	21,6%	18,9%	27,0%	16,2%	16,2%
	Animation D	8,1%	18,9%	24,3%	32,4%	16,2%
	Animation E	27,0%	37,8%	13,5%	8,1%	13,5%

Section three of the experimental was designed to determine whether the perceived duration of animation is different for determinate loading animation than for indeterminate (Figure 2). Participants were presented with three groups of animations. The loaders in three groups differ in design. Each group consisted of one determinate and one indeterminate loading animation. Indeterminate animations were designed to have higher speed. Participants were asked to judge which loader animation takes longer time to finish. Overall, the indeterminate loaders were perceived to take longer time to finish, compared to determinate.

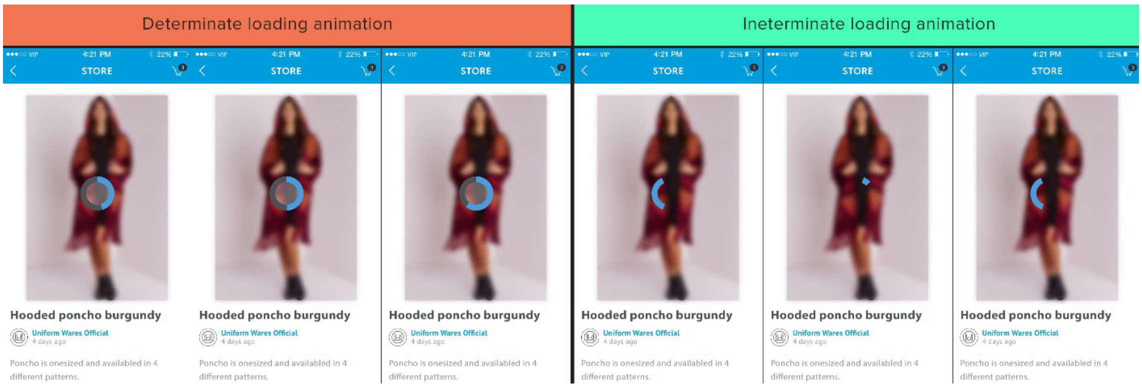

Figure 2. Loader animation stimuli from the section 3 of the research: Group 1, time lapse of determinate loading animation (left) and indeterminate loading animation (right) stimuli.

Table 2. Section 3 research question: Which loader animation takes longer time to finish?

Speed			
	Determinate	Indeterminate	The same
Group 1	6,3%	43,2%	40,5%
Group 2	19%	43,2%	37,8%
Group 3	24,6%	29,7%	45,9%

In section four of the experimental participants were presented with three groups of animated videos designed as prototypes of shopping applications.
Videos had the same length (5 seconds). Each group consisted of two examples of user interface for the same (shopping) application. One of the examples, shown in all three groups, was a loading spinner commonly used for this kind of application. The second example was designed as more interesting, fluid and novel solution. The speed of more interesting design was slower Participants were asked to choose a loader design which is more visually interesting and appealing (Table 3). Also, they had to judge which loading time lasted longer (Table 4) and which design is more suitable for the application.

Table 3. Section 4 research question: Which loader animation is more appealing and visually interesting?

	Group1		Group2		Group 3	
	Common design	Interesting design	Common design	Interesting design	Common design	Interesting design
Appeal	18,2%	81,8%	29,7%	70,3%	27,0%	73,0%
Visual interest	5,4%	94,6%	24,3%	75,7%	16,2%	83,8%
More suitable for this app	51,4%	48,6%	48,6%	51,4%	48,6%	51,4%

Table 4. Section 4 research question: Which loader animation takes longer time to finish?

Speed			
	Common design	Interesting design	The same
Group 1	29,7%	45,9%	24,3%
Group 2	29,7%	43,2%	27,0%
Group 3	35,1%	27,0%	37,8%

3 RESULTS & DISCUSSION

The results of the section one of the experimental have proven that the speed of loading animation has an influence on perceived wait time. Despite some individual variation, the quickest animation was ranked as the one with shortest duration and the slowest animation was ranked as the longest.

In the second part of experimental, where participants were asked to rank different animations according to the perceived duration, animation D achieved the best results. Animation D was also judged as the most visually interesting and appealing. The findings bring to the conclusion that human perception of time is influenced not only by speed but also by the design of animated loader.

The third's section results have proved that the indeterminate loaders were perceived to take longer time to finish, compared to determinate. Even though the speed of indeterminate loaders was faster than the speed of determinate, the participants have declared that the animation's duration of determinate loaders were shorter. On the bases of results we can conclude that participants would be more willing to wait if presented with determinate loaders than with indeterminate.

The fourth section results have showed that loader's animation design is not the main contributing factor in terms of participant's perception of duration. Faster animations were perceived to have shorter duration even if designed as less visually interesting and appealing. When questiond which design is more suitable for this kind of applicatons, the participant's answers were divided in half.

4 CONCLUSIONS

Visual feedback in the format of loading indicator helps users understand that system is working on their request. Mobile applications utilize visually interesting animations when loading it's content to prevent users from geting boared or uncertant. Loading animations keep the user occupied with visual feedback and as a result, users perceive a shorter wait time.This research's results are in line with previous research findings about human perception of time (Harrison, 2010). The study made on Carnegie Mellon University proposed and evaluated variations on two visual designs for progress bars that alter users' perception of time passing, and "appear" faster when in fact they are not. As a baseline, it used standard, solid-color progress bars, prevalent in many user interfaces. In a series of direct comparison tests, the study ranked how these augmentations compare to one another. On the bases of results, the conclusion was made that progress bars with animated ribbing that move backwards in a decelerating manner proved to have the strongest effect.

The study has proven that animations can be a good tool for making users perceive things as faster than they really are. Faster animation of generic spinners create a sense of shorter waiting time. Users prefer determinate progress indicators over indeterminate, even if the later are moving faster. Contrary to the expectation, animation's speed is perceived as more important factor for a positive user experience than visually interesting and appealing animation design.

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Poster section

AVAILABILITY OF E-TEXTBOOKS ON THE SLOVENIAN MARKET

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ABSTRACT: *The introduction of ICT in the educational process means not only the introduction of new tools, but also changes to the roles of the learner and teacher, the use of new teaching methods (e.g. flipped learning), and consequently the new role of the textbook. The objectives of our research was to analyse the Slovenian e-learning materials market, in particular e-textbooks. According to the results 39 i-textbooks have been developed and approved for use in primary and secondary schools. Several publishers develop e-learning materials that come in different forms such as digitalised printed versions of textbooks or workbooks having multimedia and interactive elements. E-learning materials are also offered on different platforms. Some materials are active, while others are not. As we noticed through the research and as was communicated to us through interviews, there are the problems associated with the continued use of e-textbooks, however those problems are more pedagogical than technical.*

Keywords: e-learning material, e-textbook, Slovenian market, publisher.

1 INTRODUCTION

The textbook represents the basic teaching material for the achievement of the educational goals and standards of knowledge defined in a specific curriculum. A textbook may take printed, electronic or printed and electronic form. [1] The main difference between traditional and e-textbooks lies in the digitalisation of the entire learning environment. In addition to traditional elements (text and graphical presentations), the latter also include interactive elements (didactic applications, games, animations, etc.) and multimedia elements (simulations, videos, sounds, etc.). As a rule, e-textbooks are accessible on the web regardless of time and place, while that accessibility is dependent on the user's internet connection. An e-textbook is a digital teaching source or an asset stored on electronic media that can be used to replace printed media. Technical tools are, however, required for the use of an e-textbook [2].

Pesek, Zmazek and Mohorčič [3] categorise e-textbooks to three levels. The first level comprises so-called digitalised textbooks or d-textbooks, which are electronic copies of printed textbooks in PDF or EPUB2 format. D-textbooks can be read/displayed by applications that facilitate the addition of bookmarks, records and work with interactive tables. The second level includes so-called rich textbooks or r-textbooks, which are d-textbooks upgraded with sounds and videos. Because some r-textbooks also have simple integrated questions that provide simultaneous feedback to learners, they are quite popular among publishers. Interactive or i-textbooks comprise the third level of e-textbooks. The content of such textbooks is adapted to human-computer interaction. I-textbooks include interactive elements (e.g. video, soundtracks, computer animations, hyperlinks and, in the future, most likely augmented reality, which will be popular in presentations of practical samples) and interactive examinations (instant and significantly improved feedback). They also facilitate the storage of responses, the analysis of effectiveness and the monitoring of users.

The introduction of electronic learning materials (hereinafter: e-learning materials) in Slovenian primary and secondary schools has proceeded under the auspices of governmental organisations. The Guidelines for the evaluation of e-learning materials, which were linked with the Trubar catalogue for learning materials, were prepared in 1995. The first tenders for smaller projects addressing the preparation of online e-learning materials were released after 1997. E-learning materials were prepared by certain individual teachers or groups of teachers in the scope of the aforementioned projects [4].

In 2006, an action plan for continuing scholastic informatisation [5] was presented. The plan stated that the role of learners is changing from passive to active, and that all ICT tools can be used. The role of teachers is changing from that of knowledge "provider" to tutor and education coordinator, as well as moderator for the evaluation of information. The existing services of the school system are changing, while new services are being developed. The system is thus taking on a greater role in terms of the assessment and application of development results, and in terms of connecting the system with the outside world (e.g. the economy). According to the aforementioned plan, it was necessary to expand the offer of e-learning materials, and to raise the level of those materials to modern, qualitative and (publicly) accessible e-materials that exploit the opportunities presented by the media (e.g. interactivity and multimedia). From 2006 to 2008, the first calls were made for projects addressing the preparation of extensive online e-learning materials. Those materials were drawn up in accordance with relevant curricula. They included interactive and multimedia elements and were freely accessible. [6]

Slovenia's Development strategy for the information society [7] stated that the main subject of the informatisation of the learning and teaching process is the learner, while the teacher is a critical factor for success. The teacher must accept advanced ICT, which will not replace or eliminate traditional learning, but will offer an additional opportunity to change the learning and teaching process, making it more effective and attractive, user-friendly and can be used anywhere at any time, and facilitates examinations, team work (web classrooms), research work and remote learning.

In the period 2009 to 2013, the first extensive project was implemented under the name E-education. [8], [9] Two smaller sub-projects were implemented in the scope of the aforementioned project: E-competent teacher and E-support. After the project was completed, teachers and schools tested and evaluated e-learning materials and e-services via two additional projects: E-textbooks for science classes in primary school, the objectives of which were to upgrade existing e-materials to modern, freely accessible e-textbooks, to evaluate their usefulness in the teaching and learning process and to identify requirements for their proper use (ICT infrastructure, specific training for teachers, etc.) [10]. A new project under the name E-Schoolbag [11] was kicked off after the successful implementation of the E-textbooks for science classes in primary school project. The main objective of the E-Schoolbag project was to develop i-textbooks for the field of social sciences for the eighth and ninth grades of primary school, and for the first year of secondary school (gymnasium). Another objective was to ensure accessibility to and support for newly developed e-services and e-content. The project was based on the three pillars of the 21st century school: the establishment of an e-learning environment, the development of appropriate e-content and the training of e-competent teachers. In order to test e-content and e-services, the participating teachers and learners were equipped with tablets, while all participating schools were equipped with a wireless network. The E-Schoolbag project was completed in November 2015. In January 2016 [10]. In 2014, 44 schools were chosen to participate in a pilot project under the name Testing e-learning contents and e-services. Learners were equipped with tablets or computers provided by their schools. During testing, the main emphases were on planning lessons, focusing on the added value of achieving objectives through the use of ICT, and on evaluating learners' achievements.

Projects relating to the e-learning environment in primary and secondary schools have been mostly completed. However, the search continues for efficient and lasting systemic solutions for the editing and maintenance of existing e-materials and e-services, while technical support will also be required as new ideas emerge and are implemented [12]. Consequently, new projects have already been launched this year. As was concluded in a study by Hopson, Simms and Knezek [13], the positive effects of using technologies in teaching lead to learners' desire to continue using those technologies, ever after a project is completed.

In terms of higher education in Slovenia, the faculty members of universities have implemented several individual and integrated projects that mainly involved the installation of the ICT infrastructure. Some members have participated in various (particularly European) projects in which they secured funding for the establishment of key elements of e-learning. Some members were also involved in the aforementioned projects as advisers and to develop specific activities. According to the Development strategy for the information society until 2020 [14], support should be given to projects aimed at the modernisation of higher educational didactics, through the requisite use of ICT and the transition to digital education. Innovative and flexible forms of teaching should also be established. Consequently, a call was issued in the year 2017 for the inclusion of ICT into the higher education pedagogical process for a period of four years.

2 EXPERIMENTAL

Our research was focused on the Slovenian e-learning materials market, in particular e-textbooks. For that purpose, we searched the internet sources/pages of different publishers, ministries, organisations, etc., and contacted some in search of reliable answers. During our research, we analysed 10 different publishers, e-textbooks issued by the National Education Institute Slovenia and different e-platforms containing e-learning materials. In this research, some publishers were also contacted to get exact answers about their e-materials.

After we analysed e-material from mentioned sources, new questions arose about the real use of e-textbooks, evidence and a vision for the future. Answers were obtained through interviews with people responsible for Slovenian e-content projects.

3 RESULTS & DISCUSSION

According to the Rules on the approval of textbooks [1], textbooks may take printed, electronic or printed and electronic form. According to the aforementioned rules, e-textbooks are divided into two levels: d-textbooks that are digitalised editions of printed textbooks and include only text and figures; and i-textbooks that include interactive elements, constructions and interactive tasks with multiple feedback to the text, and the storing of results and monitoring of users. If a textbook corresponds to the curriculum for which it is intended, the Council of Experts for General Education approves it in accordance with the procedure described in the rules.

Among the numerous textbooks approved for primary and secondary school, 27 i-textbooks [15] have been approved for primary school and 12 for secondary school (Fig. 1). All i-textbooks were issued by the National Education Institute Slovenia in the E-Schoolbag and E-textbooks emphasising natural sciences in primary school projects in 2014 and 2015. Many authors, illustrators, animators, reviewers and other experts from different fields were included in the development of i-textbooks, together with Slovenian companies that offered support during the development process. I-textbooks are freely accessible, and may be used in schools and at home, free of charge. They can be used on computers and tablets that run Windows, Android and iOS operating systems, and can be used online or downloaded using different clients and used offline on mobile devices. I-textbooks that have already received official approval cover the following subjects: the Slovene, English and German languages, mathematics, chemistry, natural sciences and techniques, physics, geography, music and fine arts. An i-textbook for sport is currently in the approval process [16].

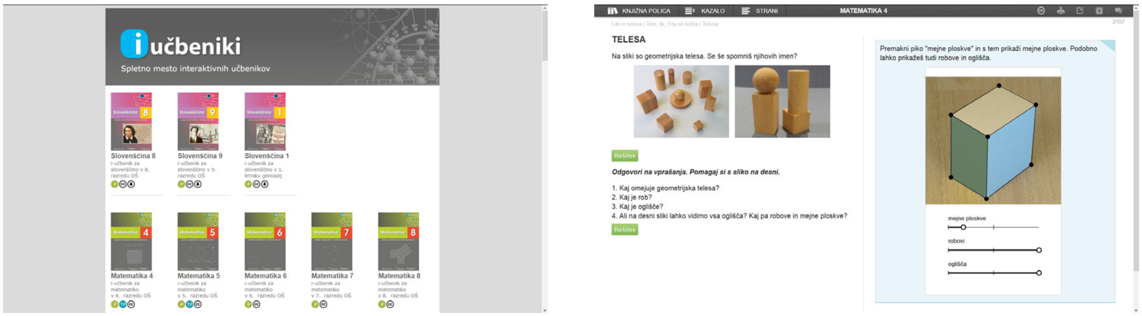

Figure 1. Web portal iUčbeniki (www.eucbeniki.sio.si).

In addition to approved i-textbooks, a list of other e-learning materials developed through tenders issued by the Ministry of Education, Science and Sport are collected on the SIO.si portal [17]. In our research, we analysed the e-learning materials found on this portal, and discovered that many are inactive. For example, the E-um portal (www.e-um.si), where mathematical tasks for primary and secondary schools are available, was last updated in 2015. The same problem was identified with the Nauk.si web portal (www.nauka.si), which was developed for mathematics (for secondary school), and for physics, logic and computer sciences (for primary and secondary schools). The portal was developed by the NAUK Group with the main ideas to put teachers "back in the game", as their role in developing e-materials is often neglected [18].

The e-gradiva web portal (www.egradiva.si) appears more active and offers e-content from different subject areas, while different news is also available on their Facebook page. A great deal of the e-learning materials developed by different schools and companies are unavailable, or web portals do not exist. All those e-portals were developed in the scope of different projects. Unfortunately, it seems that maintaining existing e-learning materials was overlooked.

E-portal that should be mentioned and is freely accessible is Učiteljska.net (www.uciteljska.net) (Fig. 2). This e-platform was edited in 2003 and is still active. It is intended for teachers, students and other pedagogical workers. It offers the free exchange and use of school learning materials, preparations, seminar papers, tests, exercises, articles, etc., all of which are edited voluntarily by teachers.

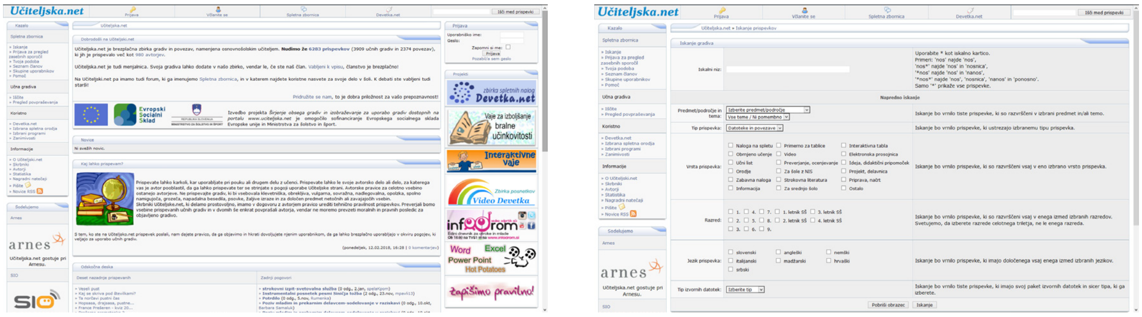

Figure 2. Web portal Učiteljska.net (www.uciteljska.net).

E-learning materials are also developed and offered by different Slovenian publishers. E-learning materials are usually available on web portals, the most popular of which are i-Modrian (www.modrian.si), Lilibi.si (www.lilibi.si) (Fig. 3), Radovednih pet (www.radovednih-pet.si) (Fig. 4), iRokus (www.irokus.si), iRokus+ (www.irokusplus.si), Vedeževo e-okolje (www.vedez.dzs.si), Naša ulica (www.nasaulica.si) and UČIMte.com (www.ucimte.com).

Figure 3. Web portal Lilibi.si (www.lilibi.si).

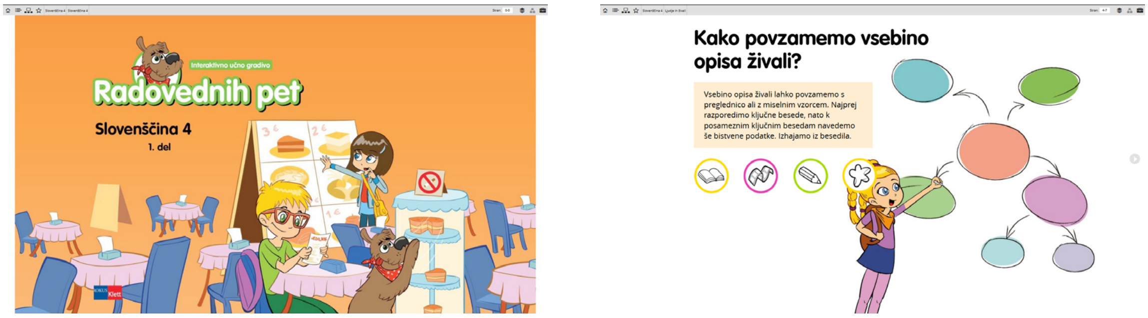

Figure 4. Web portals Radovednih pet (www.radovednih-pet.si).

E-textbooks, e-workbooks and other different multimedia and interactive materials can be accessed on those portals. E-textbooks are substantially and formally identical to printed editions, as those textbooks are approved by the Council of Experts for General Education. E-textbooks and e-workbooks on some of the aforementioned portals have a simple toolbar, which allows a user to scroll through the pages, write and draw on the pages, tag words, enter notes, add web links and enlarge individual parts of a page. Some e-materials are also created as multimedia-interactive pages enriched with videos, 3D models, sound records, animations, interactive tasks and other add-ons. Some platforms also include an LMS, through which teachers can monitor certain activities relating to learners or groups of learners, create their own tests and surveys, create and follow activities using a working calendar, select additional media materials, and track statistics regarding the success and progress of an individual or group of learners. On the other hand, success in solving tasks in relation to an entire group is also available to learners. Some platforms are freely accessible, while others require payment. On the latter, teachers and learners receive access to portals at the beginning of the scholastic year, typically in conjunction with a learning kit that includes printed versions of textbooks, workbooks and other accessories.

A few companies offer web portals with interactive tasks for specific subjects. One of them is Moja matematika (www.moja-matematika.si) (Fig. 5), where interactive mathematical tasks are available from the first to fifth grades of primary school. Although this portal requires payment, it has functioned successfully for more than six years, mainly because tasks are interesting, useful and regularly updated with the new challenges. In addition, each learner can trace their own success in solving tasks and also in relation to other learners.

Figure 5. Web portal Moja matematika (www.moja-matematika.si).

Textbooks for students in higher education are usually published by a university faculty member. Some textbooks are already published as d-textbook, however, no i-textbook was found on the market.

As is evident from the data obtained, learners and teachers in Slovenian primary and secondary schools have significant opportunities to use the e-learning materials that have been developed over the last few years. Since the 2007/2008 scholastic year, teachers autonomously select textbooks from a catalogue, which lists textbooks approved by the Council of Experts for General Education. It is thus the teacher's responsibility to choose the most suitable learning materials for their learners. According to an analysis performed during the 2012/2013 scholastic year, the most effective and most frequently chosen combination by teachers today is the use of a printed textbook and e-learning materials [19].

4 CONCLUSIONS

According to the results of an analysis of the Slovenian market, 39 i-textbooks have been developed and approved for use in primary and secondary schools in Slovenia. All of those i-textbooks have been issued by the National Education Institute Slovenia and are freely accessible. In addition, several publishers develop e-learning materials. Those materials come in different forms such as digitalised printed versions of textbooks or workbooks, which in some cases have multimedia and interactive elements. E-learning materials are also offered on different platforms, some of which require payment and some of which are free. Some materials are active, while others are not. As was communicated to us through interviews, the problems associated with the continued use of e-textbooks are more pedagogical than technical. Open issues include: how to change current ways of teaching; how to use e-textbooks as an effective tool for teachers and learners; how to instruct teachers on changing their teaching plans, etc. On the other hand, [6] believe that the lifespan of e-learning materials and e-services in Slovenia, despite proven their effectiveness, is currently equal to the duration of the associated projects. They suggest that it is necessary to find effective and lasting systemic solutions for editing and maintaining existing e-learning materials and e-services, and for providing technical support for new ideas as they emerge and for the implementation thereof.

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BLUEPRINTING - AN ANCIENT BUT STILL LIVING WAY OF PRINTING TEXTILES

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ABSTRACT: *Dyeing with indigo is one of the oldest ways of dyeing and printing of textiles in the world. In this study, samples made by classical blueprint processes prepared by one of Czech workshops were tested. A 100% cotton fabric was used. Basic parameter such as mass per unit area and thickness were analyzed before and after dyeing. Colour fastness of dyed samples to washing, light and rubbing (crock test) were measured. Colour fastness to washing was measured at 40°C, 60°C and 90°C, respectively. For the light fastness test the sample was exposed to the artificial light for 72 hours. Wet and dry crock fastness were measured. It was found out that the fastness to washing and light of blueprinted cotton fabric are very good, whereas the blueprint is very sensitive to rubbing.*

Keywords: indigo, blueprint, textile dyeing, cotton fabric, colour fastness.

1 INTRODUCTION

The blueprint started to be used in Slovakia and Czech Republic in 18th century and has remained until today. Few blueprint workshops are still producing fabrics by traditional techniques. There are two companies in Czech Republic and just one in Slovakia. Historically, indigo was a natural dye extracted from the leaves of certain plants. A large percentage of indigo dye produced today is synthetic. Several thousand tons are synthesized each year to produce denim cloth and blue jeans [1].

Indigo is a vat dye and it is not soluble in water. To be dissolved, it must undergo a chemical change (reduction). Reduction converts indigo into water-soluble leuco-indigo. When a submerged fabric is taken out from the dye bath, the leuco-indigo quickly react with oxygen in the air and the insoluble, intensively colored indigo is restored [2].

Difference between blueprinting and dyeing with indigo solution, is that blueprint uses reserve to create pattern and then is dyed in the indigo solution. It means that blueprint is type of resist printing [3]. The name of technique is derived from the colour of the final product and from the fact that the pattern was printed using wooden models. The formation of pattern on the fabric is a two-step process. First, the reserve is printed by hand onto pre-starched fabric with wooden forms. Nowadays also screen printing technique can be employed in the process of reserve application. Reserve consists of several chemicals and each workshop usually has its unique formulation. When the reserve is completely dry (it takes about 7 days), the dyeing can start. Textile is dyed in big barrels with indigo solution. One dyeing takes 5-10 minutes. Then it is taken out and left for few minutes in the air to oxidize [1]. Textile must be completely immersed into the indigo solution. Reserve protects printed places on the textile from dyeing producing a white pattern. The resulting shade depends on the number of dyeing steps. The more dyeing steps, the darker is the shade of the fabric. After dyeing the fabric must be washed. First with clean water to remove redundant indigo and other dyeing additives. Second wash is then in weak sulfuric acid solution to remove reserve from the fabric.

2 EXPERIMENTAL

100% cotton fabric supplied by a blueprint company Arimo spol, s. r. o. - Strážnice from the Czech Republic, was used. Before dyeing the fabric was starched. Mass per unit area of the fabric is 156 g/m^2.

2.1 Printing and dyeing

Before dyeing fabric was flat-screen printed by hand with a resist printing paste. Screen mash was 120 threads per cm. One squeegee stroke was enough for applying reserve. Printed samples were left on the table to dry in the air. General recipe of the resist printing paste is shown in Table 1. Figure 1 shows the printing pattern.

The pattern consists of lines with different thickness, dots with varying resolution and density, text in Arial with Different font size and a Siemens star. This pattern was evaluated only visually.

Fabric was dyed in blueprint company Arimo spol, s. r. o. - Strážnice. Fabric was immersed into indigo dyeing bath for five minutes. Then it was pulled out for a five minutes to oxidize. The dyeing consisted of seven of these cycles. After the dyeing, the fabric was washed. First washing process was done in solution of weak sulfuric acid to remove the reserve from the fabric. Second washing was done with clean water to remove residual indigo and dyeing additives.

Table 1. Approximate recipe of the resist printing paste and indigo dyeing bath [4].

Recipe of resist printing paste	Recipe of indigo dyeing bath
Lead (II) nitrate	indigo dye
Copper (II) sulfate	sodium hydroxide
Lead (II) acetate	sodium hydrosulphite
Kaolin	
Arabic gum	

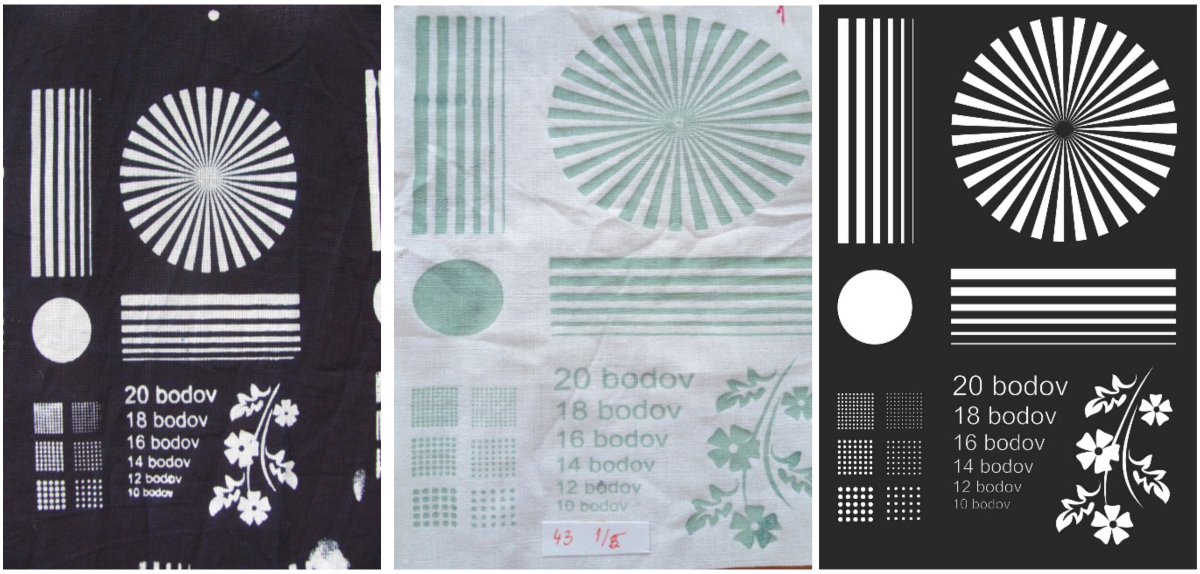

Figure 1. Design of the print pattern (left), reserve printed on the cotton fabric (middle), finished sample after printing, dyeing and washing (right).

2.2 Analysis

Colour fastness to washing

The colour fastness to washing of dyed samples was tested in accordance to standard ISO 105-C10: 2006 at 40, 60 and 90°C. Washing was carried out for 30 minutes at 40 rpm, 1, 3 and 5 times. A gray scale was used to evaluate the samples.

Light fastness - exposure to artificial lights

Samples were illuminated for 72 hours in Xenostest Alpha instrument by artificial xenon lamp. The test was performed in accordance to standard ISO 105-B02: 1994. A blue scale was used to evaluate the samples.

Crockfastness

Testing was carried out in accordance to standard ISO 105: X12: 1993 to determine abrasion resistance for dry and wet rubbing. Testing was done for 10 rubbing steps. The coloured layer was captured on the surface of the abrasion fabric at 9N. The Electronic Crockmeter M238BB instrument was used for the measurement.

Change of mass per unit area and thickness

Ten samples were used for measurement of mass per unit area before and after dyeing. The samples were 4×4 cm in size and area of one sample is about 0.0016 m^2. Values were averaged and interpreted in terms of g/m^2.

The thickness of dyed and raw fabric was measured at 5 spots. Values were averaged.

Colour measurements
To obtain CIELAB values spectrophotometer Datacolor Spectrum Flash® SF600 PLUS-CT was used. Measurement geometry was de: 8 with circular aperture of 9 mm in diameter. Colorimetric values were captured by Datacolor Datamaster software (standard D65 illumination and 10°standard observer). MS Excel was used for evaluation of colour different ΔE* according to the Equation (1).

$$\Delta E^*=\sqrt{(L^*_s-L^*_m)^2+(a^*_s-a^*_m)^2+(b^*_s-b^*_m)^2} \quad (1)$$

where L^*_s, a^*_s, b^*_s are values of reference, and L^*_m, a^*_m, b^*_m are values for measured sample.

3 RESULTS & DISSCUSION

Colour scale
The final colour shade of fabric depends on the numbers of dyeing steps. To illustrate the change of colour shade after each dyeing a colour scale was made. Table 2 shows L*a*b* values of scale samples and colour difference ΔE* between dyeing cycles showing how much the shade was changed. ΔE*1 is calculated between each dyeing cycles, ΔE*2 is calculated between first and following dyeing cycles. With each dyeing cycle the colour of the fabric becomes darker and less saturated. The highest colour difference is between first and second dyeing cycle. The final dying cycle differs from the first for 24 units ΔE*. Figure 2 shows colour scale and colour differences after each dyeing cycle.

Table 2. L*a*b* values of colour scale and colour differences ΔE* between samples dyed at different cycles.

Dyeing cycle	L*	a*	b*	ΔE*1	ΔE*2
1st	33.73	-2.50	-23.98	0	0
2nd	27.56	0.06	-22.10	6.94	6.94
3th	24.21	0.75	-19.59	4.24	10.98
4th	21.89	1.90	-16.87	3.76	14.49
5th	19.93	3.01	-13.99	3.66	17.91
6th	18.10	3.53	-9.75	4.65	21.98
7th	17.13	3.8	-7.96	2.05	23.91

ΔE*1 difference between each dyeing cycle, ΔE*2 difference between respective dyeing cycle and first dyeing

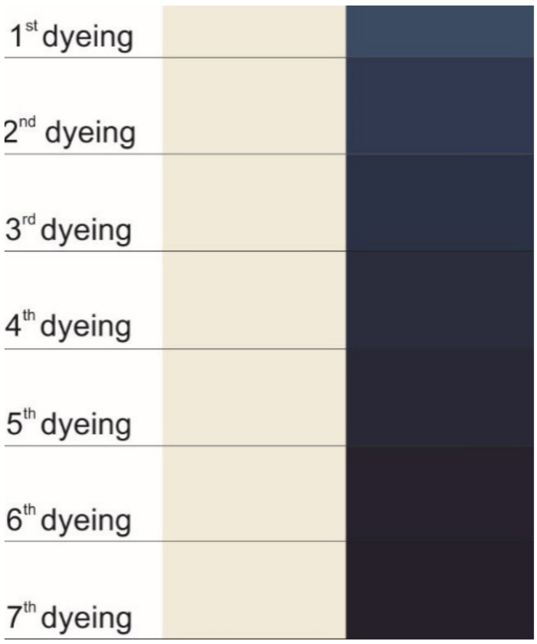

Figure 2. Simulation of colour scale (right side), colour of white fabric.

Colour fastness to washing
Table 3 shows grey scale rating for washed samples after first, second and fifth washing. For 40 and 60 °C the colour fastness of samples is considered to be very good. After washing, the viscose samples were stained more than cotton samples.

Table 3. Grey scale rating for colour fastness to washing.

		Grey scale rating		
Temperature	Wash	Alt[a]	Sta-Co[b]	Sta-Cv[c]
40 °C	1st	5	5	3
	2nd	5	5	3/4
	5th	5	4/5	4
60 °C	1st	4/5	4/5	3/4
	2nd	5	5	4/5
	5th	5	4/5	4
90 °C	1st	4/5	4/5	4/5
	2nd	4	4/5	4/5
	5th	2/3	5	4/5

[a] Alteration of colour, [b] Staining of cotton adjacent fabric, [c] Staining of viscose adjacent fabric

Light fastness - exposure to artificial lights
The cotton fabric dyed with indigo can be considered as very stable when exposed to light. On the blue-scale from 1 (bad) to 7 (good) samples were rated by 7.

Crock fastness
Staining of white fabric at dry rubbing was evaluated by a grade 2/3 and at wet rubbing by the grade 3. The results indicate that the resistance to rubbing is low.

Change of mass per unit area and thickness before and after dyeing
The mass per unit area of the fabric increased by 0.14 g/m² after dyeing. The thickness of the fabric increased by 0.08 mm after dyeing. Both results indicate that the dyeing and printing process do not have significant impact on these parameters. The original mechanical properties of the fabric remained unchanged.

4 CONCLUSION

Samples which were made by traditional blueprint technique were tested regarding their colour fastness. The results of colour fastness to light indicate that cotton fabric dyed by indigo can be considered as very good. The washing test shows no colour change of dyed samples, although the adjacent fabrics were stained remarkably. Viscose samples were stained more than cotton samples. All of viscose samples had light blue shade. Worst results were found for washing at 90 °C. The best colour fastness to washing was found for washing at 40 °C. The crockfastness test shows that samples were not resistant to rubbing. A lot of dyes transferred to the white fabric during rubbing. The reason for this is the surplus of the dye on the surface of the fabric, which arise from seven dyeing cycles. Measuring of weight and thickness shows only negligible increase of values after dyeing.

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COLOUR AND ODOUR PERCEPTION AT COSMETIC PACKAGING

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ABSTRACT: *The aim of our research was to study the relation between colour and fragrance of a cosmetic product. A group of observers described the selected colour samples with colour characteristics which were chosen in accordance with previous investigations and reflected six pairs of opposite characteristics: active-passive, warm-cool, hard-soft, heavy-light, clean-dirty, male-female. In the second part, the observers described the colour samples with the characteristics of odour which represented some of the most common scents. The results have shown that colours exhibit their typical character and odour characteristics, but the responses of male and female observers were not always the same. According to the results, the colours which are positioned closely in the CIELAB colour space also exhibit similar associations. In conclusion, our senses are capable of connecting the visual perception with other influences from the environment and this should be taken into consideration when designing different products and packaging.*

Key words: colour perception, odour, CIELAB colour space, cosmetic packaging.

1 INTRODUCTION

Colour is a subjective perception, generated in the brain and triggered by the light, entering the eyes of the observer (Golob, 2001). Beside their esthetic value colours also exhibit biological, psychological, sociological and cultural values (Kovačev, 1997). The influence of colours on our physical and emotional response is increasingly investigated.

A certain colour can often be connected with a specific odour (Kim, 2013, Plümacher, 2007). A group of researchers performed an experiment to find out whether the linking between the colours and different odours is universal or whether it originates from the cultural factors such as language. As it shows, the connections are not always consequent. The scent of almond, for example, is connected with red in Canada, whereas with blue in Australia (Chang, 2014). The interactions between colour and fragrance family were investigated (Kim, 2013) and the results confirmed the existence of cross-modal correspondences between vision and sense of smell, which are differently interpreted by men or women.

For the majority of the people, the sense of smell along with the sense of flavour represents the biggest and most direct influence on emotions (Wrzesniewski, 1999). By connecting the perception of colour and odour, more distinctive impact of a product could be achieved (Barkat, 2003). Different authors tried to explain the relationship between the characteristics of colours and the perception of other sensations, such as smell and touch (Ou, 2004, Jraissati, 2016), but several dilemmas remain unsolved. In our research, we aimed at establishing the connections between the colours and fragrances of cosmetic products. We investigated the differences between male and female observers in Slovenia.

2 EXPERIMENTAL

The research was based on the experiment, in which the selected colour samples were described by a group of observers, firstly with their colour characteristics and secondly with typical odour characteristics. 20 colour samples of size 65 mm × 65 mm were prepared, with Konica Minolta bizhub C364 printer and Color Copy (Mondi) paper with grammage 160 g/m2. CIELAB values of the samples were measured (Figure 1) in accordance with ISO 13655 : 2009 by using the spectrophotometer Eye One (X-Rite).
The investigation included 10 observers, 5 male and 5 female, of age 20-30 years. The testing was performed under constant and controlled lighting conditions. The surrounding was isolated from additional odours. The research was divided in two parts. In the first part, the observers were asked to describe the samples with selected colour characteristics, which were chosen in accordance with previous investigations and to describe six pairs of opposite characteristics (Ou, 2004): active-passive, warm-cool, hard-soft, heavy-light, clean-dirty, male-female. In the second part, the observers described the colour samples with the characteristics of odour, which were selected in accordance with previous investigations and represent some of the most common scents: floral, fruity, woody, bitter, fresh, sweet, mouldy, youthful and herbal (Levitan, 2014).

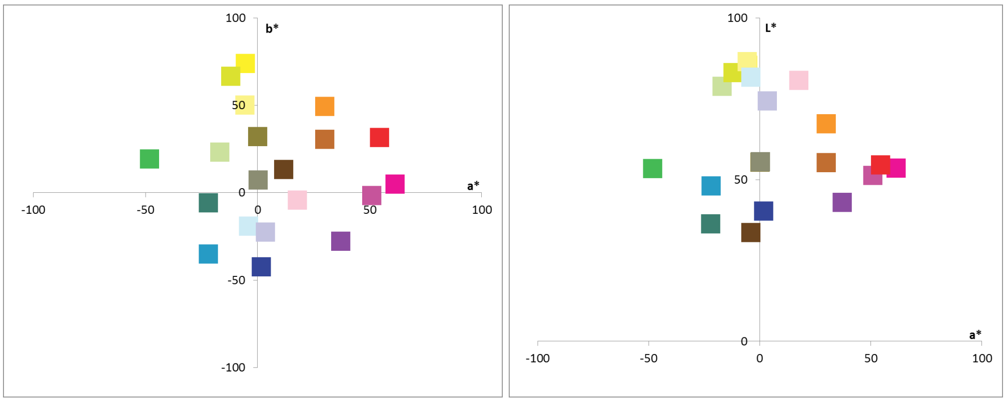

Figure 1. Colour samples in the a*b* (left) and a*L* plane (right) of CIELAB colour space.

3 RESULTS & DISCUSSION

The bubble charts in the a*b* plane of the CIELAB colour space (Figure 2) show typical colour characteristics for twenty colour samples. Six pairs of opposite characteristics (Ou, 2004) were used to describe each sample and the diameters of circles represent the number of selections.

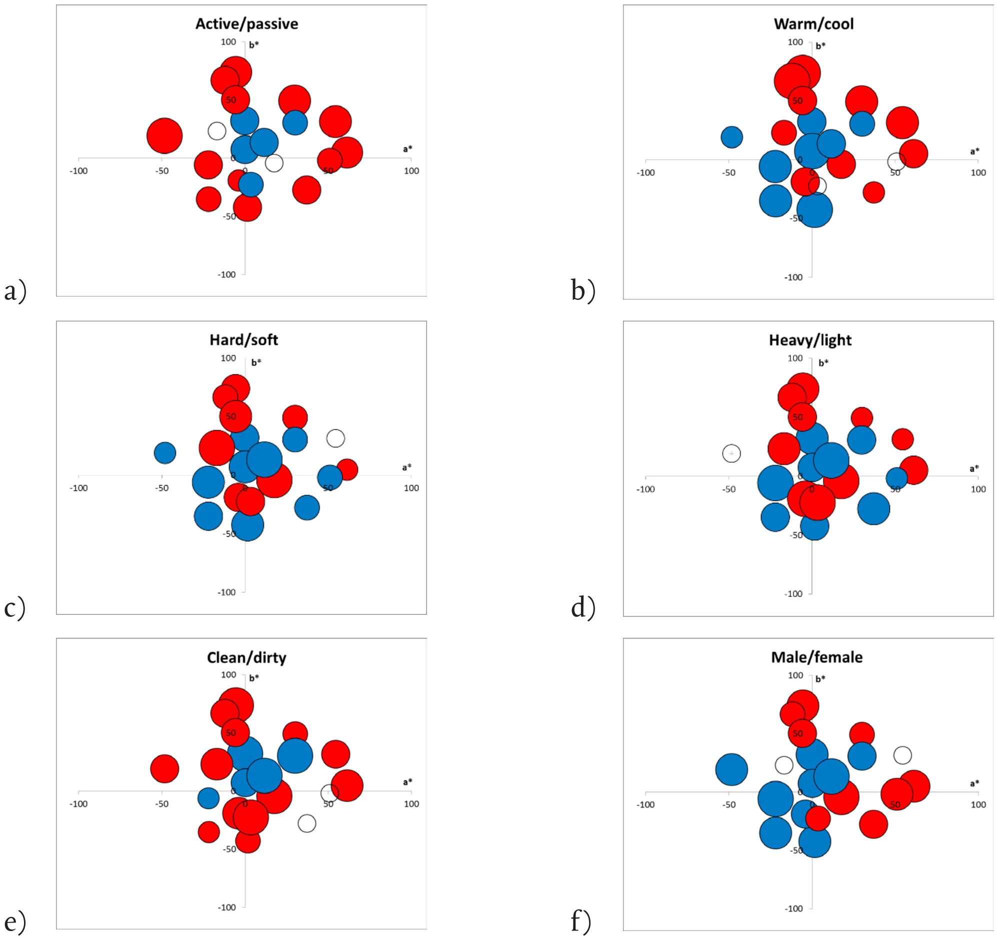

Figure 2. Colour samples in the a*b* plane of CIELAB colour space, representing selected opposite properties of colour: a) active/passive b) warm/cool c) hard/soft d) heavy/light e) clean/dirty f) male/female.
● positive properties: active, warm, soft, light, clean, female
● negative properties: passive, cool, hard, heavy, dirty, male
○ neutral colours.

According to the results shown in the Figure 2a, yellow, red and green were described as the most active colours. Grey, brown and olive green, on the other hand were described as the least active, which confirms the results of previous investigations (Ou, 2004). The activity of colours increases when saturation is increased. The colours described as warm can be found in the red-yellow area of the CIELAB colour space whereas cool colours are located mostly in the green-blue-violet area. The results show that when saturation is increased, warm colours are described as warmer and cool colours as colder (Figure 2b). Brown, grey and purple were described as heavy colours (Figure 2d), while unsaturated colours, such as pink and light purple, were described as light. Those findings are in accordance with results of previous investigations (Ou, 2004).

We also investigated the differences in the response of male and female observers. Figure 3 shows the results for those colours where the disagreements were the most obvious: magenta, blue, violet, red and green. Men described magenta as warm and active colour, women, on the other hand, perceive it as hard and heavy. Light blue was described as active and clean colour by men but as passive and dirty by the women. The opposite opinions were also given for the samples of pink and unsaturated green colour: the male observers described those colours as passive and women as active. Surprisingly, men believe that red is soft and masculine colour, women on the other hand perceive it as hard and feminine.

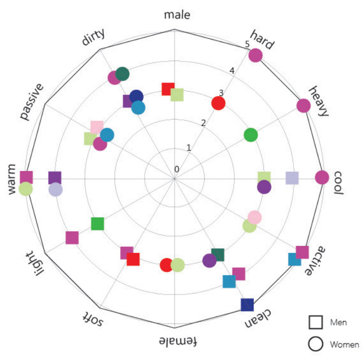

Figure 3. Description of colour samples by male (□) and female (○) observers.

Figure 4 represents the arrangement of colour samples in the fragrance wheel which is divided into four parts according to its author Michael Edwards (Kim, 2013): floral, oriental, woody and fresh tones. According to our group of observers, floral fragrances are associated mostly with different shades of purple and fresh scents with blue and yellow hues. Oriental fragrances are described mostly with purple, brown and red and the group of wooden fragrances with different hues of brown, grey and olive green. Yellow colour causes several different associations: it is perceived as sour, floral, bitter, youthful, fresh and sweet. The magenta was connected with fruity and sweet scents, different shades of blue with sports tones. In accordance with previous research (Kim, 2013), our group of observers connected floral scents with warm colours with higher lightness and wooden scents with cooler colours of lower lightness.

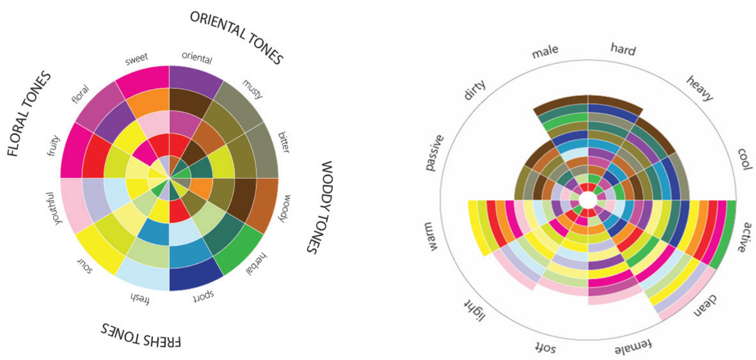

Figure 4. Description of colour samples regarding the selected odour properties (left) and by properties of colour (right).

Beyond the cultural influences, the sensation of odour is influenced by the age, gender and past experiences (Levitan, 2014). According to the results of our study (Figure 5), there are some differences between male and female observers in Slovenia. Floral scent, for example is connected with different hues of purple and yellow by the men, but women connect it with a purple sample. Men connect fruity scent with red or orange colour, women on the other hand with magenta and light yellow. There were also some differences in the description of a sweet fragrance. A more uniform response was observed at wooden and herbal fragrances. Also, a dark blue was connected with a sports scent and a light blue with a fresh scent.

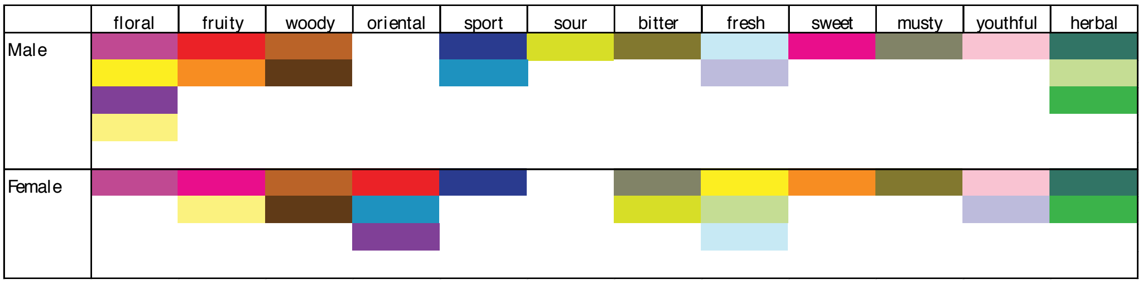

Figure 5. The perception of odour and colour: the differences between male and female observers.

The bubble chart (Figure 6) shows the colours representing six selected odours (floral, fruity, youthful, fresh, herbal, bitter) placed in the a*b*plane of the CIELAB colour space. The diameter of each circle represents the number of selections. The comparison of Figs 6a and 6b shows that floral and fruity scents provoke very similar responses of the observers regarding the colour selection, as the positioning of the samples in the a*b* plane is very similar. These colours can mostly be found in the red-yellow region, at a considerable distance from the origin of the CIELAB space, thus their saturation is very high.

The groups of fresh and youthful scents also show some similarities. These scents are mostly connected with colours of low saturation, i.e. neutral tones. The majority of those samples is positioned along the b* axis of the CIELAB colour space, therefore yellow and blue hues prevail (Figures 6c and 6d). Some similarities can also be found between the groups of herbal and bitter scents. They are mostly associated with yellow-green colours (Figures 6e and 6f).

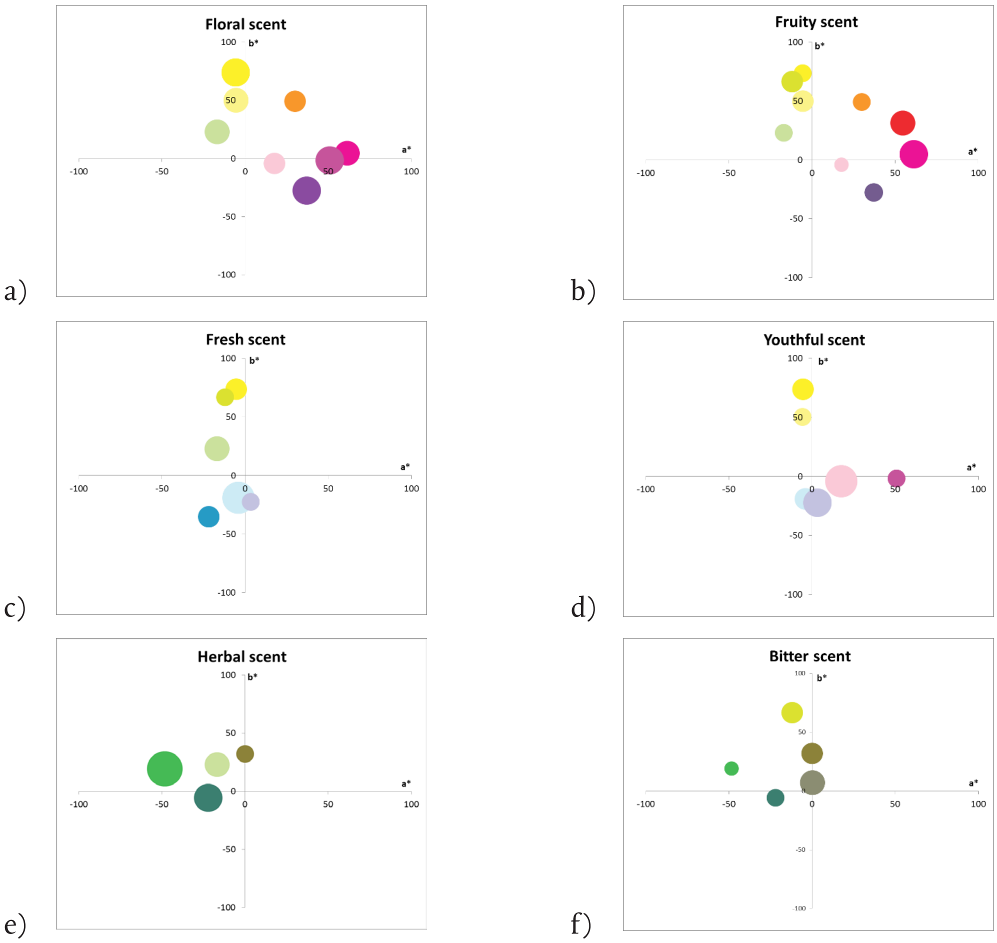

Figure 6. Colour samples in the a*b* plane of CIELAB colour space, representing selected odours: a) floral, b) fruity, c) fresh, d) youthful, e) herbal, f) bitter.

4 CONCLUSIONS

In the present research, we investigated the relation between the colour and fragrance of cosmetic products. The results have shown that colours exhibit their typical character and odour characteristics, but the responses of male and female observers were not always the same. Despite this fact, different colour groups can be defined by fundamental colour attributes. Colours with higher lightness and higher saturation were described as active, soft, feminine, light and clean. The opposite characteristics were connected with darker and less saturated colours. The feeling of activity increases with the saturation of colour. When chroma is increased, warm colours are perceived as even warmer and cool colours as cooler. Floral scents were connected with warm and brighter colours, wooden fragrances on the other hand with darker and cooler colours. According to the results, the colours which are positioned closely in the CIELAB colour space also exhibit similar associations regarding odour and colour characteristics. In conclusion, our senses are capable of connecting the visual perception with other influences from the environment and this should be taken into consideration when designing different products and packaging.

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COLOR OF TASTE

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ABSTRACT: The present study focused on the impact of taste on the choice of corresponding colors, and the correlation between observation and the choice of individual color. In the experiment, we used the Tobii X-120 eye-tracking device. There were 48 subjects participating in the study. After calibrating the eye-tracking device for each subject, the subjects selected a color they associated with each individual taste (salty, sweet, sour, bitter and umami) from among 24 different color samples shown on the screen. After the measurements for each individual taste were obtained, we marked Areas of Interested (AOI), based on the results visualized as Heat Maps, and analyzed each AOI in detail. Within each AOI, we obtained the number of fixations and fixation duration. We thus acquired an assortment of six colors that the subjects associated most with each individual taste.

Keywords: taste, color, eye movements, eye-tracking.

1 INTRODUCTION

The color of the food and packaging of food products can convey an extremely strong message. Color is also the main aspect in our decision to pick a certain packaging in favor of another. Prior to our direct contact with its contents it should try to induce in us various feelings of specific tastes (ISO 5492). While we initially tend to associate its color with the odor, it is the flavor itself that comes last: it may trigger feelings of satisfaction in us or perhaps even shock if the color led us to anticipate a different flavor. In tasting food and beverages we therefore have a multi-sensoric perception of taste, where our sensors must be synchronized in order to offer us perfect satisfaction and pleasure (Chylinski, 2015). Color constitutes one of the most salient of visual cues converning the likely sensor properties of food and drink (Delwiche, 2012).

Most mammals are dichromats and can only distinguish between two dimensions of colour: bright versus dark and blue versus yellow. In contrast, humans are trichromats, our extra class cone cells enabling us to discriminate between reds and greens which would otherwise appear identical. Trichromacy evolved as an aid to frugivory. This notion is particularly attractive, as many fruits gradually turn yellow, red or orange during ripening. These colours are strikingly visible to trichromats, but dichromats have difficulty distinguishing them from a dappled background of green leaves (Wolf, 2002).

Under most everyday conditions, consumers have the opportunity to inspect food and bewerage color before deciding on whether or not to purchase or taste it (Spence, 2015). Throughout the history of gastronomy, there has always been an understanding that food is both a human necessity as well as being a great source of pleasure. What happens to our senses when the taste is different than expected? But what exactly happens in our mind at this point? These questions require a thorough understanding of what the term "flavor perception" really means, starting with its very definition. It turns out that what most people have in mind when they talk about "taste" is really "flavor"; that is, the result of the integration of inputs from several different senses (Piqueras-Fiszman, 2016). By themselves, the gustatory receptors on the tongue only provide information about the so-called basic tastes, such as sweet, salty, bitter, sour, and umami (Umami or savory taste, is one of the five basic tastes (together with sweetness, sourness, bitterness, and saltiness). It has been described as savory, and characteristic of broths and cooked meats (Stuckey, 2012). In fact, according to one oft-quoted statistic, somewhere between 75% and 95% of what most people commonly describe as the "taste" of food actually comes from inputs detected in the nose (Piqueras-Fiszman, 2016). Trigeminal inputs contribute to our perception of food and drink, giving rise to hot, cold, tingling, burning, and electric sensations. Over the last 80 years or so, researchers have investigated the psychological impact of food color (Spence, 2016).

1.1 Taste and color

Most consumers expect a more intense food color, associating it with greater taste intensity. In the last 50 years, various studies of food and beverages established that the intensity of coloring gives people a more intense sense of taste (Spence, 2016, Johnson, 1982, Calvo, 2001). Perhaps the most robustly demonstrated effect of adding (or changing) food coloring has been on the ability of people to identify the flavor of food or, more commonly, drink (Spence et al., 2015). Studies of the effect of color intensity in yoghurts with strawberry, orange and fruit-of-the-forest flavors on the sweetness established that greater color intensity led to a greater perception of sweetness only in the yoghurts with fruit-of-the-forest flavor. For the rest of the flavors, the perception of sweetness was not impacted by the color and remained unchanged (Calvo et al., 2001). Studies of non-fizzy beverages with green, red and orange colorant showed that color masking dramatically decreased flavor identification of fruit- flavored beverages, while atypical colors induced incorrect flavor responses that were characteristically associated with the atypical color. In addition, the color level of beverages had significant effects on their overall acceptability, acceptability of color and of flavor, as well as on flavor intensity (DuBose 1980). In Oram et al.'s (1995) study, the subjects (children and adults) tested four different flavors (chocolate, orange, pineapple, and strawberry) in four different colors (brown, yellow, orange and red). The subjects tried to guess the correct taste of the beverage. For the typical drinks, the selection of the correct name was greater than 80% for all ages. Subsequent research by demonstrated that adult participants were often confused by the addition of inappropriate color to a range of fruit-flavored soft drinks. The accuracy of participants' flavor discrimination performance was significantly lower when the solutions were colored inappropriately than when they were colored appropriately (Zampini et al., 2017) Maga's (1974) study focusing on colorant adding (red, green, yellow) for basic flavors showed that adding colorant to food influences taste threshold sensitivity. Adding green colorant decreased sour taste sensitivity and increased sweet taste sensitivity. Adding yellow decreased both sour and sweet taste sensitivity, while red decreased bitter taste sensitivity. Recent research revealed a strong association between salty and white and, to a lesser extent, between salty and blue (Spence, 2015). In O'Mahony's (1983) study, most subjects chose white for salty taste, red for sweet taste, yellow for sour taste and green for bitter taste. In Heller's (2004) study, most subjects chose white for salty taste, red for sweet taste, yellow for sour taste and purple for bitter taste. Koch and Koch's (2003) study established that most subjects chose white for salty taste, red for sweet taste, yellow for sour taste and black for bitter taste. Wan et al.'s (2014) study compared tastes, and addressed the issue of color correspondences across cultures: it was established that white was associated with salty taste, pink with sweet taste, green with sour taste, black with bitter taste and brown with umami taste. Lavin and Lawless (1998) investigated the influence of varying the intensity of food coloring on people's ratings of sweetness intensity for two pairs of strawberry-flavored drinks. One pair light- and dark-red, the other pair light- and dark-green. The drinks were equally physically sweet and varied only in terms of their color intensity. The adults who took part in this study rated the dark-red and lightgreen drinks as tasting sweeter than the light-red and dark-green samples, respectively (Lavin, 1989). In Franken et al.'s (2012) study, the subjects chose from among 15 different colors of fruit juice, shown on screen; using eye-tracking technology, it was established that the subjects chose from among different shades of yellow in most cases. Jantathai et al. (2013) also employed eye-tracking technology; however, their aim was to investigate how the subjects choose from among the different colors of food products regardless of the taste. Most of the above studies did not employ eye-tracking technology; we therefore decided to test the tastes, and search for a suitable color using the eye-tracking method.

In addition to color, other factors also influence the taste. Lufthansa uses 1.7 million liters of tomato sauce a year (Jackson, 2014, Engeber, 2016). Researchers at the Fraunhofer Institute investigated why tomato sauce tastes better than we are used to at altitudes of approximately 9000 meters: they found that due to the low air humidity, the receptors for taste and smell function differently. In fact, a parallel can be drawn with having a cold (Schroeder, 2010). Our sense of smell is 30% less effective; our sweet and salty perceptions are diminished. The salty perception is diminished by 20-30% and the sweet perception by 15-30%. The sour and fruity perceptions remain virtually unaffected. While the taste known as umami is heightened. Thirsty passengers may find they yearn specifically for something rich and savory, and they frequently choose tomato juice (Eitner, 2010).

1.2 Marketing in food color

Changing the color of food and beverages, and adding colorants have long been used as effective marketing moves. (Spence, 2016, Jantathaia 2014). Margarine producers colored margarine yellow because they wanted to highlight its similarity to butter. Butter producers tried to stop this at all costs (Masurovski, 1939). Today, margarine remains yellow. A similar case is familiar from the beverage industry: all the colas have a color similar to that of Coca-Cola. They also try to imitate it by using red in their packaging design, with the notable exception of Pepsi, where blue is the dominant color. Moreover, there are well-known examples of changing the color of drinks in established brands, including Coca-Cola. Several years ago, a colorless Coca-Cola was launched; however, it was a complete marketing failure. The Italian apéritif producer Campari is a similar example: the attempt to replace its characteristic red color with a colorless version was a failure (Sertl, 2007). In

2017 the Spanish launch a blue wine which shocks both wine connoisseurs as well as ordinary buyers (Bruner, 2017). With blue wine, it is not about producing an artificial wine substitute, but about isolating anthocyanin, a blue pigment, from red wine, and adding indigo pigment (Mateus et al., 2003, Schrieberg, 2017). The color itself makes it virtually impossible for people to choose blue wine for reasons other than curiosity and momentary trend.

2 EXPERIMENTAL

2.1 Apparatus

To track the eye movement we used the Tobii X120 eye tracking device and the Tobii Studio 3.4.4 software. The eye tracker tracks the movement of the eye by following the reflection of the image from the cornea. This reflection is generated when the infrared illuminators at the front side of the eye tracker create patterns of light reflecting from the cornea. Eye tracker contains an infrared-sensitive camera that tracks the individual's eye movements and fixations. Prior to the measurement, each individual adapted to the lighting conditions of the room for 5 minutes and then underwent a 5-point screen-based calibration. For calibration procedure, subjects had to follow a red dot on the screen with their eyes. The dot was moving from the screen center to the corners. This procedure allows the eye tracker to adjust the analysis algorithm to the specific eye configuration of the tested individual. We measured the number of fixation and fixation duration of each taste by each individual. The color samples were displayed on 25-inch LCD screen with a resolution 2560 × 1440 pixels (pixel size 0.216 mm) at a 60 Hz refresh rate on light grey backgrounds. The tested individuals were positioned 60 (± 3) cm from the screen according to the recommendations of the ISO 9241 standard (2012). Each test started with an instruction text and text describing the taste on the screen. After completing the eye-tracking procedure, subjects were asked to look at color images on the display showing the differently colored samples (green, pink, and yellow) and to choose the most preferred color variant for each taste. The texts describing the taste were displayed in the middle of the screen. Consecutive instructions were invoked by successive mouse clicks.

2.2 Preliminary measurments

There were 48 participants, 24 were male and 24 female, aged 19 to 51, with an average of 24.76 years (±6.52); all participants had normal or corrected-to-normal vision. The participants were divided into 4 groups of 12 participants. We have tried to better understand our color-induced sensory expectations by facing individuals with various flavors, which they tried to match to individual colors presented on a LCD screen. The participants within a single group observed presentation of 256 different color samples for 9 second for each taste. For color samples we used 256 web safe colors. In our preliminary measurements we have chosen only the basic colors, which were later supplemented by additional shades. The color samples were shown to all 4 groups in different orders, using the so-called Latin square design. Before the main experiment, we attempted to select the most frequently chosen colors for each individual taste from among 256 colors (Web safe colors) shown on the screen. he time of showing of the colors was limited to 9 seconds. For each individual taste, we marked the areas of interest (AOI) for individual colors using the most frequent fixations and the Heat Maps obtained.

2.3 Main measurments

These preliminary measurements enabled us to choose 24 color samples, which we then showed to each individual subject separately for each taste. The time of showing of the colors was limited to 9 seconds. As with the preliminary measurements, we also marked the AOI using gaze density presented as a Heat Maps (Figure 1), and analyzed the time and duration of fixations (Figure 2). There were also 48 participants, 24 were male and 24 female, aged 18 to 51, with an average of 25.24 years (±7.32). The participants were divided into 4 groups of 12 participants.

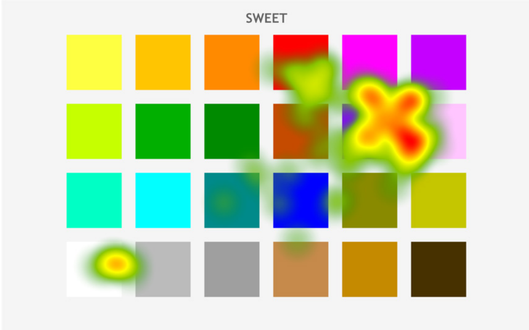

Figure 1. Heat maps for sweet taste.

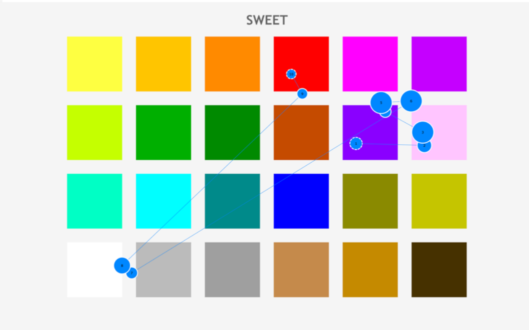

Figure 2. Fixations from one tested person.

3 RESULTS & DISCUSIONS

This study investigated the effect of taste on using eye-tracking technology and the correlation between gazing behavior and color choice decision. In presenting the results we have focused on the number of fixation and fixation duration On average, the subjects had a fixation duration of 20.86 seconds over the entire surface. The average time of all the pauses was 7.68 seconds. In the presentation and evaluation of the results, we only focus on the 6 most common colors, where the subjects' fixation duration was longest, separately for each taste.

3.1 Salty taste

For salty taste, the subjects generally tended to have the most fixations in the area of white #FFFFFF, specifically, 7.4 fixations with the average fixation time of 2.92 seconds. The maximum fixation time was 1.27 seconds, and the minimum was 0.05 second. The area of turquoise #00FFCC had the least fixations, specifically, 1.2 fixations with the average fixation time of 0.23 second (Table 1).

Table 1. Salty taste.

Color	#FFFFFF	#CCCCCC	#00FFFF	#999999	#009999	#00FFFF
No. of fixations	7,40	4,57	3,57	2,17	1,60	1,20
Fixation duration in sec.	2,92	1,64	1,55	0,81	0,72	0,23
Max. fix. duration in sec.	1,27	1,02	2,01	0,57	0,91	0,25
Min. fix. duration in sec.	0,05	0,05	0,16	0,01	0,22	0,23

3.2 Sweet taste

For sweet taste, the subjects generally tended to have the most fixations in the area of light pink #FFCCFF, specifically, 3.29 fixations with the average fixation time of 1.18 second. The maximum fixation time was 1.17 second, and the minimum was 0.07 second. The area of red #FF0000 had the least fixations, specifically, 1.67 fixations with the average fixation time of 0.73 second (Table 2).

Table 2. Sweet taste.

Color	#FFCCFF	#CC00FF	#FF00FF	#8000FF	#FFFFFF	#FF0000
No. of fixations	3,29	2,50	2,25	2,13	1,88	1,67
Fixation duration in sec.	1,18	0,77	0,78	0,67	0,78	0,73
Max. fix. duration in sec.	1,17	1,05	0,63	0,60	0,60	0,56
Min. fix. duration in sec.	0,07	0,17	0,16	0,12	0,05	0,17

3.3 Sour taste

For sour taste, the subjects generally tended to have the most fixations in the area of spring bud color #99FF00, specifically, 3.90 fixations with the average fixation time of 1.51 second. The maximum fixation time was 1.13 second, and the minimum was 0.91 second. The area of olive #999900 had the least fixations, specifically, 1.80 fixations with the average fixation time of 0.95 second (Table 3).

Table 3. Sour taste.

Color	#99FF00	#009900	#FFFF00	#006600	#009999	#999900
No. of fixations	3,90	3,00	2,88	2,17	1,80	1,80
Fixation duration in sec.	1,51	1,34	1,15	1,12	0,98	0,95
Max. fix. duration in sec.	1,13	1,02	1,53	0,91	0,90	0,86
Min. fix. duration in sec.	0,91	0,13	0,1	0,05	0,04	0,13

3.4 Bitter taste

For bitter taste, the subjects generally tended to have the most fixations in the area of olive color #999900, specifically, 7.50 fixations with the average fixation time of 3.60 second. The maximum fixation time was 0.80 second, and the minimum was 0.17 second. The area of blue #0000FF had the least fixations, specifically, 2.13 fixations with the average fixation time of 0.65 second (Table 4).

Table 4. Bitter taste.

Color	#999900	#999933	#996633	#996600	#009999	#0000FF
No. of fixations	7,50	4,33	4,00	2,83	2,43	2,13
Fixation duration in sec.	3,60	1,93	1,23	1,14	0,98	0,65
Max. fix. duration in sec.	0,80	0,77	0,44	0,42	0,42	0,35
Min. fix. duration in sec.	0,17	0,24	0,15	0,15	0,13	0,13

3.5 Umami taste

For umami taste, the subjects generally tended to have the most fixations in the area of golden brown color #996600, specifically, 6.25 fixations with the average fixation time of 2.11 second. The maximum fixation time was 1.61 second, and the minimum was 0.6 second. The area of light orange #FF9900 had the least fixations, specifically, 2.00 fixations with the average fixation time of 0.65 second (Table 5).

Table 5. Umami taste.

Color	#996600	#996633	#666633	#999900	#990000	#FF9900
No. of fixations	6.25	4.33	3.40	3.14	2.25	2.00
Fixation duration in sec.	2.11	2.02	1.48	1.14	0.69	0.65
Max. fix. duration in sec.	1.61	1.27	1.08	1.02	0.95	0.93
Min. fix. duration in sec.	0.6	0.11	0.05	0.05	0.05	0.08

The results showed that the method is appropriate for determining a suitable color for different tastes. For salty taste, our subjects generally chose white, which is very much in accordance with previous research by Spence et al. (2015) and Wan et al. (2014). Similarly, Heller (2004) also claims that the subjects in her studies generally chose white for salty taste, as do Koch and Koch (2003).
In our studies, sweet taste is associated with pink, magenta and their various shades. In Wan et al.'s (2014) study, sweet taste also corresponded to pink. For sweet taste, red color was in the sixth place, although red is the closest to sweet taste according to Heller (2004). O'Mahony (1983), on the other hand, maintains that yellow has the strongest correspondence to sweet taste. It is interesting that Maga's (1974) in Lavin's (1989) studies suggest that it is green that increases sweet taste.
With sour taste, our subjects mostly chose between different shades of green, which is in accordance with the results of Wan et al.'s (2014) study, and yellow, which is in accordance with Heller's (2004) findings that her subjects chose yellow for sour taste.
In our study, bitter taste was most strongly associated with olive green and light brown, which may remind us of the taste of beer; this corresponds to the findings of O'Mahony (1983). Heller (2004) and Wan et al. (2014) report that black is associated with bitter taste. We did not test for black because black is virtually non-existent in the food and beverage industry.
Our findings about the choice of brown and light brown for the umami taste correspond to the findings of Wan et al. (2014).

4 CONCLUSIONS

Using eye-tracking technology for successfully monitoring eye fixations and determining the colors corresponding to the individual tastes, we obtained results similar to those obtained in studies not employing eye-tracking technology. There was not much divergence for the individual tastes and colors among individual subjects. When the measurements were carried out, it became evident that the samples should have been placed wider apart. The actual presentation of the color samples should have been more aligned with the individual tastes. It was often the case that the subjects only passed a certain sample when searching for the right color; nevertheless, the eye tracker recorded their fixation on the color they passed. The sample invoked no associations for a given taste, yet it was recorded in the measurements. In future research, we would limit the number of samples shown and increase the spacing between the samples. The measurements obtained by eye-tracking were shown to be precise, and will continue to be used in research on the interaction of tastes and colors, as well as research on the interaction of aromas, colors and tastes. The research was carried out consistently under the same conditions; however, we know that when tasting food, other factors, including temperature, humidity, noise and last, but not least, our personal mood, also influence food tasting.

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COMPARISON OF DIGITAL AND TRANSFER PRINTING OF COTTON FABRIC

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ABSTRACT: *The aim of this work was to examine the printing of the fabric by two different methods of printing. We compared the direct digital printing of textile with pigmented inks and indirect transfer printing on textile with a foil. Both methods were applied to 100% cotton fabric. The fabric was directly printed on a Kornit Digital printing machine, which uses water-based pigmented inks. For the transfer printing Turbo print 4036 matt foil was used. The print motif was printed on the foil using a Mimaki JV33-160 digital printer, which uses Mild solvent printing inks. Only magenta colour was used for printing. Printed samples were subjected to rubbing, artificial light ageing, washing and heat. The resistance to rubbing was done according to the ISO 105-X12: 1993 standard at 50, 250, 500 and 1000 abrasion steps. The lightfastness test was performed in accordance to ISO 105-B02: 1994. A further test was the washing test, which was made in accordance to ISO 105-C10: 2006. Washing was performed 1x, 3x and 5x at 40, 60 and 90°C. The results were interpreted by visual assessment and by CIELab coordinates. To characterise the printed cotton fabric, the weight, the thickness and the air permeability were measured.*

Keywords: cotton fabric, digital printing, transfer printing, foil, fastness properties.

1 INTRODUCTION

Nowadays almost every material can be printed. This is valid also for textiles. Textile printing can be described as an industrial art, having a long history and with a steady future perspective. It requires a knowledge of science and technology, but will always be a multidisciplinary activity. Different techniques and different colorants are used for fibres of different chemical structures and different appearance. The choice of the appropriate fabric, appropriate colorant system and appropriate printing technology is very important for achieving appropriate quality of the final product [1].

Textile can be printed directly or indirectly. Screen printing and ink-jet printing are the predominant direct printing techniques nowadays. Different colorants are applied directly onto the surface of the fabric. Mainly pigment colorants are employed in printing processes. They are easy to use, offer a solid range of colouring with a very good end-use properties at reasonable cost on a wide range of base fabrics [2].

Indirect printing is also called transfer printing. The motive is first printed with special inks on a paper and then transferred from the paper to the textile with the help of high temperature and high pressure in a transfer press. In the case of sublimation transfer, the paper is printed with dispersive dyes, which are then transferred to polyester fibres. In the case of film-release transfer the print motive can be cut out from a special foil or a motive can be printed on a foil and subsequently cut out from it. In both cases, the motive can be finally transferred to almost all kinds of textile materials, from natural to synthetic fibres [1, 3].

The special foil is made of several layers: a white foil on which the printing is made, a layer of adhesive and a carrier foil that protects the adhesive layer. The printed motif on the foil is cut on a plotter cutter after printing, and excessing foil (foil that does not carry the printed image) is removed from the carrier by peeling. The print motif ready for transfer to the fabric is left on the print pad.

The benefit of the indirect transfer printing is that it is possible to transfer the print motif first to another medium (paper or foil) and to apply it to the textile material only when needed.

Proper fabric printing depends on many aspects including proper printing conditions and application of suitable printing inks. Important factor influencing the printing is the fabric to be printed. The emphasis put on the fabric is mainly regarding its physical and chemical properties, which are different for each fabric. These properties are influenced by their chemical composition and method of their preparation and subsequent treatment prior to printing [4]. Cotton fabric was chosen in our research because of its frequent use in the manufacture of clothing [4]. Cotton is widely used fabric because of its high liquid absorption, lower binding properties of greasy dirt and pleasant touch. It is a natural material of plant origin.

Digital printing with pigmented inks and transfer printing with a foil onto a 100% cotton fabric were compared in presented research. Differently printed samples were subjected to rubbing, artificial light ageing, washing and heat. The results were interpreted by visual assessment and by CIELab colorimetry. To technically characterise the printed materials the weight, the thickness, and the air permeability were measured.

2 EXPERIMENTAL

A 100% cotton fabric, 150 cm wide, from KOH-I-NOOR, a.s., was used for printing. The fabric has the following characteristics:

- weight – 144 g/m^2,
- thickness – 0.26 mm,
- air permeability – 70.7 l/min (at an area of 10 cm^2 and a pressure of 1000 Pa).

2.1 Printing

Digital printing

Digital printing was made using a digital printer Kornit Digital using water-based pigmented inks [5]. Fabric printing was done directly in the printing machine. The fabric was first placed in the instrument and mounted in a special frame so it did not move, preventing the blurring of the test pattern during printing. Subsequently, a pre-conditioning fixation agent containing 5% acetic acid solution was applied to the fabric. The purpose of this treatment is to fill the voids between the individual mesh fabrics. Printing was done on a wet fabric. The fabric was printed with a water-soluble Kornit V223 magenta ink. The fabric was placed in the hot-air tunnel and let to dry. During the first washing, the pre-conditioning agent is removed and the ink stays on the fabric. Figure 1 represents the ink-jet printed sample.

Figure 1. Direct digital printing on cotton fabric.

Transfer printing

The transfer print was made using a Mimaki JV33-160 digital printer and a special white Turbo print matt foil from POLI-TAPE GROUP – TAPE, Ltd. [6]. This digital printer uses solvent-based inks for printing. Only magenta ink was used. The test pattern was subsequently cut out on a cutting device. Excessive foil parts without printed parts that did not create the print motif were removed by hand. The transfer of the test pattern was done via the DIGITAPE402 transfer foil from ALPHASET d.o.o. [6]. Test pattern was finished in the hot press. In the press the material are stacked in order – fabric, foil with printed motif, transparent transfer foil with a glue layer. The transfer was carried out at 150 °C for 20 seconds and pressure of 3 Pa. Figure 2 represent the sample of the transfer print.

Figure 2. Indirect transfer printing on cotton fabric.

2.2 Analysis

Colour fastness to washing
Printed samples were tested for colour fastness to washing in accordance to standard ISO 105-C10: 2006 [8] at 40, 60 and 90°C. Washing was carried out for 30 minutes at 40 rpm, 1, 3 and 5 times.
The evaluation of colour change and staining of adjacent fabric was done according to the gray scale with 5 grades. The fabric labelled with grade 5 is resistant to the tests and shows no signs of staining. The fabric labelled with grade 1 is the least resistant to the test.

Crock fastness
Testing was carried out in accordance to standard ISO 105: X12: 1993 [9] to determine the resistance to dry and wet rubbing. Testing was done for 10 rubbing steps with a frictional force of 9 N. The Electronic Crockmeter M238BB instrument was used for the measurement.

Resistance to rubbing
Resistance to rubbing was also performed on Martindale apparatus. Samples were subjected to 50, 250, 500, and 100 abrasion steps at 9 kPa.

Light-fastness – exposure to an artificial light
Samples were illuminated for 72 hours in Xenostest Alpha instrument, where they were subjected to exposure of an artificial xenon lamp. The test was performed in accordance with ISO 105-B02: 1994 [10].

Colour measurements
A Datacolor Spectrum Flash® SF600 PLUS-CT spectrophotometer was used with the 8° illumination included geometry to capture colorimetric values (D65 standard illuminant and 10° standard observer). The measured area was of a circular shape with 9 mm diameter. The measured values were recorded by Datacolor Damaster software and MS Excel was used for further evaluation. Equations (1-4) were used to calculate colour difference – ΔE^*ab, difference in chroma – ΔC, difference in lightness and darkness – ΔL and difference in hue – ΔH.

$$\Delta E^*_{ab} = \sqrt{(L^*_s - L^*_m)^2 + (a^*_s - a^*_m)^2 + (b^*_s - b^*_m)^2} \quad (1)$$

where are values for standard (test pattern before tested) and are values for measured samples

$$\Delta C = C^*_s - C^*_m \quad (2)$$

where is value for standard (test pattern before tested) and is value for measured sample

$$\Delta L = |L^*_s - L^*_m| \quad (3)$$

where is value for standard (test pattern before tested) and is value for measured sample

$$\Delta H = \sqrt{\Delta E^2 - \Delta L^2 - \Delta C^2} \quad (4)$$

The evaluation of colour differences and differences in colour attributes was carried out according to [11], which specifies the deviation and how much the sample is affected before and after the tests.

3 RESULTS & DISSCUSSION

Colour fastness to washing

Samples were washed at 40, 60 and 90 °C, once, three and five times. Samples with transfer printing were washed only twice at 90 °C, because the printed foil was released from the fabric during washing. Table 1 shows the results of colour fastness to washing after the fifth wash. The results are evaluated using the grey scale grade.

Table 1. Colour fastness to washing at 40, 60 and 90 °C.

Sample	Alt[a]			Sta-Co[b]			Sta-Cv[c]		
Temperature [°C]	40	60	90	40	60	90	40	60	90
Digital print	5	5	4	5	5	5	5	5	4/5
Transfer print	5	5	–	5	5	–	5	5	–

[a] Alteration of colour, [b] Staining of cotton adjacent fabric, [c] Staining of viscose adjacent fabric

The results show that almost the same fastness to washing is obtained by both printing technologies at 40 and 60 °C. However, the digital printing with pigmented inks allows also the washing at 90 °C, while the transfer printed foil peeled of the fabric after the second wash.

Crockfastness

Table 2 shows the evaluation of the crock-test by the grey scale grade.

Table 2. Crockfastness evaluation.

Sample	Digital print		Transfer print	
	Dry rubbing	Wet rubbing	Dry rubbing	Wet rubbing
Evaluation	4	4/5	4/5	4/5

The results show that the fabrics printed with both printing methods have good abrasion resistance. The rubbing resistance is not perfect, as stains of printed inks appear on the white adjacent fabric.

The fabric resistance of the Martindale test is shown in Table 3. The test results are evaluated in terms of CIELab colour differences

Table 3. Rubbing fastness on Martindale instrument

Sample name / number of rubbing steps	Digital print				Transfer print			
	ΔE^*_{ab}	ΔL	ΔH	ΔC	ΔE^*_{ab}	ΔL	ΔH	ΔC
50	6	3	1	5	6	3	1	5
250	7	3	1	7	4	2	0	4
500	5	0	0	5	4	2	0	3
1000	5	1	0	5	4	3	0	3

Table 3 shows that the samples changed their shade during rubbing (ΔE^*ab), which can be also seen by eye. There was a big difference in chroma (ΔC), while lightness (ΔL) changed negligible and the colour hue (ΔH) was preserved.

Colour fastness to light

The results of the blue-scale evaluation of samples exposed to light are shown in Table 4.

Table 4. Colour fastness to light.

	Digital print	Transfer print
Evaluation	4	7

The results show that the ink-jet printed sample is more sensitive to light than the transfer printed one. After 72 hours of exposure to light, the ink-jet printed sample showed signs of degradation (area exposed to light had visible light-stripe), while the transfer printed samples retained its original colour.

Characteristics of the printed fabric

Table 5 lists the common characteristics of printed fabric; weight of fabric, thickness and air permeability before and after printing, respectively.

Table 5. Properties of the printed fabric.

Property	Unprinted fabric	Digitally printed fabric	Transfer printed fabric
Mass per unit area [g/m2]	144	155	246
Thickness [mm]	0.26	0.33	0.29
Air-permeability [l/min]	70.7	25.3	0

4 CONCLUSIONS

Two techniques, direct inkjet printing and indirect thermal transfer printing on cotton fabric, were tested in this study. Printed fabrics were exposed to light, washing and rubbing. Results show that the fabric with transfer printed foil is slightly more resistant than the fabric with digitally printed pigmented inks. The exception is the resistance to washing at 90 °C, where the foil separated from the fabric after the second wash. Huge differences appear at testing of the physical-mechanical properties of the fabrics. The increasing of the weight of the fabrics because of the additional ink layer made by digital technology is almost negligible. In the case of transfer printing the weight of the fabrics significantly increases. The thickness of printed fabrics at both printing methods is comparable. The air-permeability drops from 70.7 l/min to 25.3 l/min for digital printing and to 0 l/min for transfer printing. The original fabric properties are better retained at digital printing with pigments than at transfer printing with foil.

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COMPARISON OF SCREEN PRINTED AND ARDUINO-BASED SENSORS FOR ALCOHOL DETECTION

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ABSTRACT: *In the field of printed sensors, gas sensors are new coming technology which could be useful in our daily life. They consist of two printed electrodes that are coated with an active sensing layer, which changes its resistivity when exposed to the analyte.*
In our research study, the possibility of using screen printed gas sensors for alcohol detection in comparison to a commercial MQ-3 gas sensor was analysed. Screen printed electrodes were printed with conductive silver printing ink and coated with two polymers (1) ethyl cellulose and (2) poly(ethyl methacrylate) as active sensing layers in two different thicknesses. As a comparison, a commercial Arduino-based MQ-3 gas sensor that uses metal-oxide SnO_2 as a gas sensing layer was used. The sensors were evaluated with ethanol gas of 200 ppm and 1000 ppm concentrations and appropriate correlation with the type of sensing layer is presented.

Keywords: Screen printed sensors, gas sensor, alcohol detection, Arduino.

1 INTRODUCTION

Screen printing as one of the conventional printing techniques offers printers a possibility to print different printed matters that are used in everyday life. When using electrically conductive functional printing ink instead of conventional one, different functional elements can be printed. Different electrically conductive printing inks printed on various flexible, thin and lightweight printing materials are very promising also for printing low-cost and disposable printed electronics. Researchers recognized the potential in printing with functional printing inks for electronic components; especially in the field of printed RFID antennas, batteries and sensors. The last mentioned, printed sensors on flexible substrates, are presenting a growing market according to IDTechEx who also predicts that the next generation of printed sensors will enable applications from human-machine interfaces to environmental sensing. (Chansin, 2017)

In the field of printed sensors, gas sensors play a vital role among the most important technologies in our daily life. Typical applications of gas sensors include the detection of toxic analytes and explosive gases for the purpose of public and domestic safety, industrial processes, and monitoring of environmental pollution and air quality. (Zhang, 2016)

Printed gas sensors consist of two printed electrodes that are coated with an active sensing layer. During exposure, the analyte interacts with the active sensing layer and the resistance between the electrodes changes. The interaction between gas molecules and materials mainly takes place on the surface of an active sensing layer, hence the selection of active sensing layer has a crucial influence on the sensor performance. (Zhang, 2016) Gas sensing methods (Liu, 2012) based on detection of electrical variation normally use metal-oxide semiconductors, polymers, carbon nanotubes or moisture absorbing material for active sensing material. Most often sensors that use metal-oxides have been used, also in different commercially available gas sensors. Those sensors are affordable and have high sensitivity. The sensitivity of the metal-oxides sensor is correlated with a principle of operation, that is redox reaction between the target gas and the oxide surface. (Yamazoe, 2008) And for that, a high operating temperature is required which is a drawback of that kind of sensors.

Many types of researches have been done in the field of printed resistive and capacitive gas sensors (Mattana, 2016), also in the field of ethanol gas sensors but the majority of them are not printed and do not work at room temperature. Asgari (Asgari, 2017) presents SnO_2 decorated SiO_2 sensor for ethanol and acetone which have high selectivity at temperature 70°C to 370°C. The sensor is prepared on alumina and only the active sensing layer was printed over. Similarly, also Lee (Lee, 2017) presents microelectromechanical system (MEMS) heater-based SnO2 gas sensor, that works at 344°C and is only partially printed. Lakhane (Lakhane, 2016) presented screen printed sensors for alcohol using Ca-stilbite and Mg-stilbite that work at temperatures higher than 65°C.

Besides metal-oxides, for alcohol detection also enzymes are used. Inkjet printed breathalyser on paper, with the enzyme alcohol dehydrogenase and its cofactor that detects ethanol as a solution and as vapour, is presented by Bihar (Bihar, 2016). Rama (Rama, 2012) compared electrochemical response of different alcohol enzyme sensors based on different commercial screen printed carbon electrodes. Gaidan et al. (Gaidan, 2017) present screen printed sensor for propanol using different compositions of TiO_2 and ZnO mixed into polyvinyl butyral which made the sensor operating at room temperature which is novel, while other metal-oxide sensors work at higher temperatures.

To overcome this limitation, and to detect gas at room temperature, sensors use polymers as an active sensing layer. Polymers used for gas sensors can be conductive or non-conductive, but the mechanism of the reaction of the gases on the surface of the films is still not well understood. (Gaidan, 2017, Liu, 2012) According to Ruchika (Ruchika, 2015) gas-solid interactions may be of the form of adsorption or chemical reactions.

In our research study, the comparison of a commercial MQ-3 (Hanwei Electronics) gas sensor and screen printed gas sensors for alcohol detection has been done. The sensors were evaluated with ethanol gas of different concentrations and appropriate correlation with the type of sensing layer and coated thickness was done.

2 EXPERIMENTAL

The interdigitated comb-like electrodes were firstly designed and printed using a semi-automatic screen printing machine. Electrodes were printed on PVC foil using silver conductive thermal drying printing ink (SunChemical) with monofilament polyester plain weave mesh 120 l/cm. After printing, samples were dried 10 min at 150°C.

As active sensing layers ethyl cellulose (EC) and poly(ethyl methacrylate) (PEMA) were used. Firstly both polymers (EC and PEMA), that have been purchased as a powder, were dissolved. A solution of EC and PEMA have been printed over electrodes in two thicknesses (using screen mesh of 62 l/cm and 100 l/cm).

The preparation of gaseous ethanol followed. Ethanol was diluted with water to get a concentration in the gas phase of 200 ppm and 1000 ppm (according to Henry's law (Sander, 2015)).

After that, each sensor element (with different active sensing layer and different thicknesses) was exposed to 200 ppm and 1000 ppm of gas ethanol and the resistance was measured using multimeter Fluke. The sensors' resistance was measured for 2 minutes, 1 min in ethanol gas and 1 min after the sensor was removed from ethanol gas.

The same procedure was taken for the MQ-3 sensor.

Besides that FT-IR spectroscopy has been done to get the information about possible changes in chemical structure of active sensing layer (EC and PEMA) when exposed to ethanol gas.

3 RESULTS & DISCUSSION

Even though the compared gas sensors (printed and the tested commercial one) do not work on the same principle, all sensors give an immediate response to ethanol gas. Printed sensors use polymers as active sensing layer and work at room temperature without heating, while the tested cheap commercial one uses metal-oxide (SnO_2) that needs the heater to provide the necessary working condition.

The comparison of a change in resistance of sensors (with different active sensing layer of different thickness and exposed to different ethanol concentration) is shown in Figures 1, 2 and 3. It is obvious, that all samples did not conduct when not exposed to ethanol gas, and started to conduct in first 3 seconds after exposure to ethanol gas. The resistance dropped immediately and stabilised after approximately 30 seconds. When the samples were taken out of the ethanol gas, samples stopped conduct in less than 15 seconds. Oppositely, the commercial MQ-3 gas sensor provides intrinsic values of the sensor ranging from 27 in the air to almost 275 when exposed to 1000 ppm of ethanol gas (Figure 4) and it takes more than a minute to get back to the initial value.

Comparing active sensing layers (Figure 1), one can observe that PEMA gives a better response (the change in resistance in one minute of exposure to ethanol gas is larger) than EC. It is seen that PEMA reaches lower values of resistance than EC within 1 minute, other obvious differences are not noticeable. We suppose that the reason for that could be moisture itself that can change the resistance of the sensor as well.

The comparison of response in different gas concentration (Figure 2) reveals, that there is not as huge difference as one could expect. The change in resistance of printed sensors, on the other hand, does not change proportionally to analyte concentration but the difference in response of the MQ-3 sensor presents the concentration much more.

The difference in thicknesses of active sensing layer does not have great influence on the resistance change in our case, only slight delay in response when testing sensors with the thicker active sensing layer.

Also the design of experiments (DoE) showed that the greatest impact on change in resistance after 30 second of exposure to ethanol gas has the selected active sensing layer. Thickness of the active sensing layer and gas concentration have same, much lower impact and do not show a significant difference in resistance change.

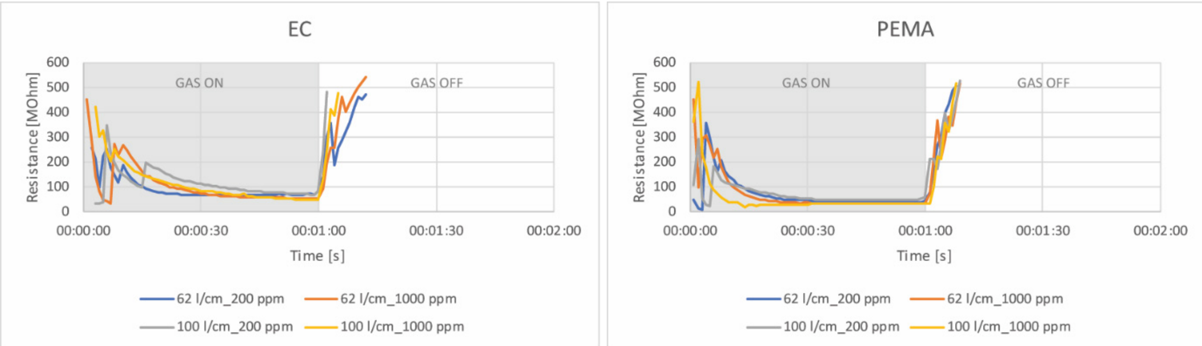

Figure 1. Resistance of the sensors with EC (left) and PEMA (right) active sensing layer.

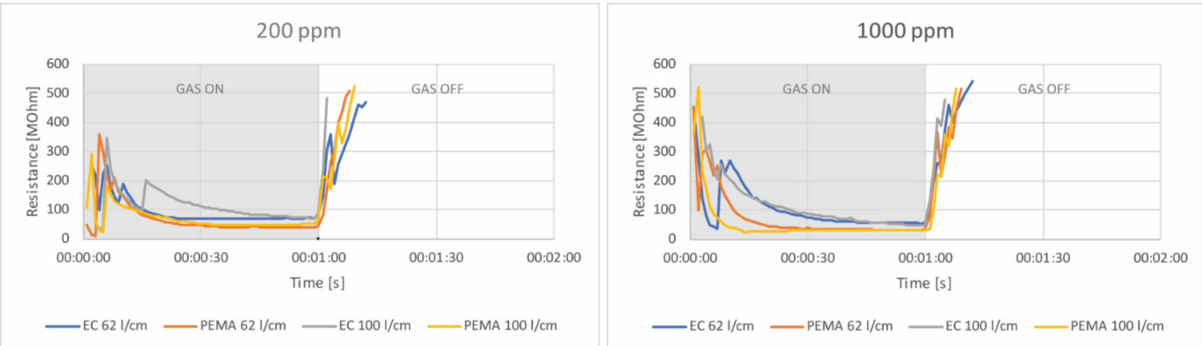

Figure 2. Resistance of the sensors when exposed to 200 ppm (left) and 1000 ppm (right) concentration of ethanol.

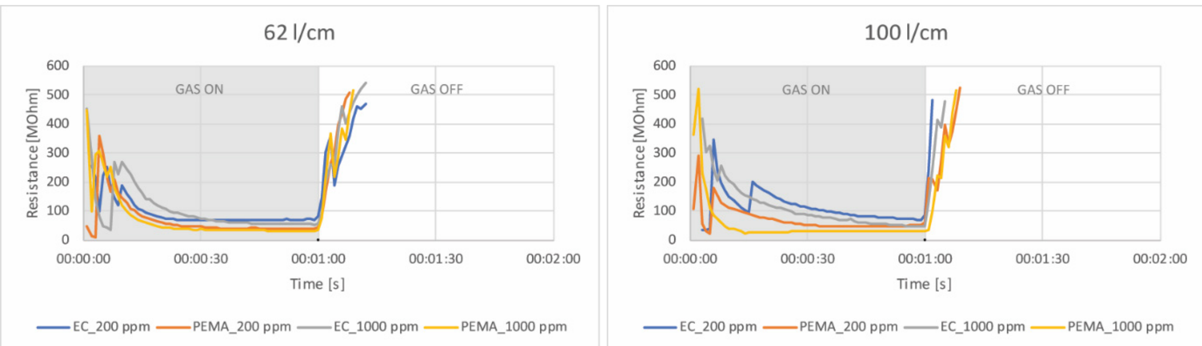

Figure 3. Resistance of the sensors with active sensing layer printed with screen 62 l/cm (left) and 100 l/cm (right).

When testing printed sensors, that were printed under constant conditions, it was noticed that there are also major fluctuations among samples, especially if the same sample was exposed to ethanol gas more times.

Therefore the FT-IR analysis of active sensing layer has been done. In Figure 4 one can observe, that the intensity of peaks at different wave numbers fall when EC is exposed to ethanol gas and increase when PEMA is exposed to ethanol gas in comparison to samples that were not exposed to ethanol gas. From the results of FT-IR analysis, it can be assumed that there was a minor chemical change on the surface of the active sensing layer and consequently that the samples of sensors are not completely reversible, which means that that kind of printed sensors is not reusable.

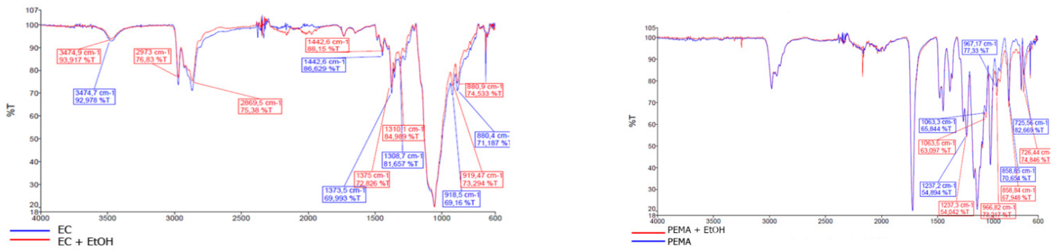

Figure 4. ATR FT-IR spectre of samples with EC (left) and PEMA (right) active sensing layer exposed (red line) and not exposed (blue line) to ethanol gas.

On the other hand, the commercial MQ-3 sensor (Figure 5) could be used many times while it has high repeatability, high sensitivity to alcohol, fast response, is stable and has a long life expectancy. Its response is fast and it is highly dependent on gas concentration. Contrary to printed sensors, that has very low recovery time (few seconds), the commercial MQ-3 sensor uses more than a minute to recover.

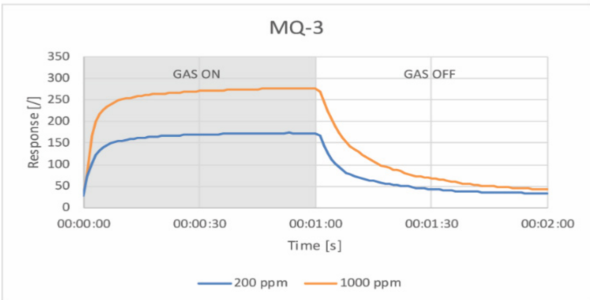

Figure 5. Response of the MQ-3 sensor.

Comparing sensors' recovery time, it is obvious, that printed sensors have shorter recovery time than commercial one. Besides that, printable sensors could be used immediately, while commercial one needs for about 10 minutes to heat up and to work properly.

4 CONCLUSIONS

A good sensor has to be sensitive, stable, reversible, selective, reliable and has to response quickly. According to that, it can be concluded that all sensors (printed and commercial one) are sensitive to ethanol at room temperature and have a quick response, but it can not be claimed that sensors (printed and commercial one) are selective. All sensors are dependent at least on humidity and temperature too. They are all reversible at first sight, but as it was seen from the FT-IR spectre, there are some chemical changes left on the surface of the active sensing layer of printed sensors after exposure to ethanol. In the future, the active sensing layer (before and after exposure to the analyte) should be analysed in detail and the operation principle should be studied deeply. The stability of the MQ-3 sensor is regular and the amount of resistance change is proportional to the concentration of the analyte. Printed sensors, on the other hand, are still in research phase, as stability and reliability are questionable.

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CREATION OF INTERACTIVE BOARD FOR LEARNING ABOUT TYPOGRAPHY

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ABSTRACT: *Typography is all around us, as it can be seen on every step. But understanding of typography requires interaction between the observer and typefaces, that standard learning methods cannot provide. The main goal of our research was to design interactive board that will help in understanding of typography. In the introduction, standard and interactive teaching methods were described along with the advantages of interactive methods. In the experimental part, the possibilities of preparing letters for 3D printing using Blender, were investigated. A comparison between different types of communication was made. All the components used for communication were tested and then assembled into a functioning whole. The commands with which the Arduino microcontroller manages all the components were designed and tested. Our final product includes different fields of profession (3D printing, electronics, typography) that create functional and visually attractive interactive board for the purpose of interactive teaching of typography.*

Keywords: 3D print, Arduino, Blender, interactive board, typography.

1 INTRODUCTION

Educational games improve the acquisition of knowledge when compared to traditional methods, and increase the sense of satisfaction that occurs. The use of educational games led to changes in relation to work due to the high level of involvement in the process. Positive feelings that students feel when solving the game do not contribute fully to improving the knowledge, but it increases the desire for progress (Giannakos, 2013). By using interactive games, students also improve, the challenge solving skills (Green, Batool, 2017).

There are increasing initiatives for the transition from traditional to interactive methods of learning, since they represent fewer restrictions and open the door to a new world of discoveries and learning process (Pamuk et al., 2013). In the last 20 years, interactive games have been developing and continually incorporating new technologies to enhance gaming experience.

Interactive games reflect changes in the media culture as they bring together various media with many purposes. They represent a new direction in education by combining new media, learning, and playing. Optimal use of interactivity allows the user a sufficient degree of control, where there is also the possibility of failure. By doing this, the user is constantly attentive to the individual steps that should be performed. Communication between the user and the game is crucial because it is an intermediate link that keeps the user on the right track (Booth, 2016). The use of interactive technologies suggests that simple use and interactivity have influence on emotional processes (authenticity, cognitive activity) that affect memory. The results show that when users perceive interaction with technology as intuitive and interactive, they experience a higher level of understanding and involvement (Pallud, 2017). An interactive educational game based on cooperation, improve the learning process, raise motivation, improve student's achievements and self-efficacy (Sung, Hwang, 2013). Learning process and motivation do not depend only on the entertainment side of the game, but on the ability to constantly transfer the knowledge to the student. In this context, precisely instruction and guidance through the game provide a successful path of education. It would be very interesting to include more educational games into the work program in different fields of education, since it is well known that the use of educational games leads to a higher level of motivation, enjoyment and knowledge acquisition (Erhel, Jamet, 2013). An interactive learning board is a fun learning tool that helps students to recognize the advantages and disadvantages of their knowledge. Additionally, it adds a new dimension to teaching and learning.

Interactive boards are based on a variety of low cost devices that allow the rapid and efficient development of prototypes. Such an example of the device is the Arduino microcontroller (Irigoyen, Larzabal, Priego, 2013) that is easy to use, compatible with many electronic components and has broad support in the Arduino community (Jamieson, Herdtner, 2015).

An example of use of the Arduino microcontroller is an interactive science board where Arduino Nano controls the operation of the LCD screen, MP3 player, keys and individual LED lights. The components were connected to each other using a circuit with the exact connection plan (Make: DIY Projects nad Ideas for Makers, 2016).

Method that we used to produce components of interactive boards is 3D printing technology, also called as the pioneer of the new industrial revolution. In comparison with other technologies 3D printing technology

allows creation and adaptation of items to the specific requirements (Weller, Kleer, Piller, 2015). 3D technologies can be used in various fields, with the printing of various materials (Muck, Križanovskij, 2015).
The main goal of our research was to design and create visually attractive interactive board that will help in understanding of typography.

2 EXPERIMENTAL

2.1 Materials

The main part of the interactive board is the Arduino Uno microcontroller (Arduino), which enables communication with all the components used on the interactive board. Other components include: LCD display (Winstar), MCP chip (Microchip Technology Inc.), LEDs (Kingbright), RGB LEDs (Optosupply), electric wires, metal plates, self-adhesive magnetic tapes and plexiglass.
For the preparation and printing of 3D letters, we used an open source program Blender (Blender Foundation) and CubePro (3D Systems).
The application Blender was used for 3D modeling of the letters. Then, we set the appropriate settings for 3D printing and exported them in CubePro. We printed the letters with the Cube Duo Pro (3D Systems) printer using ABS material.

2.2 Methods

Design of interactive board: Program code for recognising letters and their order was created and implemented. Each letter of the typeface had only one correct position on the interactive board. This would be implemented by specifying a unique communication that would make the letters recognizable to controler, by using the path of an electric current. A properly-placed letter would trigger a response that would be interpreted by microcontroller and converted to user recognisable output. Any correct layout of the whole set of letters would turn on the green LED. By correctly placing all the letters on the interactive board, the user would receive a LED signal that would indicate the correctly completed game. The interactive board would have a on/off power switch.

Choosing 12 typefaces for the interactive board: When choosing the typefaces for the interactive board, several factors were taken into account, such as historical importance, purpose and style of diversity. We chose the typefaces from six styles: Humanist, Garald, Transitional, Modern, Slab-serif and Sans serif. Based on certain factors, we made a selection of 12 typefaces, two from each style.

Restriction of the set to twenty-five letters: We compared all the lower-case letters of the Slovene alphabets. From the set of lower-case letters we eliminated all letters consisting of two parts, such as letters with carons and dots. We also removed letters that due to their simplicity do not contain enough information about typeface family. We chose among letters with many different strokes. Our final choice was three letters consists of x-height and upper case, x-heignt, and x-heignt and lower case. The layout of letters on the support box according to the basic position of the base line is shown in Figure 1.

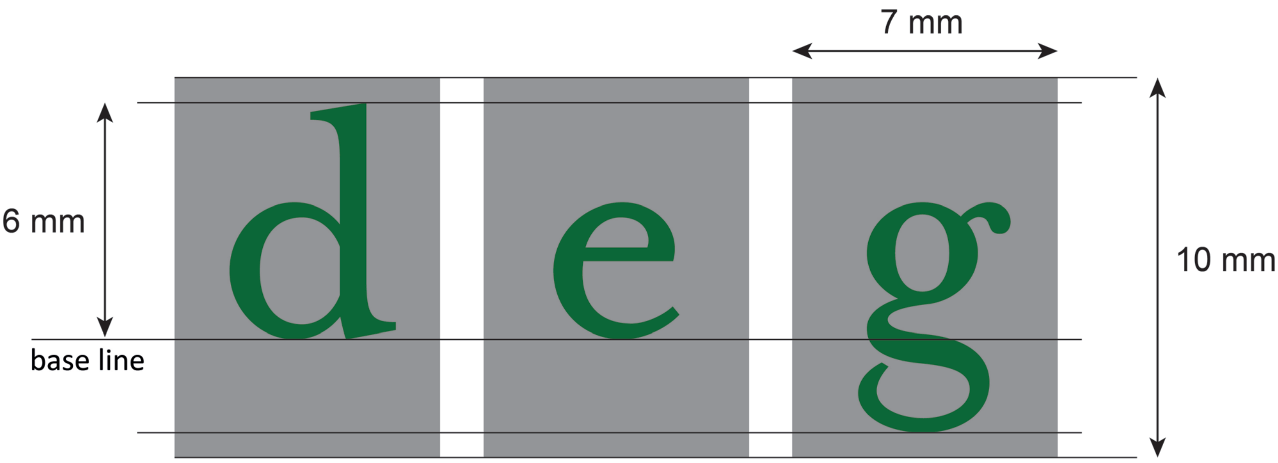

Figure 1. The layout of letters on the support box according to the basic position of the base line.

Defining the text that describe appropriate letter: We have defined the description of the letter image, the style of letter, and the historical information about the typeface. With terms, we created letter descriptions, which help us to determine the position of the letters on the interactive board. The terms were then included on the interactive board under each set of letters of one typeface.

Selection of 3D printing material: The selection of various materials for printing was performed by comparing the properties and purpose of using both materials for 3D printing. We compared the more flexible and durable ABS and a PLA material that is more rigid.

Defining the properties of the printed letters: The properties of the printed letters were determined by comparing the different type sizes and errors that occur during printing. The size of the letters was determined by testing the layout of the letters on the carrier box. By calculating the material usage and the relative costs, we compared two methods of printing – printing of hollow letters that do not contain fillings and full-letter printing. The final decision was based on cost savings.

3 RESULTS & DISCUSSION

In the first step of our research – when preparing the letters in the Blender program, we wanted to found out whether it is possible to print the letters of all the styles with the 3D printing technique.
Letters when imported in Blender were created with many poligons and were not suitable for further manipulation in 3D program. If they were used as such they produced uneven surfaces, duplicate edges and random dots. Most errors were represented by intersect faces. The number of cross sections was too large to be manually removed. We tried alternative solutions to create space in letters using the method of counting the volume of characters from the volume of the letter, but the methods did not solve the challenges of the complexity of the letters network. Often, the problem has become even worse and more difficult to solve. We also tried to import the border of letters created in Adobe Illustrator into the Blender program and build a three-dimensional image of the letters, but this method also encountered similar problems. We have found out that the errors originate mainly from the fonts themselves, which are designed in a way that it is not suitable for editing in the Blender. The errors were not present when solid leters were printed, but it resulted in greater use of material.
Better method would be to print holow letters because the printed walls do not extend beyond the outer edge of the letters. We also found out that the overhang faces were acceptable for printing if the errors were at the bottom of the letter. Cross-sections were not affected in the print since they were no longer present in the structure after exporting the .stl file, they were fused together in one image and they did not extend beyond the image of the letters.
With the experimental prints of the letters of different styles, we wanted to determine whether all the typeface styles can be correctly printed. Without errors hollow letters of Slab-serif and Sans-serif typefaces were printed. In some cases, the printing of Humanist, Garalde and Transitional typefaces caused problems, while in the Modern typefaces we did not manage to avoid printing errors. We have found out that if we want to use only the typefaces that were printed without error, we should greatly narrow the typeface selection, which would consequently mean that the interactive board would not contain selected typographic styles. Moreover, it would contain only typefaces with small differences and thus would lower the diversity. It would be also difficult to identify typefaces and find the correct position on the interactive board. However, as the full-letter printing did not allow the correction of errors in the printing of letters with thin strokes, we decided to use a set of all selected typefaces on the interactive board, and manually repaired the errors that occurred during (Figure 2). Subsequently, the letters were sandwiched on parts where we casted the material and thus eliminated numerous irregularities.

Figure 2. Letters "d" and "g" with corrected errors of uncompleted surfaces.

When writing code for the operation of the Arduino microcontroller, we found out that the components can be managed with different commands. Through the code, for each digital pin that allows communication, we determined the direction of the electric current and the command that is made when changing it. By doing so, we have set the conditions on which different commands are executed, depending on the status recorded. The result was a set of settings and commands, tested with different methods of work.
With the preparation and 3D printing, we managed to create 3D image formats representing different typeface styles. We managed to print the details of the letters, so the letters retained their basic images. From the set of different components we managed to select those who added value to the interactive board and enabled the communication between the user and the board. We have prepared a sequence of commands that allow the interactive operation of the board using the Arduino microcontroller. By creating a working interactive table (Figure 3), we achieved the goal, since we created a learning aid for learning about typography.

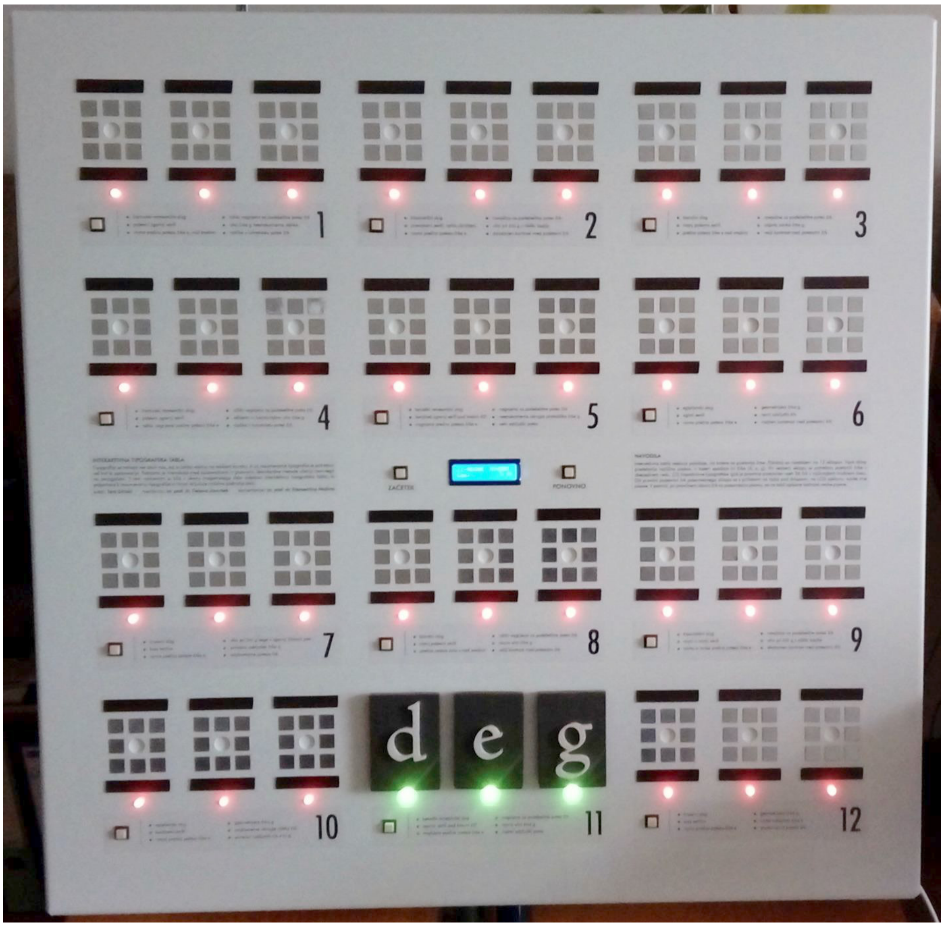

Figure 3. Interactive board during operation.

4 CONCLUSIONS

During the creation of the interactive board, we had to select the typefaces that are an important part of the interactive board and prepared them for 3D printing with the Blender program. With the study of different typeface styles, we determined the criteria by which we prepared the letters of individual styles for 3D printing. With the help of the Arduino microcontroller and appropriate components, we tested different ways of communication between the user and the interactive board. Our final product is a fusion of different fields, such as 3D printing, electronics, typography and graphic design. Together, they create functional and visually attractive board, which serves the purpose of interactive teaching of typography.

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DESIGN OF A GIFT CERTIFICATE USING PROTECTIVE ELEMENTS IN A STANDARD TRIAD

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ABSTRACT: *Features of graphic design for reproduction a gift certificate are considered in the article. Despite the development of electronic payment systems and electronic document management systems, cash tickets and documents on paper are widely used at present and there is no significant reduction in their number in the future. One of the main peculiarities of gift certificates is the possession of copywriting and the presence of some currency value equivalent adopted in the state of the issuer. In addition, an integral part of the standard gift certificate should have beautiful design and high quality of printing. The examples of gift certificates with full color screenless images by the technology formulate above are given in the work.*

Keywords: rose elements, protection, design, gift certificate, printing production.

1 INTRODUCTION

Practically in any beauty salon, boutique or supermarket you can buy a beautifully decorated document for a certain amount of money - a gift certificate. A gift certificate (gift card) is usually a card (certificate) or a plastic card that has some form of copy protection, which carries a certain equivalent value in the currency accepted in the issuer's country.

Gift certificates are not only a way to profitably sell goods and services. This is also a way to attract new customers. After all, a certificate can be given to a person who has never heard of a company, and, since the services have already been paid, they will definitely use them. So the gift certificate will also play an advertising role.

The main requirement for the design of the gift certificate is the availability of the name of the organization and the amount for which the purchase can be made. In addition, the design should meet the expectations of the audience, as well as give birth to images, associations and emotions.

Most companies make a unified design of the gift card, regardless of denomination.

Figure 1. Examples of gift certificates.

Another majority of companies change the design or color scheme of the gift certificate depending on the denomination.

Figure 2. Examples of gift certificates.

At all times, there have often been cases of making fakes of various printing products. To avoid this, a lot of special protections for printing products were invented, many of which are used today.
All produced printing products have a certain set of protective elements, which corresponds to the level of value of the manufactured product and the wishes of the client.

A set of protective elements of printing products can consist of a whole complex of means of protecting the product from counterfeits. Such means of protection can include the following:
- Rose elements;
- latent (latent) elements;
- relief grids;
- special protective rasters;
- microtext;
- graphic elements of protection from photocopying and others.

2 EXPERIMENTAL

Autotyped color synthesis - obtaining shades of color on the print by combining raster or line images printed with colors of different colors, for example, triad colors: cyan, magenta and yellow (CMY). Images consist of strokes having the same thickness of the ink layer on the impression. Microelements have a different area and constant frequency. In this case, the total color halftone image is formed using three colors. When overlaid raster elements of the image on the impression during printing. Autotype color synthesis has a mixed additive-subtractive character.

Previously developed elements were analyzed using various scanning techniques. Originally imprinted on a digital printing machine, the image was scanned at a low resolution. The result of the scan showed that the boundary contours cease to be perceived as composite, and reproduced in the form of a raster. An example of the result of scanning and determining the color coordinates on the border zones is shown in Fig. 4. The coordinates of point 1 (pure yellow on the Yellow-Magenta border) are equal to Cyan 4%, Yellow 64%. Point 2 (pure purple on the border of Magenta -Yellow) - Magenta 44%, Yellow 38%. Point 3 (neutral color between the lines of magenta and yellow) - Magenta 26%, Yellow 47%. Point 4 (pure purple on a white background) - Magenta 64%, Yellow 4.

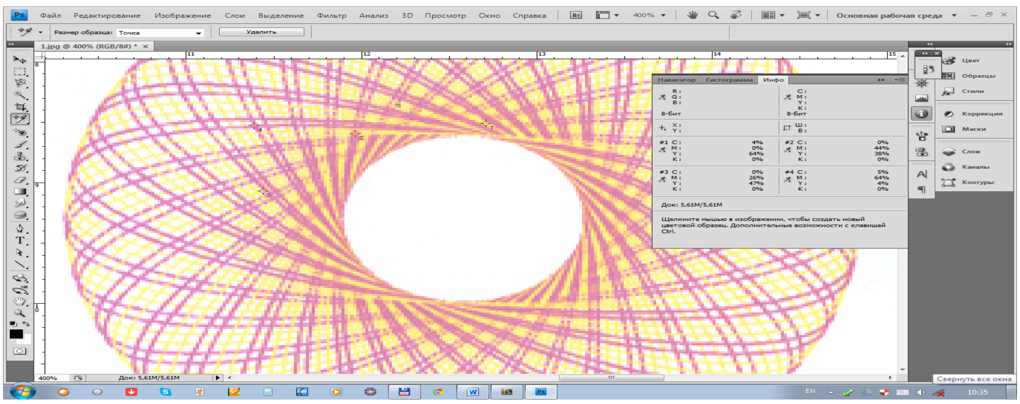

Figure 3. The result of scanning and determining the color coordinates.

An analysis of the data shows that on the boundary zones the sum of the coordinates gives shades of red. Pure colors give a 64% sensation of a plicate yellow and magenta color with a small content (4%) of cyan and yellow, respectively. That is, no point is reproduced with a given color coordinate. If you do not know about the parameters of the color guilloche element initially, then it will be impossible to reproduce the similar effect of the blurred technology in the CMY system.

Another task was to determine the maximum color coverage of the CMY system. Color coverage is the number of shades that can be rendered using a certain set of colors.

To establish the maximum color coverage by scaling, the square-shaped elements shown in Figure 4 were created. To paint the outline, all possible combinations of three colors were used. The results were printed on an ordinary white sheet and on protected paper, adding figures dyed with clean spot colors.

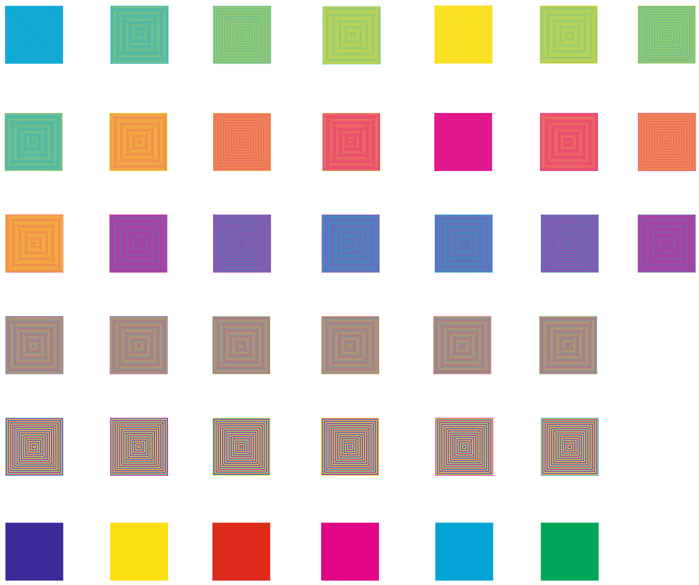

Figure 4. Elements for establishing the maximum color gamut.

The color information was read using the X-Rite 500 spectrodensitometer. Conversion of the color coordinates to the xyZ system allowed us to graphically display the CMYK standard colors in the form of dots of uniform colors and reproduced using patterns on the chromaticity diagram xy. The result is shown in Figure 5.

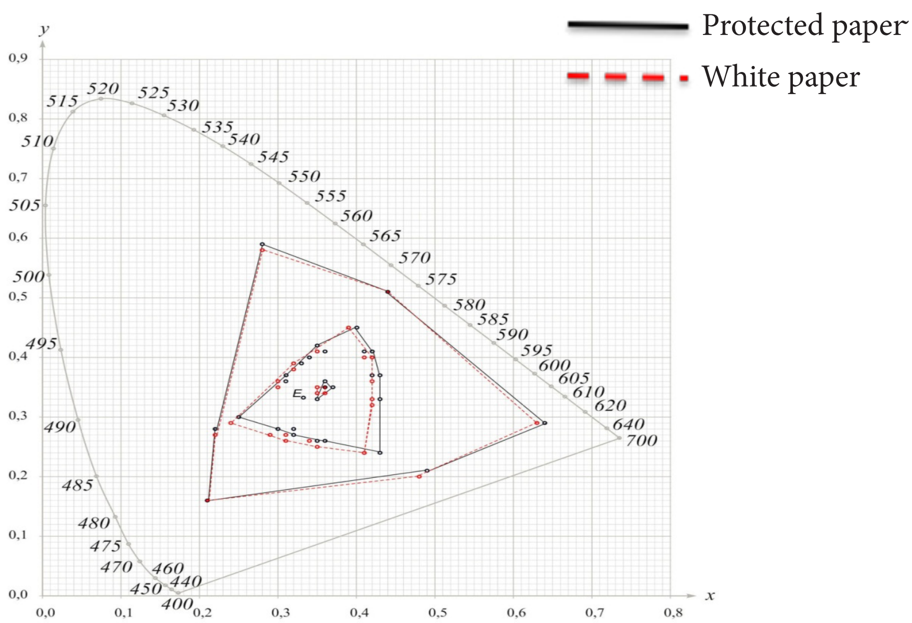

Figure 5. Color gamut.

Figure 5 shows that there is a shift in color coverage. Pure spot colors are more shifted in the red color zone. Colors obtained as a result of autotypic synthesis in the zone of blue flowers. Displacement occurs because of the lack of whiteness of the protected paper, manufactured without special bleaching agents. Some points on the chart are duplicated. You can see that these are the coordinates of the colors that were created by different combinations of all three elements of the CMY system, from which it follows that the color is practically independent of the sequence of arrangement of the color contours. It also follows from the graph that the area of color coverage obtained as a result of autotypic synthesis is 5 times smaller than the area of color coverage of pure spot colors, which proves an increase in the degree of protection from falsification when using this method of protection.

The displacement of the axis of the locus is due to the fact that all the elements were not located closely (the outline to the outline), but with a certain step that gave the color tone bleach, the color shift and its rotation, i.e. the color of the substrate changes the sense of color tone.

For the characteristics of information, units of measurement are used, which allows some piece of information to ascribe numbers-the quantitative characteristics of information. At the moment, the following methods for measuring the amount of information (measure of the amount of information) are the most known: structural (volume), entropic, algorithmic.

The most common methods for determining the information capacity for text and raster graphics are based on the Hartley formula:

$$I = l \times \log_2 h,$$

where h — the base of the number system (the number of states that an element holding a given number can take); l — number of elements.

As for vector graphics, well-known techniques for determining the information capacity were not revealed. Therefore, the task was to determine what the information volume of the vector graphic file depends on. For the initial analysis, the files created in the CorelDRAW graphics editor were taken. The volumes of an empty file, a file with a colorless object, files with black and colored objects, a file with several objects were analyzed. The following formula for the determination of the information volume of a vector file is derived by experience:

$$h = V_б + N_в \cdot 512 + V_{цв},$$

где – base file size * .cdr with built-in color profile; – number of vertices; – the volume occupied by the color. Also similar dependence is observed in files of * .svg format.

3 RESULTS & DISCUSSION

One way to protect is applying rose elements. Rose elements are continuous interlacing narrow lines forming complex geometric figures; Used as a background on the print. Means of protection against forgery of banknotes and securities.

In CorelDRAW, such elements can be created from the simplest shapes by turning and scaling. From the rose elements, replacing the black and white contours with colored ones, we obtain diffraction patterns. Combining cyan, yellow and magenta can create a large number of shades.

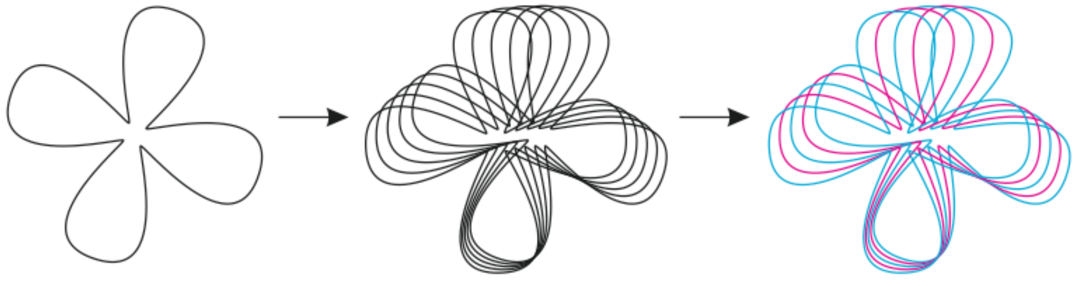

Figure 6. Creature of rose elements.

Based on the previously created diffraction patterns, a version of the gift certificate was developed.

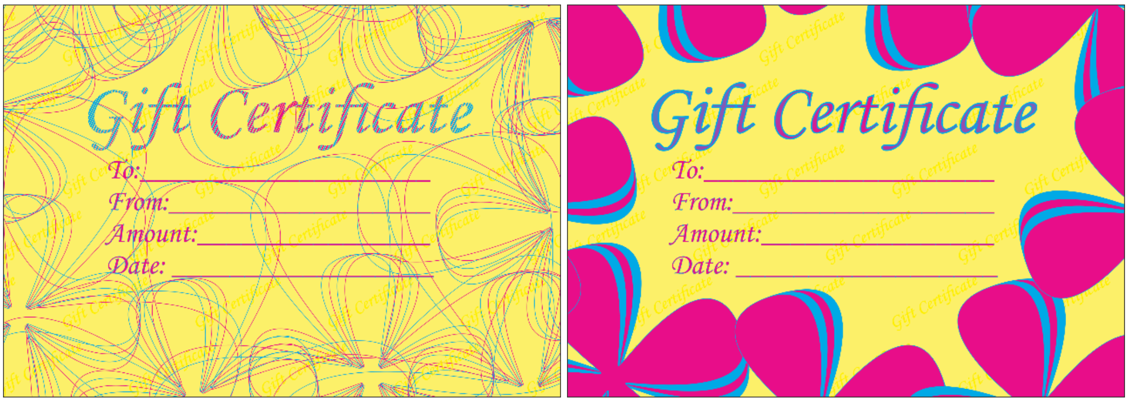

Figure 6. Gift certificate with rose elements and standard gift certificate.

The calculation made it possible to determine that with the use of rose elements the information capacity of the gift certificate increases 4.5 times.

4 CONCLUSIONS

Analysis shows that the most effective protections are hidden protections, which can be identified only in conditions of professional environment (in expert laboratories and equipped certificate centers). The application of this form of protection is most appropriate for a documentary group of product. To create a protected product with a unique design it is proposed to use rose elements that provide copywriting and better visualization of printing production.

Rose elements are built on the laws of symmetry which allows them to be introduced into software products by their design. Color rose elements create imitation of rainbow printing. In this case, the feature of the element is the preservation of the bar-like elements in multi-color printing even with the use of standard printing equipment. Composition of designed rose elements is based on without screening technology. The effect of iridescence is realized due to mixing of subtractive and additive types of synthesis. Subtractive synthesis is used due to printing technique, and additive one is a result of visual intersections of rays from ink reflections of CMYK triad base. Program realization of this method helps to include such elements in any type of printing production and facilitate the process of its designing.

Work include the justification for the method of protection. The technology for assessing the degree of protection is based on determining the structure of file size and then equation the information capacity index for a vector image, taking into account the features of its structure, the complexity of the curves being formed, and the quantitative analysis of the points forming the basis of the vector image and the levels of symmetric reproduction.

An alternative option for calculating the information capacity index extends the methods for assessing the results of scientific research and allows them to be applied in quantitative description of digital and graphic information, to systematize data on the structure of graphic security elements and to bring its mathematical description.

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DEVELOPMENT OF dispersion barrier coating FOR GREASE, MINERAL OIL AND WATER VAPOUR

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ABSTRACT: *The repulpable and more sustainable grease, mineral oil and water vapour barriers for the safe paper-based packaging were created by dispersion coating. All created composite barrier coatings were water-based and prepared from dextrin, latex and two barrier components B1 and B2. The created barriers enabled the achievement of the highest KIT value equals to 12 and decrease of the Cobb-Unger oil absorbency of 0.14 g/m2, i.e. decrease of about 90%. Simultaneously, these barriers decreased the water vapour transmission rate for about 80%. The prepared multifunctional barrier coatings can be considered as repulpable and more sustainable, which is of high importance for the development of the safe paper-based packaging as alternative to currently used bioaccumulative plastic counterparts.*

Keywords: dispersion coating, paper, grease and mineral oil barrier, water vapour barrier.

1 INTRODUCTION

Packaging provides protection against environmental influences, i.e. light, water vapour, oxygen, microorganisms, aromas as well as against grease and oils. Typical plastic packaging materials or barrier coatings used in the industry are based on the synthetic polymers (polyolefins, PET, polyamides, PLA, EVOH, PVDC, etc.) and their combinations in the laminated structures. However, due to the high stability of these petroleum-derived polymers, the latter negatively contributes to the global environmental pollution and the preservation of the limited petroleum resources.
Therefore, the current research is directed towards the development of new green alternative composite coatings, which should be prepared from more sustainable and renewable resources, and should be more repulpable and recyclable, biodegradable, and suitable for direct food contact (Lagaron et al. 2017). These composite coatings are created by dispersing different micro- and nano-sized materials in the continuous matrix (Wang and Jing, 2017; Weizman et al. 2016; Ovaska et al. 2016). Consequently, the chemistry of the continuous phase and the surface of the dispersing phase dictate the interface interactions, which influence the properties and tortuosity factor of the created composite coatings.
The objective of our study was to develop more sustainable repulpable water-based dispersion coating for the paper-based food packaging. Oil and grease resistance, and resistance to water vapour transmission were selected as the main barrier properties aimed to be achieved. The evaluation of the viscosity of the prepared dispersions and the barrier properties of the coated papers enabled selection of the barrier coatings with the best performance.

2 EXPERIMENTAL

2.1 Materials and application procedure

Two different non-wet-strength label papers P1 (80 g/m^2) and P2 (55 g/m^2) were provided by Paper Mill Vevče d.o.o. (Ljubljana, Slovenia). The coating dispersions were made from dextrin, latex and two barrier components B1 and B2 of three increasing concentrations c1, c2 and c3. The coatings were prepared on the back side of the papers by using the RK Multicoater K303 (RK Print Coat Instruments) (Figure 1). The samples' codes and the composition of the coatings are presented in Table 1.

Figure 1. Application of the barrier coating on the RK Multicoater K303.

Table 1. Sample codes and the composition of the coatings.

Sample code	Composition of the coating
P1	Without barrier coating
P1-B1-c1	Dextrin, latex, barrier component B1 of concentration c1
P1-B1-c2	Dextrin, latex, barrier component B1 of concentration c2
P1-B1-c3	Dextrin, latex, barrier component B1 of concentration c3
P1-B2-c1	Dextrin, latex, barrier component B2 of concentration c1
P1-B2-c2	Dextrin, latex, barrier component B2 of concentration c2
P1-B2-c3	Dextrin, latex, barrier component B2 of concentration c3
P2	Without barrier coating
P2-B1-c1	Dextrin, latex, barrier component B1 of concentration c1
P2-B1-c2	Dextrin, latex, barrier component B1 of concentration c2
P2-B1-c3	Dextrin, latex, barrier component B1 of concentration c3
P2-B2-c1	Dextrin, latex, barrier component B2 of concentration c1
P2-B2-c2	Dextrin, latex, barrier component B2 of concentration c2
P2-B2-c3	Dextrin, latex, barrier component B2 of concentration c3

2.2 Characterisation methods

Viscosity of the barrier suspensions was determined by the dynamic rheological measurements.
Morphology of the sample surfaces and cross-sections was investigated by scanning electron microscopy (SEM).
Grease resistance of the papers was determined by the TAPPI grease resistance KIT test T 559 cm^{-12} (KIT value from 1 to 12).
Oil absorbency was determined by the Cobb-Unger method SCAN-P 37:77.
Water vapour transmission rate (WVTR) was determined according to the Standard ISO 2528 (gravimetric dish method).
Coat weight of the coatings was determined as follows:

$$\text{Coat weight} = \text{grammage}_1 - \text{grammage}_2 \ \ (g/m^2) \qquad (1)$$

where grammage$_1$ belongs to the paper with the barrier coating and grammage$_2$ to the paper without the barrier coating.

3 RESULTS & DISCUSSION

3.1 Viscosity of the barrier suspension

The viscosity of the prepared dispersions was measured at 100 rpm, i.e. at a constant shear rate of 1.6667 s-1 and the results are presented in Figure 2. It can be seen that the viscosity of the barriers suspensions varied from 6500 to 10000 mPa×s. The highest values were obtained for dispersions with the lowest concentration (c1) of the barrier components irrespective to their composition. The increase of the barrier components concentrations decreased the suspensions viscosity.

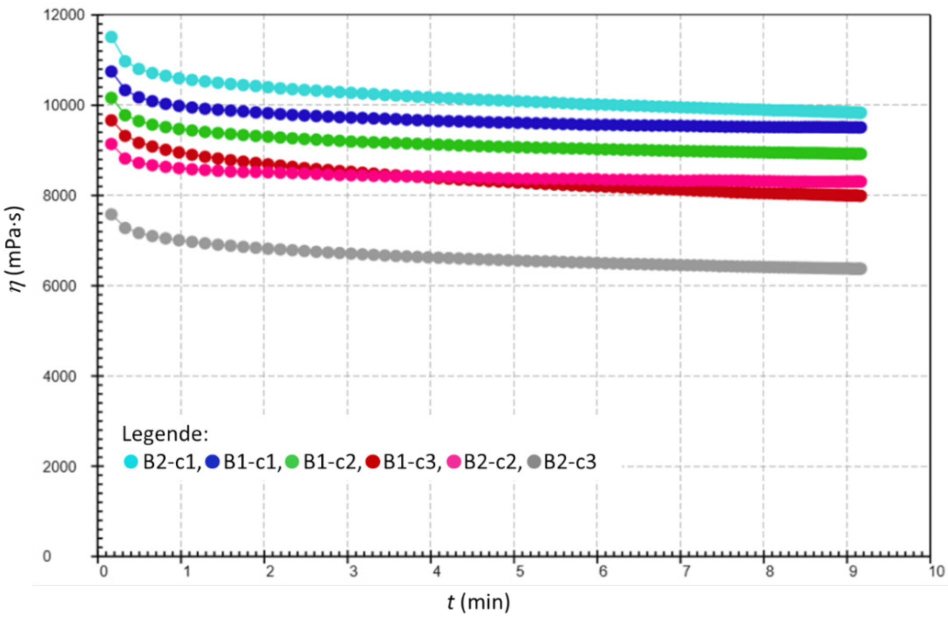
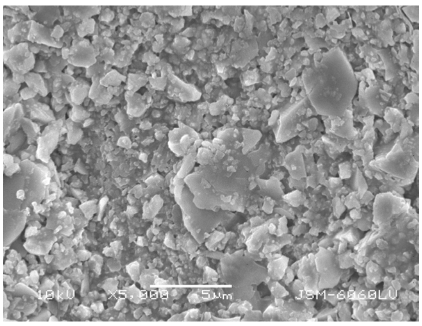
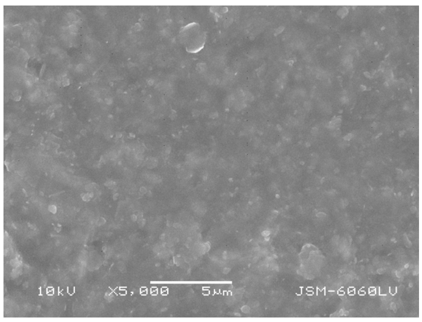


Figure 2. Viscosity, *h*, of the barrier suspensions versus time, t, at the constant share rate equals to 1.6667 s-1.

3.2 Surface morphology

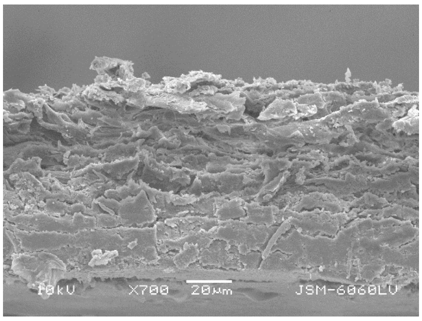
SEM images of the surface and the cross section of the representative paper samples without and with barrier coating are presented in Figures 3 and 4. Figure 3 shows that the barrier coating completely covered the surface of the paper, closed the paper structure and decreased the surface roughness. This resulted in the increase of the paper gloss. SEM images of the paper cross sections in Figure 4 revealed that there is no sharp boundary between the surface of the paper and the barrier coating (continued 10 microns thick), which indicates their compatible structural composition.



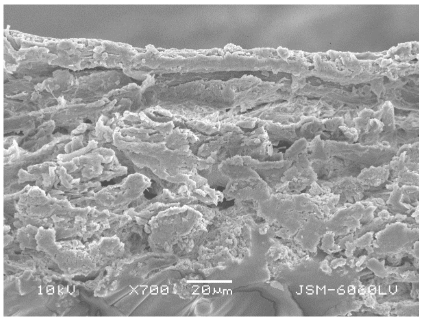


P1 P1-B1-c3

Figure 3. SEM images of the surface of the representative paper samples without and with barrier coating.



P1



P1-B1-c3

Figure 4. SEM images of the cross section of the representative paper samples without and with barrier coating.

3.3 Coat weight

The coat weight values are presented in Figure 5. The results show that the coat weight values of the created coatings were between 5.5 g/m² and 7.5 g/m² in the case of the P1-samples and between 5.3 g/m² and 8.4 g/m2 in the case of the P2-samples. It should be stressed that the barrier coatings did not increase the grammage of the paper P1 by more than 9% which is very low. A comparison of Figures 2 and 5 also show that the highest coat weight values were obtained by the use of the barrier suspension B2-c1 with the highest viscosity. However, in other samples, the viscosity of the barriers suspensions did not significantly influence the coat weight.

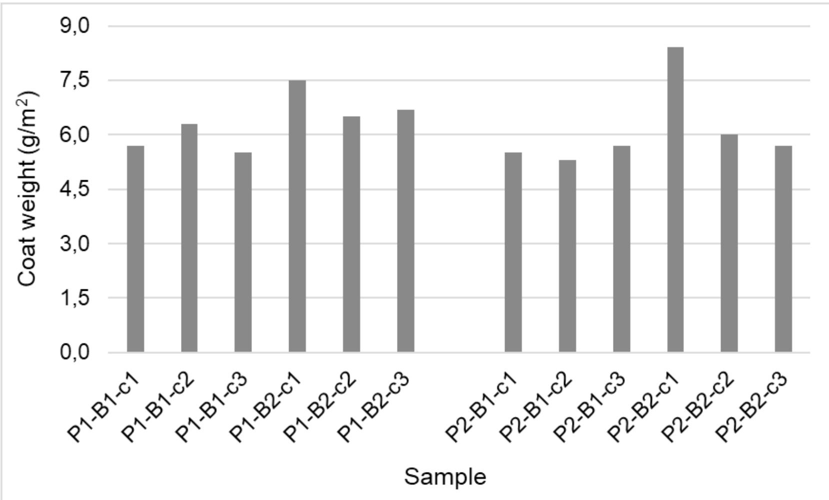


Figure 5. Coat weight of the created coatings.

3.4 Barrier properties

The barrier properties of the coatings are presented in Table 2. The results show that the paper samples without the barrier coatings, P1 and P2, are not resistant to grease and oils because even Castrol oil penetrates into both papers. The presence of all barrier coatings significantly increased the grease resistance of the papers resulting in the increase of the KIT values to 11-12 or even 12 which is the highest value. The results also revealed that the barrier component B2, irrespective to its concentration, provided excellent barrier for grease. In the case of the coatings including the barrier component B1, the KIT values were slightly lower.
Furthermore, the presence of all barrier coatings importantly decreased the Cobb-Unger oil absorbency of both papers. The oil absorbency was not significantly influenced by the structure of the barrier component, but it was in general decreased by the increase of the component concentration.
Both paper samples P1 and P2 were porous and provided high transmission of the water vapour. The presence of the barrier coatings decreased the water vapour transmission rate for more than 3-times in the case of P1 and more than 2.2-times for P2. Whereas both barrier components provided similar barrier for the water vapour on P1, the barrier component B1 was more effective on P2 in comparison with B1.

Table 2. KIT value, oil absorbency, water vapour transmission rate (WVTR) for paper samples without and with barrier coatings.

Sample code	KIT value	Cobb-Unger oil absorbency (g/m²)	WVTR (g/(m² 24h))
P1	non rating	2.40	430
P1-B1-c1	12	0.33	140
P1-B1-c2	11-12	0.17	130
P1-B1-c3	11-12	0.20	130
P1-B2-c1	12	0.27	130
P1-B2-c2	12	0.14	130
P1-B2-c3	12	0.18	120
P2	non rating	1.44	440
P2-B1-c1	11-12	0.16	200
P2-B1-c2	11-12	0.19	120
P2-B1-c3	12	0.16	120
P2-B2-c1	12	0.18	180
P2-B2-c2	12	0.14	170
P2-B2-c3	12	0.17	180

4 CONCLUSIONS

In this research, new effective water-based dispersion barrier coatings for grease, mineral oil and water vapour resistance were developed and successfully applied to the back side of two papers of different grammage, i.e. paper P1 with 80 g/m² and paper P2 of 55 g/m². Dispersions with higher concentrations of the barrier components displayed the best performance. The barrier coatings pass the TAPI T559 standard as well as the Cobb-Unger oil absorbency test on both papers and significantly decreased the water vapour transmission through the papers. However, to improve the water vapour barrier, the porosity of the coatings should be decreased. This remains our major challenge. Considering the importance of the development and implementation of the repulpable and more sustainable barrier coatings on the industrial level, these barrier coatings will be optimised in order to meet the requirements regarding the runnability of the application process.

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ENZYMATIC DEINKING OF FLEXOGRAPHIC PRINTED PAPER

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ABSTRACT: *Flexographic printing ink removal is a current and urgent issue to be solved by CEPIPRINT and its members. The reason that this topic came to their attention is the spread of flexographic for packaging printing. Extended range of flexographic prints could pose a major threat to European recycling targets (INGEDE, 2008). In our study, we tested the performance of different types of enzymes in comparison with the chemicals in deinking of flexo printed paper samples. The flexo samples were printed with water based and solvent based flexo inks on 150g/m2 matte coated paper. The samples were determined by the thickness, grammage and their optical properties (ISO whiteness, CIE Whiteness, with and without UV component).*

Keywords: chemicals, deinking, enzymes, flexo ink, recycling paper.

1 INTRODUCTION

In the European paper industry recovered paper plays an important role in achieving goals. It is observed that a large part of waste paper belongs to graphic papers, which are problematic in the deinking process. Deinking is a complex process and it depends on many factors (e.g. quality of the paper, type of printing process, properties of the printing ink, etc). Numerous studies include process optimization, but unfortunately, we have not noticed an actual progress in the deinking process (CEPI, 2009). Today, huge quantities of chemicals are used in the deinking process such as NaOH, Na_2SiO_3, Na_2CO_3, H_2O_2, chelating agent and surfactants (Pathak et al., 2010). In any case, it is very important to reduce chemicals and replaced them with environmentally more friendly substances, for example, enzymes. Bajpai (2014) reports that the use of enzymes has been suggested as an environmentally friendly alternative to supplement conventional deinking chemicals. Enzymes could reduce the demand for chemicals and would lower the process costs and the environmental impact. These enzymes include cellulases, pectinases, amylases, lipases, esterases and laccases. If the proportion of hydrophilic inks is large, it represents a major issues for deinking process, because flexographic and other hydrophilic inks are not able to be removed by flotation. This means that it is very important to find a suitable solution for removing this type of ink (Josephson & Krishnagopalan, 2015). Such a challenge involves optimization of pulping conditions, including use of different type of enzymes. But however, existing technologies have not been able to fully reduce the negative impact of pigmented inks on deinking of recycled paper (Hsieh, 2012; Kemppainen et al., 2011; Bhattacharyya e tal., 2009; Miller, 2009). Also, Lee et al. (2013) were not effective in their research, because they have not been shown to remove hydrophilic inks such as inkjet and flexographic inks to an acceptable degree.

During our study, we have shown that the efficiency of enzyme treatment is comparable to the efficiency of chemical treatment. First we have determined the optical properties, which are considered by the point that they are the most important, because of removing ink particles. In the following, more attention will be paid to mechanical properties.

2 EXPERIMENTAL

In our study, we compared different deinking processes by using chemicals and specific enzymes (cellulase, enzyme mixture). We investigated which treatment was more efficient by determining the optical properties of the laboratory paper sheets after.

2.1 Samples

Samples were printed with water based and solvent based flexographic inks on 150 g/m^2 matte coated paper (Figure 1).

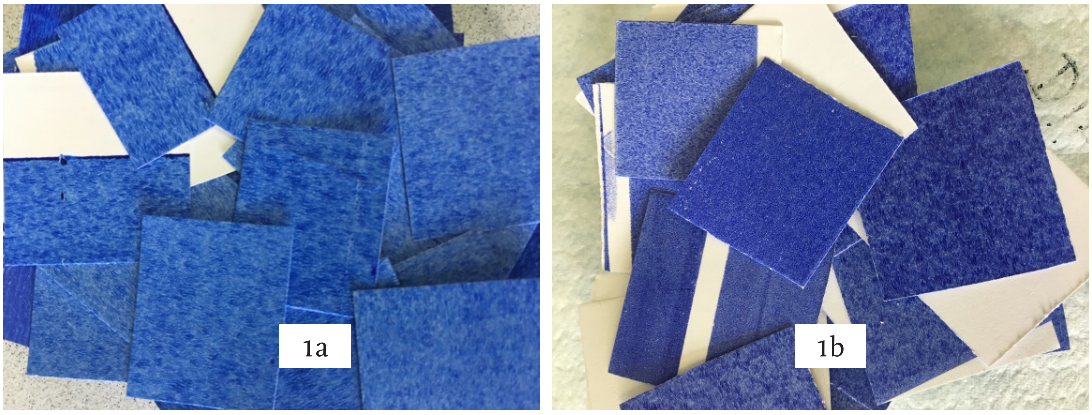

Figure 1. Flexographic prints – water (1a) and solvent based (1b) samples.

2.2 Deinking process

Samples were merged and cut to pieces of 2x2 cm. We also determined dry matter, according to the standard EN 14346: 2007, and the loss on ignition according to the standard DIN EN 12879: 2001. Each sample weighed 75 g of absolutely dry matter.

The deinking process was carried out by slightly modified INGEDE 11 method.

Chemical deinking process
During the experiment we used the following chemicals: sodium hydroxide (NaOH), collector (Nopco fleet), sodium silicate (Na_2SiO_3) and hydrogen peroxide (H_2O_2). All these chemicals were obtained from the Slovenian paper mill Vipap Videm Krško d.d..
100 mL of H_2O_2 was added into the solution of chemicals (400 mL) and the mixture was diluted with water to a volume of 1500 mL. 75 g of absolutely dry sample was added to the mixture of chemicals during constant stirring at 3000 rpm in a thermostat spreader (T = 45 °C, time of mixing 20 minutes). The temperature was maintained by using a water bath. Once the dissolution was completed, the mixture was stabilized in a water bath for 60 minutes at a constant temperature of 45 °C. Based on the standard, the recommended pH value was 9.48. Next step was flotation of the previously dissolved sample, which took place in a flotation cell in the presence of water (18 L). Substance concentration during flotation was 0.42%. After flotation process laboratory paper sheets were prepared.

Enzymatic deinking process
75 g of absolutely dry sample was added to 1200 mL of water during constant stirring at 3000 rpm in a thermostat spreader (T = 45 °C, time of mixing 5 minutes). The temperature was maintained by using a water bath. Once dissolution was completed, we added 100 mL of enzyme dilution we prepared (99 mL of water was added 1 mL of enzyme, at temperature 55 °C), for 20 min at 55 °C and occasional stirring. At the end of the enzyme treatment collector (Nopco fleet) was added to the mixture.

Analysis of optical properties
ISO brightness and CIE L*a*b* coordinates of laboratory paper sheets were measured using WinPaper Elrepho 450 X Datacolor spectrophotometer. CIE76 delta E formula was used to determine the quality of the deinking process. Imaginary white surface with L*a*b* coordinates 0, 0, 100 was used as the reference in calculations.

3 RESULTS & DISCUSSION

3.1 Optical properties

Higher ISO brightness was achieved by enzyme deinking of water based flexographic print in comparison with chemical deinking: + 0.51% with cellulase and + 2.61% with enzyme mixture treatment. ISO brightness of solvent based flexographic print was also higher by enzyme deinking in comparison with chemical deinking: + 0.14% with cellulose and + 1.69% with enzyme mixture treatment.

Table 1. ISO brightness after deinking process.

	ISO brightness (%)		
Sample	Chemical treatment	Enzyme treatment (cellulase)	Enzyme treatment (mixture)
Flexographic print - water	80.71	81.22	83.32
Flexographic print - solvent	83.04	83.18	84.73

Delta E value of flexographic print with solvent based is lower in comparison with water based, which corresponds to higher ISO brightness values of solvent based inks, as seen in Table 1. We assigned it as the consequence of different inks used.
The lowest delta E value was achieved with mixture enzyme treatment, following cellulase treatment and chemical treatment (Figure 4 and 5).

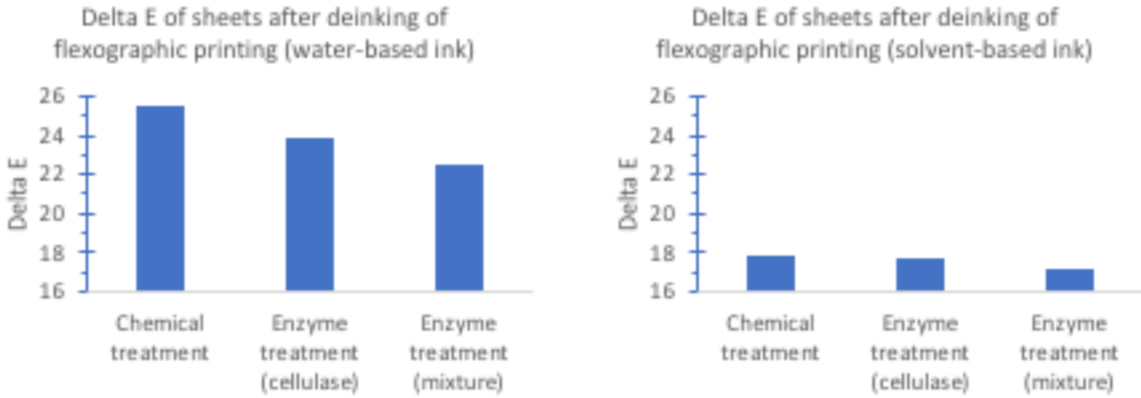

Figure 4, 5. Delta E after deinking process.

Based on the results we can conclude, that deinking with enzymes is at least same efficient as chemical deinking in the case of flexographic ink removal. In a few years' time, we can expect even more studies in this field especially because of especially because of environmental legislation that is increasingly strict.

3.2 Reduction of pulping time

During the study we succeeded shorter processing time by enzymes. Duration time during enzyme treatment (pulping) was 25 minutes and 80 minutes by chemicals.

4 CONCLUSIONS

In our study, we focused on enzyme treatment, with the aim to replace chemicals using during the deinking process. We determined the optical properties, and on the basis of these we determined the efficiency of the ink removal. The issue was also to reduce the pulping time, because this is very important in terms of process costs. The processing time with enzymes was reducing by about 3 times. The fact that we have proved that the chemicals can be at least partially replaced with enzymes is definitely a big contribution for papermaking industry, since the impact on the environment considerably lower.

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EVOLUTION OF NATURAL PATTERNS from RANDOM FIELDS

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ABSTRACT: In the article a transition from pattern evolution equation of reaction-diffusion type to a cellular automaton (CA) is described. The applicability of CA is demonstrated by generating patterns of complex irregular structure on a hexagonal and quadratic lattice. With this aim a random initial field is transformed by a sequence of CA actions into a new pattern. On the hexagonal lattice this pattern resembles a lizard skin. The properties of CA are specified by the most simple majority rule that adapts selected cell state to the most frequent state of cells in its surrounding. The method could be of interest for manufacturing of textiles as well as for modeling of patterns on skin of various animals.

Keywords: random field transformation, cellular automata, labyrinthine pattern, lizard skin.

1 INTRODUCTION

Many technological problems require physical characterization of developing fields by a quantitative field variable S(r,t) denoting measureable properties like material composition, surface roughness, color, etc. This variable generally depends on the position r and time t. The development of the field can be physically described by the evolution equation [1]:

$$\partial \boldsymbol{S}(\boldsymbol{r},t) \,/\, \partial t = \mathbf{G}(\boldsymbol{S}(\boldsymbol{r_o}, t);\ \boldsymbol{r_o} \in \mathrm{O}(\boldsymbol{r})) \tag{1}$$

Here O(r) indicates a properly selected surrounding of the point r and G(...) denotes a nonlinear field generator function that generally includes differential and integral operators. Eq. 1 has already been utilized in the study of various rather complex phenomena leading to formation of patterns in technical and natural environments [1-7]. Among them the generation of patterns by various reaction-diffusion processes in chemical reactors, plasma and biological environments are the most outstanding [2,7,8]. Fig.1 shows the field of ionization waves in a turbulent plasma developed from random initial conditions as determined by the numerical solution of a nonlinear integro-differential reaction-diffusion equation of type Eq. 1. Surprisingly, it resembles a characteristic pattern of a muscular structure.

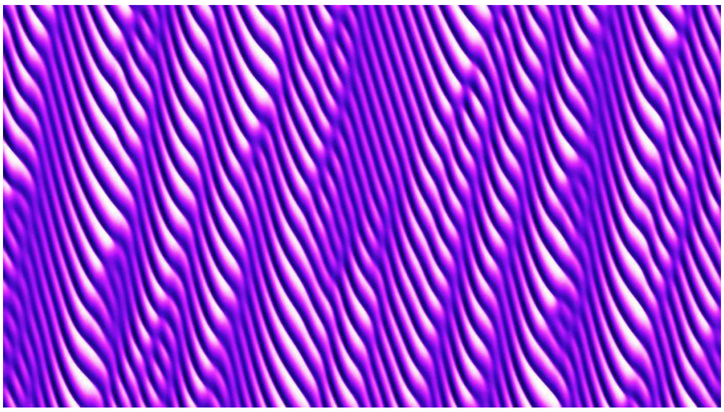


Figure 1. Distribution of turbulent ionization waves in a plasma of a glow discharge in a tube of argon. The distribution was determined by solving a nonlinear integro-differential reaction-diffusion equation of type Eq. 1 using random initial conditions and periodic boundary conditions [2]. The horizontal coordinate corresponds to time and the vertical to the axial coordinate of the discharge tube.

For the numerical treatment a discrete joint variable s = (r,t) is usually introduced into evolution equation (1) and then it is transformed into the mapping relation [2,4]:

$$S(s) = G(S(s_o);\ s_o \in O(s)) \qquad (2)$$

This relation maps the old field distribution into the new one: S(so)®S(s). In such a case Eq. 2 represents a general form of multi-dimensional cellular automaton (CA) [8]. In order to apply it, one has to specify the generator function G(…), a discrete lattice of cells, initial and boundary conditions, as well as to solve Eq. 2 numerically. The generator function G(...) can be specified either theoretically, based upon physical laws governing the treated phenomenon [8], or empirically from experimental records of the field S(s) [4,6]. In the last case a neural network can be applied to express the generator function in terms of recorded data [1,3,4,5]. Eq. 2 is convenient for modeling of patterns in graphic art and technology as well as in biology [1-7].

Figure 2. A characteristic pattern on a lizard skin.

2 SPECIFICATION OF CELLULAR AUTOMATON

The goal of the present article is to demonstrate applicability of Eq. 2 by modeling patterns of complex irregular form. For this purpose we first consider transformation of an initially random field by a two-dimensional cellular automaton into a new pattern resembling a lizard skin. This example is selected since it could be of interest for manufacturing of textiles as well as for modeling of patterns on skin of various animals [6]. For the specification of the CA structure we examine the pattern on a sample of lizard skin shown in Fig. 2. The pattern is comprised of scales representing approximately hexagonal cells, and consequently, we first accept a hexagonal lattice as the basis for the operation of our two-dimensional CA. In this case each cell is surrounded by six neighbor cells as shown in Fig.3.

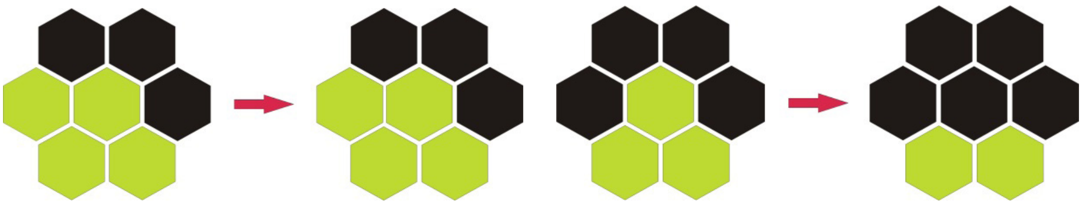
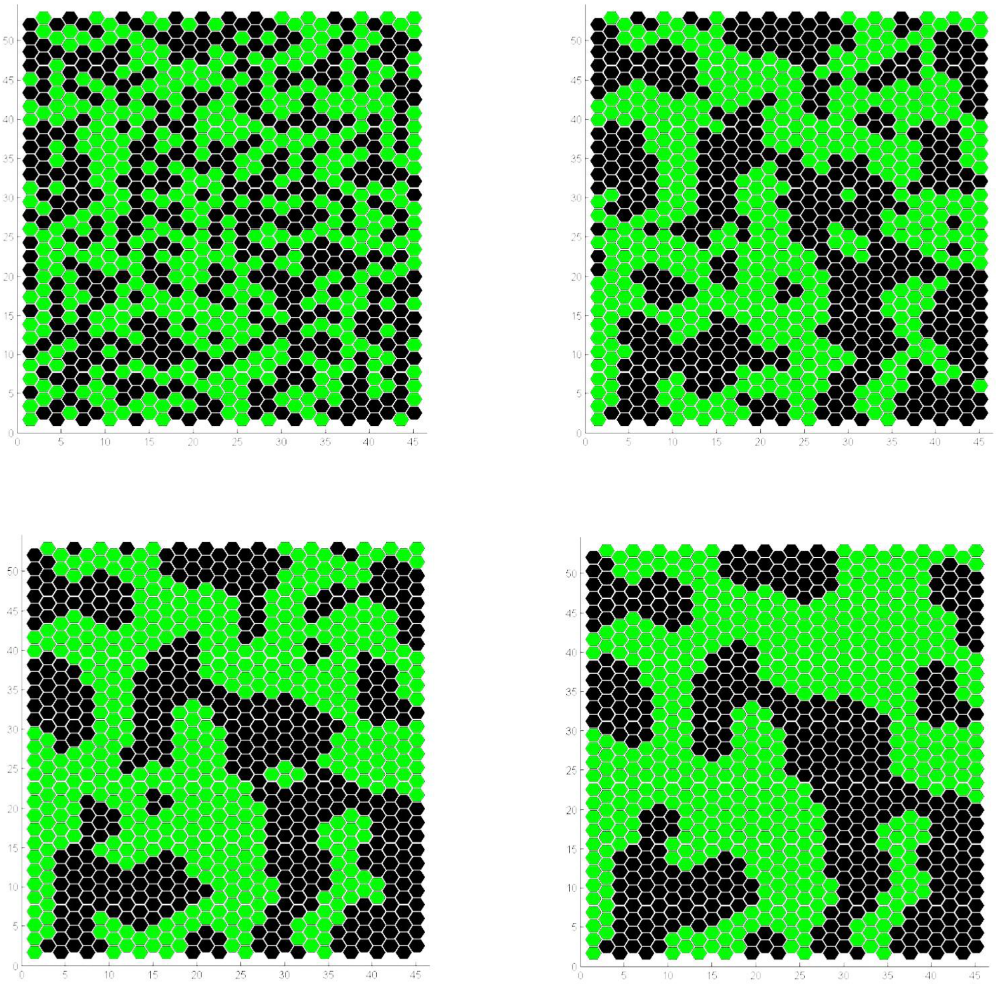


Figure 3. Two characteristic examples of center cell adaptation to its surrounding by the majority rule, left: without change, right: with a change of state.

3 EXAMPLES

In the first example we apply the hexagonal lattice. The initial random field distribution is shown in Fig. 4 A while the distribution after 1st , 2nd , and 10th action are shown in Figs. 4 B, C, D respectively. In the first CA action many cells change the color, but the number of changes ΔN in a single action is decreasing with the number A of CA actions and ceases after several steps. This property is demonstrated in Fig. 5. It shows the total number of state changes N in dependence of the number A of CA actions. It is evident that our rule removes single jumps in the field distribution and yields more smooth variation in the final pattern. In spite of this smoothing effect the irregular character of the labyrinthine pattern is still preserved. This property does not depend on particular properties of the initial random field sample and resembles the effect of a digital filtering or changing of patterns by convolutional neural networks. Comparison of the final distribution in Fig. 4 D with the distribution on a real lizard skin shown in Fig. 2 reveals surprising similarity of characteristic features. Similar properties as on the hexagonal lattice exhibits CA also on a quadratic lattice. Figs. 6 and 7 show results corresponding to Figs. 4 and 5. In this case the lines of the final pattern appear more cornered and the number of changes caused by CA actions is higher as in the hexagonal case. At some places a cyclic changing of state caused by successive CA actions can take place that leads to permanent increasing of N with A.



A B

C D

Figure 4. Distribution of the initial random field – A and distributions after 1st - B, 2nd - C,and 10th – D action of CA on the hexagonal lattice.

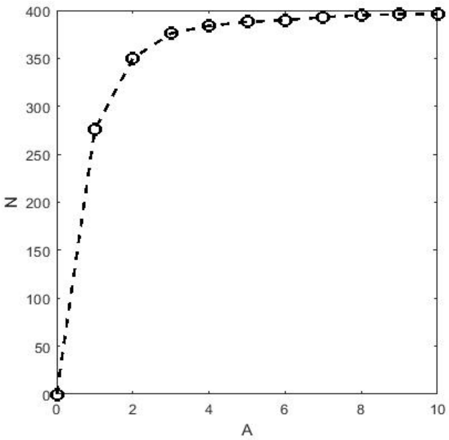
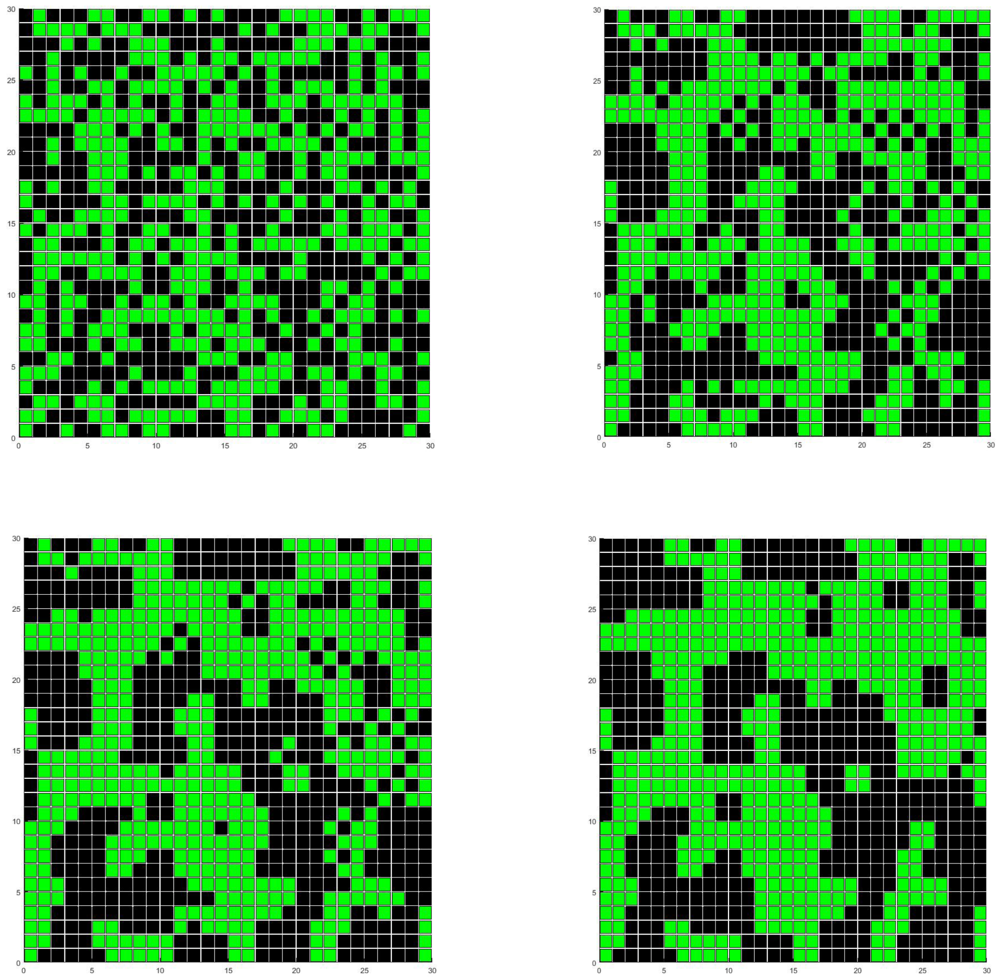


Figure 5. Number of changes N caused by A actions of CA on the hexagonal lattice.



A

B

C

D

Figure 6. Distribution of the initial random field – A and distributions after 1st - B, 2nd - C, and 10th – D action of CA on the quadratic lattice.

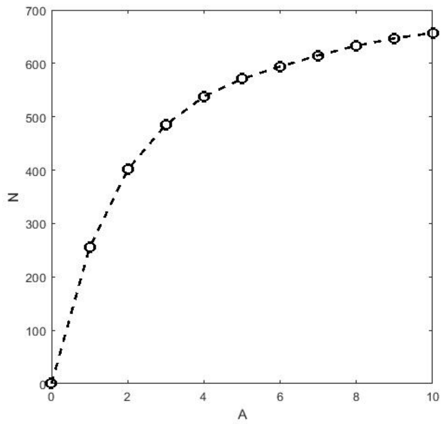


Figure 7. Number of changes N caused by A actions of CA on the quadratic lattice.

4 CONCLUSIONS

Our first example indicates applicability of the hexagonal cellular automaton for modeling of irregular complex patterns resembling the lizard skin. The second example reveals that the structure of CA lattice influences the roughness of the lines in the generated pattern. Since we consider just the nearest cells on the hexagonal or quadratic lattice, the lines of the generated patterns are rather cornered. By taking into account also more distant cells this weakness can be improved. At the specification of the generating function G(…) we here apply just the most simple majority rule. However, by changing this function, as well as the basic lattice, the properties of patterns can be well adapted to given samples [1,4,5]. For this purpose the function G(…) can be determined from given field records as has been described elsewhere [4,6].

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EYE TRACKING ANALYSIS OF INTERNAL FACIAL FEATURES IN OBSERVATION AND RECOGNITION PROCESS

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Abstract: *The aim of our research was to examine how people observe facial images for different observation times. A single test consisted of two parts: observation and recognition. Observation tests were divided according to the different observation times (1, 2, 4 and 8 seconds). First analysis of our testing was focused on the recognition test where we measured correct and incorrect recognition. In second investigation we measured observation times of the internal facial features (eyes, nose, mouth).*
Our main goal was to find possible correlation between observation times of main three facial features and recognition results. We found out that 4 second is a turning point where participants looked all face (all facial features) and their gaze returned back to the area of internal facial features. Correct and incorrect recognition has also turning point at 4 seconds test. That was also confirmed by gazeplot obtained from eye tracker.

Keywords: eye-tracking, face recognition, face image, facial features, region of interest.

1 INTRODUCTION

The use of facial images is currently very widespread, and features in many different aspects of our lives, e.g. web presentations, criminalistics, security, psychology, neuroscience, advertising, marketing, etc. It is also important that the people working for various institutions, associations and companies are represented accurately by their facial image online. How we look at and remember faces had been part of a many research studies for several decades.

During the face observation and recognition process, the most important parameter is the length of time that the face is presented during the observation phase (Reynolds, 1992, Leyk, 2008; Iskra, 2016)

Currently, there are two main directions that have been taken in facial image research. One group focuses on emotional facial expression (Malcom, 2008; Cangöz, 2013). Most researchers define six main face expressions (beside neutral) which are happy, sad, angry, disgust, surprise and fear. Some researchers add also annoyed and grumpy. The second area in facial image research that has been extensively explored is the different angles with which a face can be presented (Brooksô, 2007, Brielmann, 2014). Both areas are connected by exploring how people see different facial features (Want, 2003; Henderson, 2005). Our goal was to find any possible connection between face recognition success and procedure of face observing by investigating portion of observation for certain face features. Due to the extensive number of parameters we limited our experiment by use of only frontal face images with neutral face expression.

2 EXPERIEMENTAL

As mentioned above, we deal with several parameters that can influence the way participants observe and recognize faces. In our investigation, we focused only on frontal facial images with a neutral facial expression. We used the faces of Caucasian race and a similar age to our participants and considered them to be typical faces. We also attempted to implement the real circumstances we are faced with in everyday situations.

2.1 Participants

The test participants were our students, all of whom were aged between 19 and 23 years old with normal vision. The participants were divided into four groups according to four different observation times. There were 41 participants. Since a Tobii eye tracking detection rate of 90% was required (Tobii Studio user manual, 2012), we performed our tests in such a way to ensure that there was an equal number of participants in each test group that passed that criteria. Eigth participants were allocated to each group, which meant that the results for 32 participants were analysed in total.

2.2 Stimuli

The facial images were obtained from the Minear and Park facial database (Minear, 2004), which was created by photographing volunteers in controlled conditions. The two main categories for organizing this database were age and emotion expression and include all four main races (Caucasian, Black, Asian and Indian). We took the facial images of 20 male and 20 female Caucasian people aged 18 to 29 years old. This was done in order to have similar test participants and stimuli, and to avoid the influence of others parameters (race, age, emotion) on recognition performance. It was proven that people have different learning processes and recognition performance for faces of different races (Goldinger, 2009). All images were prepared in dimensions 1280 × 960 px.

2.3 Apparatus

All of the tests were performed using the Tobii X-120 eye tracker. The monitor was 24'' with a resolution of 1440 × 900. Although a higher resolution could be set on the monitor, we were forced to set lower resolution due to the restriction of Tobii studio 3.4.4 software which was used to collect and analyse the testing data. The distance between the participants and the monitor was around 60 cm (Goldinger, 2009; Cangöz, 2013).

2.4 Procedure

We designed four tests according to the different observation times of facial images presented. All of the facial images in the tests were the same. Each participant performed one of the four tests. As mentioned above we investigated correlation between observation time, recognition success and portion of observation time for main three face elements. Observation times were set for 1 second, 2 seconds, 4 seconds and 8 seconds. The test for the participants was divided into two parts. The first part was the observation test and the second part was the recognition test. Calibration of the eye tracking system was carried out for each participant at five control points and was performed at the beginning of the test. The observation part consisted of 20 images (10 male and 10 female images). This testing procedure was automatic and is shown in Figure 1.

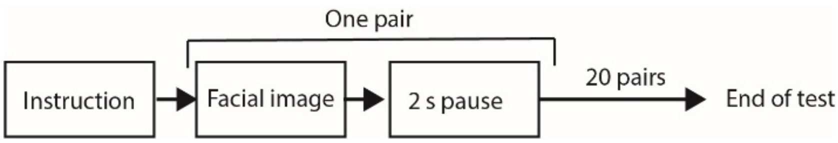

Figure 1. Procedure of the observation test.

After the initial instructions participants clicked mouse button for the first facial image. After the observation time of facial image (depending on the test), there was a 2 second pause with dark screen. The purpose was to neutralize the position of the eyes (Cangöz, 2013). In that case last fixation of the previous facial image had no influence on the first fixation on the next facial image.

The second part of our testing was focused on the recognition test, which was controlled by the participants themselves. The test comprised 40 facial images, 20 from observation test and 20 new faces from the same group as before (Caucasian race, neutral expression, aged 18–29). These 20 new faces were also equally divided into 10 male and 10 female facial images. After the instructions were provided, the first facial image was displayed. The participants were required to answer YES or NO if they saw that face image in the observation test. The answers were then recorded manually. After providing each answer, the participants clicked the mouse and the next image appeared. The order of the images presented was previously prepared (not random), but was the same for all participants. This made analyses of the results much easier to carry out than if the facial images presented to every participant would be completely random. Since there was no time limit, each participant had as much time as they needed to think about each image, but usually answers were said relatively quickly after the appearance of the face image. The recognition test procedure is presented in Figure 2.

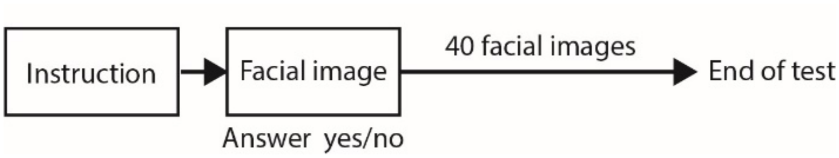

Figure 2. Recognition test procedure.

2.5 Analysis 1

First analysis was focused on recognition success. We measured the effectiveness of recognition in relation to the observation time of the facial image. We defined two terms:

- CR (correct recognition). The facial image was in the observation test and the participants confirmed this by answering YES.
- IR-FA (incorrect recognition – false alarm). The facial image was not included in the observation test, but the participant stated that he/she saw it.

2.6 Analysis 2

The focus of this analysis was on portion of observation time for three main facial features (eyes, nose and mouth). For this purpose, we drew an AOI for each face image manually. An example of an AOI is shown in Figure 3.

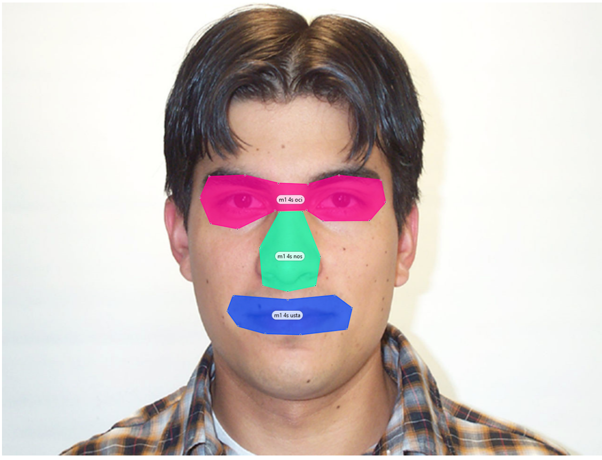

Figure 3. Setting of AOI on facial image.

Defining AOI meant that we got number of fixation, average fixation duration and total observation time for all AOI's for all facial images in the observation tests. We calculated average observation time for all participant together for each facial feature for different time tests (1s, 2s, 4s and 8s). The final results were presented as a percentage of the total observation time for every facial feature.

3 RESULTS & DISCUSSION

3.1 Analysis 1

Recognition test gave us results for correct recognition for all four observation times and can be seen in Figure 4.

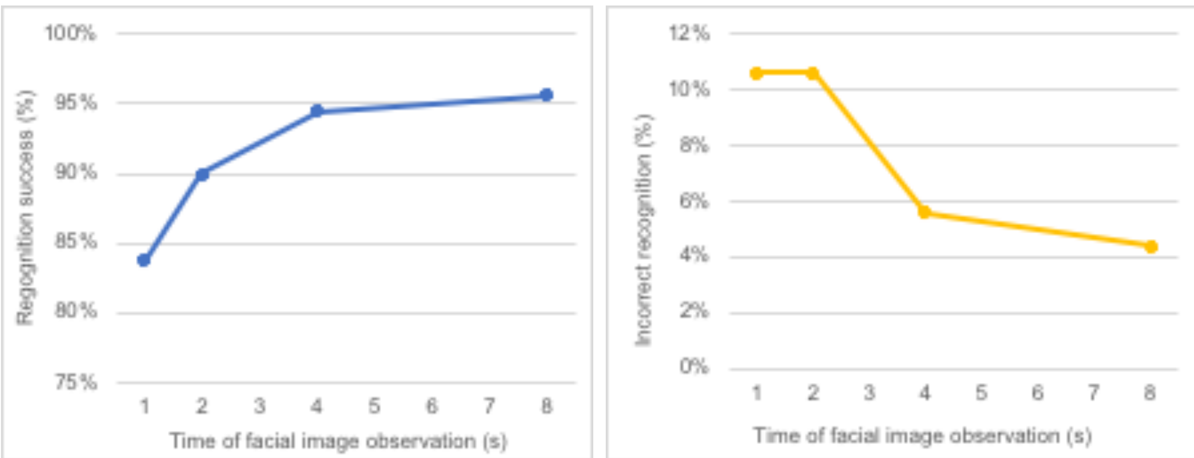

Figure 4. Recognition success (%) and incorrect recognition (%) in dependence of observation time.

Figure 4 show the predicted relationship between observation time and recognition success (correct recognition and incorrect recognition). Longer presentation of facial images meant better recognition performance. The curve is steep for a short observation time, which means that recognition success improves significantly as the observation time increases until the 4 second presentation time, which is when the curve starts to flatten out. Recognition success level got is some kind of saturation. We also analysed incorrect recognition, which is commonly also referred to as False Alarm. In this case, the participant responded that that face was presented in the observation test, despite this not being the case (the participant made a mistake). As we expected, incorrect recognition gave us opposite curve shape from the correct recognition. Longer observation time for facial images meant less number of incorrect recognition. Here the turning point is again at 4 seconds observation time, because at this point the level of incorrect recognition dropped significantly from the level at 2 seconds test. On the other hand, 8 seconds test did not improve incorrect recognition much. Also 1 second test had the same incorrect recognition level as 2 second test. This showed that 4 second face presentation in sufficient enough that incorrect recognition level is satisfactorily small. Our results of recognition success confirmed previous researches (Henderson, 2005; Iskra, 2016).

Results of second analysis gave portion of time spent on main three facial features (eyes, mouth, nose) in dependence of observed time. Tobii Studio gave us the total time spent on these AOI and we calculated the relevant portions for all the facial features. The results are presented in Figure 5.

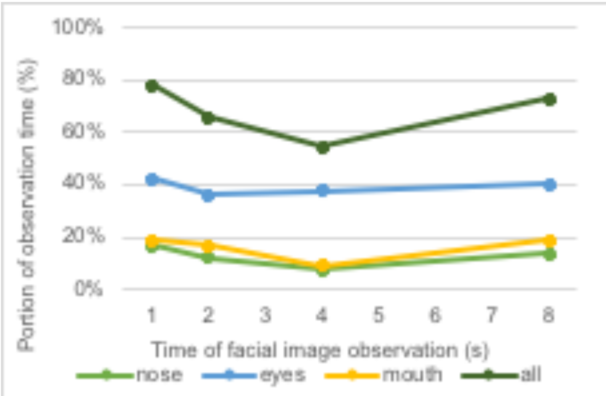

Figure 5. Portion of observation time for the main three facial features and the cumulative portion.

We attempted to discover the pattern of how participants looks at facial images when they are presented at different observation times. For observation time 1 second the percentage of observation of three main face elements were quite high. All three main facial features took over 3/4 of the total observation time (77.9%). In these short observation time, the participants' gaze mostly remained directed towards the centre of the face. These three main facial features are also referred to as internal or central facial features (Henderson, 2005; Hills, 2014).

This changed at observation time 2 seconds. Here participants had enough time to start observing also other facial feature (chin, cheeks, forehead and ears), so portion of observation for main three facial features dropped (eyes from 42.5% to 36.4%, mouth from 18,9% to 16,9%, nose from 16,6% to 12,4%). These trends continued also for 4 seconds observation time (eyes 37,9%, mouth 9%, nose 7,4%) where observation percentage for mouth and nose dropped hugely. Absolute time for observing mouth and nose were almost the same for 2 seconds and 4 seconds tests (mouth 0,34 s and 0,36 s; nose 0,25 s and 0,3 s). Percentage of eye observing already slightly increased (participant's gaze returned back to eyes). For observation time 8 seconds these "return" effect was even more obvious. The percentage of observing main three facial features (internal) again increased significantly. In total percentage from 54,2% to 72,7%. In terms of absolute observation time, this meant an increase from 2,17 seconds to 5,81 seconds (Figure 5). Therefore, from additional 4 seconds of observation facial image (difference from 4 seconds and 8 seconds tests), 3.64 seconds was spent on the three central facial features. In absolute time, a huge increase was shown in the mouth (from 0,36 s to 1,52 s) and nose (from 0,3 s to 1,09 s) area. All of these results and the scan path of the participants' gazes revealed that sequence followed when looking at the face was the eye → mouth → nose → external facial features → internal facial features. A time period of approximately 4 seconds was sufficient to observe the whole face, before reverting back to the internal facial features. This pattern can be seen in Figure 6.

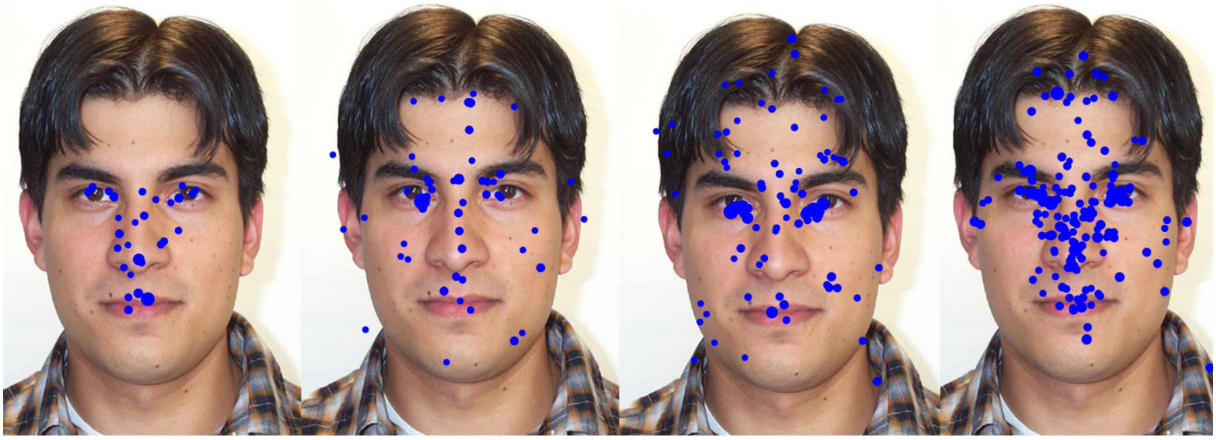

Figure 6. Gazeplots for different observation times (1 second, 2 seconds, 4 seconds and 8 seconds).

First face image shows gaze mostly at internal facial features, then participants start looking also other facial features (2 seconds test), at 4 seconds they start returning to the eyes area (mouth and nose portion are at the lowest value), at 8 seconds observation time internal facial features again had most of the fixations.

4 CONCLUSION

Results of both analyses showed us that in process of observing face image had similar pattern for most participants. First they looked at eyes, then moved their gaze to other two internal facial elements (mouth and nose), after that we observe other less important facial elements (forehead, chin, cheek). All this procedure happened in app. 4 seconds, when participants returned to the internal face elements. This 4 seconds observation time was also breaking point for memorizing faces, which was shown at recognition tests. Correct recognition reached sufficient level at 4 seconds test and longer observation time did not significantly improve recognition success. That breaking point was even more obvious at incorrect recognition, when level of wrong recognition dropped significantly at 4 seconds test. We can conclude that it took 4 seconds for the participants to see the whole face, and that this time was sufficient for all the facial features to be seen. For longer observation times, the participants just went back to observing the internal facial features, which did not improve their recognition performance.

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HOW COLOR SHAPES BRAND IDENTITY

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Abstract: The objective of this research was to analyse logotypes of the banks on the Slovenian market by colours and to compare colours with their values and principles and with the colour scheme made by the Towergate Insurance. The banks were divided into two groups by origin into the well-known old banks and the newcomers. As will be shown in the research, the most preferable colour in the logotypes of the Slovenian banks is blue, however the logotypes of the newcomers are more colourful, composed of green, red, black and blue. The colours are in most banks related to bank values and principles, although some additional colours like yellow and especially green are suggested to be used in the logotypes the well-known old banks. In research an additional quiz was performed related to the recognizability of the bank logotypes according to the colour. The results were impressive, since the logotypes of some banks scored almost 80% recognisability according to their logotype colours.

Keywords: logotype, colour, colour scheme, bank, values.

1 INTRODUCTION

A logotype is not a brand, but rather a form of a brand's expression; it has a significant impact because it represents a promise. A logotype must be something completely new, but not overly classical, so it might remain popular for a longer period (Wiedemann, 2005). Macnab (2008) suggested that a logotype should be natural and harmonious, comprising simple numbers and forms, and more focused on quality than on quantity. The symbols used must be meaningful and recognisable, regardless of the spoken language. The elements of a logotype can be pictorial, typographic or a combination of both. However, thought must be given to the selection of all elements, and the appropriate colours must also be chosen (Walch, 1995), as they may evoke both positive and negative feelings in people (Trstenjak, 1996). Chen and Chen (2007) claimed that, besides the symbols and text used, colour is also a function of communication, identification and symbolism, and that its meaning is often forgotten. The right colour or colour combination of a logotype appeals to the appropriate target audience.

The interesting observation about suitable colour for the business/institution was introduced by Jacobs et al. (1991) in the research about cross-cultural meanings of colours. They found that some colours had universal meaning while others did not. For example, the results showed that in China and Japan colour grey was associated with word inexpensive, while in the USA this colour was associated with expensive as well as high quality and dependable. On the other hand, colour blue connoted high quality in all tested societies (China, Japan, USA and South Korea) and had meaning of sincere and trustworthy in South Korea. All cultures identify colour red with love and adventure, and with good-tasting (except for China where colour red is associated also with good luck). Colour purple was associated with expensive in the Asian culture, but inexpensive in the United States. Colour black was associated with powerful and expensive in all four countries and as dependable in both China and Japan. The Chinese associated black also with being trustworthy and high quality. According to the research, colour brown was the most often associated with restaurants in USA, China, Korea and Japan; colour grey was associated with hospitals, governmental buildings, factories, and museums, while school were most often associated with colour green. An interesting conclusion was that companies with a monopoly or a superior product may not need to be concerned with colour. As long as product has little direct competition, colour may not be significant. And vice versa, when company introduces product into highly competitive foreign market it should investigate the meaning and significance of the selected colours in the target market.

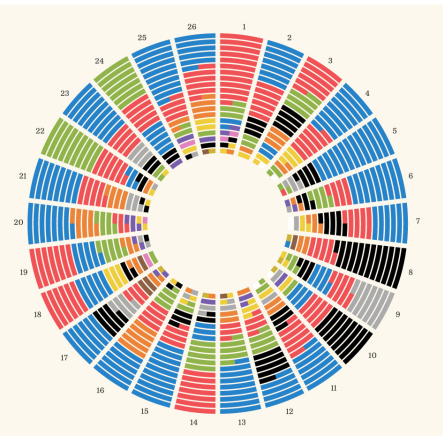
In the research of Grimes and Doole (1998), remarkable similarities were noticed among UK and Taiwanese cultures in terms of the emotions associated with colours. Also in this research it was concluded, that colour associations are likely to be similar across cultures and that the standardised use of colour can and should be a very powerful tool in creating international brand identity and awareness. They also emphasized that colour is a tool of evolution, not revolution.

In the research performed by Madden et al. (2000), it was revealed that although respondents from eight countries (Austria, Brazil, Canada, Colombia, Hong Kong, China, Taiwan and the USA) shared similar associations with colours, they have different tendencies about matching colours in a logo design. Thus, choosing colours(s) for logotypes should be done with understanding of how colours and their combinations are perceived in each culture. However, some cultural differences must be considered and thus for example, the logotype of the company McDonalds in Israel was redesigned from the traditional yellow arches and red background into blue and white, with the word "kosher" alongside for their restaurants where the kosher food is served. (Chang, 2010; McDonalds changes logo in Israel to show that its food is kosher, 2006)

Besides cultural differences, age and gender of target audience must also be held in mind when choosing logotype colour(s). In the research of Dittmar (2001) it was revealed the change of colour preferences during the life span i.e. the preference for colour blue decreased steadily from age 19 to age 90 years, while the popularity of green and red increased with ages in both gender. As it was noticed by De Bortoli and Maroto (2001), younger children were more attracted by strong, warm, and intense colours, while over the years those colours became less violent with softer shades.

A lot of studies have been focused on the selection of colours for certain business (Towergate Insurance, 2017; A Guide to Choosing Colors for Your Brand, 2017; Color Emotion Guide, 2013; MacDonald, 2018). From those studies can be seen that certain colour is not tied to any particular business. For example, colour red in the logotypes of fast-food companies (i.e. McDonalds, Burger King, KFC, DQ etc.) catches the attention of customers, but is not pleasing to look at for an extended period, meaning customers soon leave the restaurant and leave space for others. (Chiazzari, 2000) On the other hand, colour red also denotes feelings of power, energy, passion, love, motivation, aggression or danger and thus it can also be found in logotypes of different beverages (e.g. Coca-Cola, Pepsi, Red Bull), automotive and racing industries (e.g. Toyota, Mitsubishi, Honda, Formula 1), broadcasting (e.g. CNN, BBC News), entertainment/music groups (e.g. Rolling Stones, AC/DC, Epica, Iron Maiden), footwear (e.g. Puma, Diesel) etc. Depends on emotions and feelings which those logotypes should evoke, they include smaller or higher percentage of different shades of colour red.

Although logotypes mostly follow some "standardise" colour schemes, some deviations from those norms can be found on the market. In this article, the emphasis is given to the logotypes of the banks on the Slovenian market, thus some information on topic from different sources are given in the continuation. MacDonald (2018) has noticed, that "banks have tried to differentiate themselves by choosing a simple memorable colour scheme." From the Towergate Insurance survey (2017) can be seen that banking predominately uses blue to promote smart, trust and dependability and also red to promote confidence and ambition (Fig. 1). In smaller shares, banking also uses colour black in their logotypes denoted maturity and balance, colour green which is associated with wealth, initiative and growth, colour orange denoted with affordability and confidence and colour yellow associated with happiness and optimism. De Bortoli and Maroto (2001) explained that colour orange is sometimes associated with cheapness, colour grey with strength, exclusivity, and success and blue with wealth, trust and security. These associations explain why banks are more likely to use blue and grey for their logotypes rather than orange. Although "classic" and almost conservative colour schemes are usually used for bank logotypes, colours must be adjusted to the market, target audience, values and principles of companies, etc.



1. Restaurants
2. Banking
3. Beverage
4. Airlines
5. Comms Equipment
6. Computer Services
7. Consumer Electronics
8. Apparel & Accessories
9. Auto & Truck Manufacturers
10. Broadcasting & Cable
11. Consumer Finance
12. Department Store
13. Electronic Utilities
14. Food Processing
15. Heavy Equipment
16. Home Improvement
17. Hotels & Motels
18. OIl & Gas Food Retail
19. Pharmaceuticals
20. Publishing
21. Specialised Chemicals
22. Comms Services
23. Courier

Figure 1. Colour scheme of certain industries made by Towergate Insurance (2017).

The aim of our research was a) to analyse colours of the bank logotypes which can be found on the Slovenian market, b) to compare gained colour scheme with the scheme made by the Towergate Insurance (2017), c) to determine if colours correspond to values and principles of each bank and d) to investigate, if banks could be recognised through the logotype colours.

2 EXPERIMENTAL

On the Slovenian market, 12 banks were chosen and divided into two groups by origin i.e. six well-known old Slovenian banks (some with more than 100 years tradition) and six newcomers. For each bank, colours of their logotypes were analysed in whole and according to symbols and typography in program application Adobe Photoshop CC 2018. Logotype colours were taken from their corporate identity (CI) guidelines or in the case when CI was not available, colours were taken from logotypes found on their internet pages. After colours were analysed, results were compared with colour scheme made by the Towergate Insurance (2017). The values and principles of each bank were identified from their web pages and compared with their logotype colours.

During the research, we were playing with an idea, how to determine the recognisability of banks according to their logotype colours. Thus, we performed an online quiz in which respondents had to determine which colour combination is related to the specific bank. The colour combinations of bank logotypes were design in Adobe Illustrator CC 2018 and are shown in Fig. 2. The quiz was completed by 156 respondents (75.5% female, 24.5% male) mostly students (80.7% were younger than 30 years and 19,3% were older).

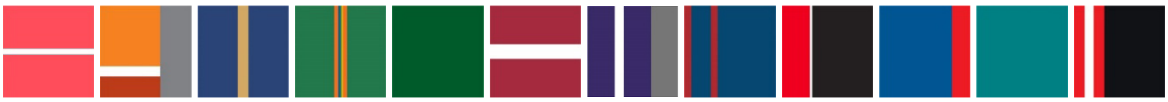


Figure 2. Colour combinations of twelve analysed logotypes.

3 RESULTS WITH DISCUSSION

3.1 Comparison of logotype colours by the Towergate Insurance colour scheme

The colour analysis of 12 different logotypes revealed some interesting results. The logotypes were analysed as a whole (Fig. 3) and separately by their symbols and typography.

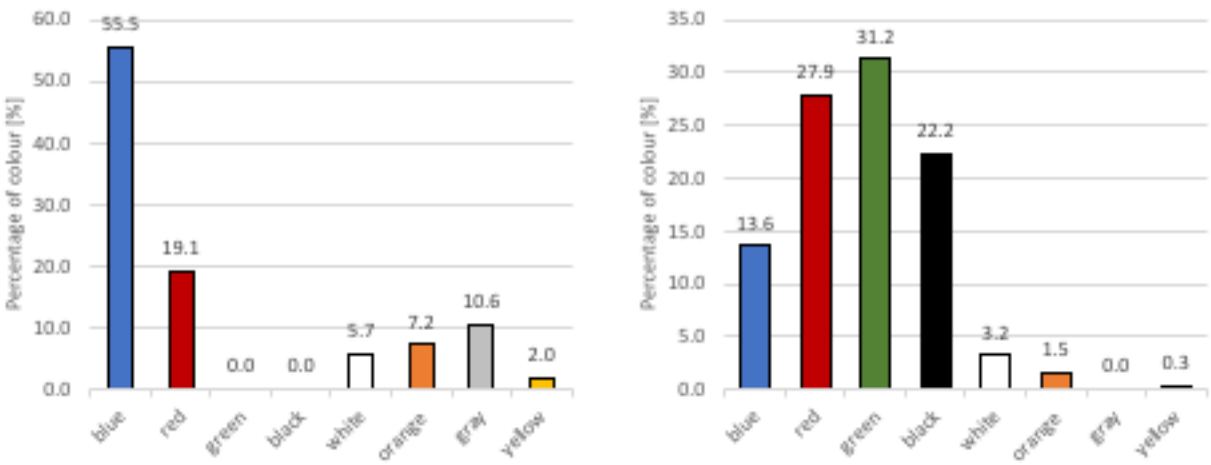


Figure 3. Colours of logotypes of well-known old banks (left) and newcomers (right).

From Fig. 3 can be seen that dominant colour in logotypes of well-known old banks was blue (55.5%), following by colour red (19.1%) and colour gray (10,6%). In smaller percentage also colours orange, white and yellow were presented in those logotypes. In contrary, logotypes of newcomers on the Slovenian market were more colourful by dominant colour green (31.2%), red (27.9%), black (22.2%) and blue (13.6%). In smaller percentage colours white, orange and yellow involved in logotypes. Comparing those results with the colour scheme of the Towergate Insurance company in which dominant colours for banking are blue, red and black, our research gave slightly different results for both type of banks. In six well-known old bank logotypes blue and red are dominant colours, however colour black was not detected in any logotype. In logotypes of newcomers, colour green was incorporated in higher percentage in two logotypes, although this colour was presented in colour scheme of the Towergate Insurance in smaller extend. Colours blue, red and black were also presented in logotypes of newcomers.

In continuation of the research, colours of symbols and typography in logotypes were also analysed. From Fig. 4 can be seen that colours in symbols of well-known old banks are slightly more colourful with dominant red blue and white colour, while colours blue, white and gray were used for typography. The symbols of newcomer's logotypes were mostly in red and green, while other colours were represented in smaller extend. Typography of those logotypes were in colours black, white, green and blue.

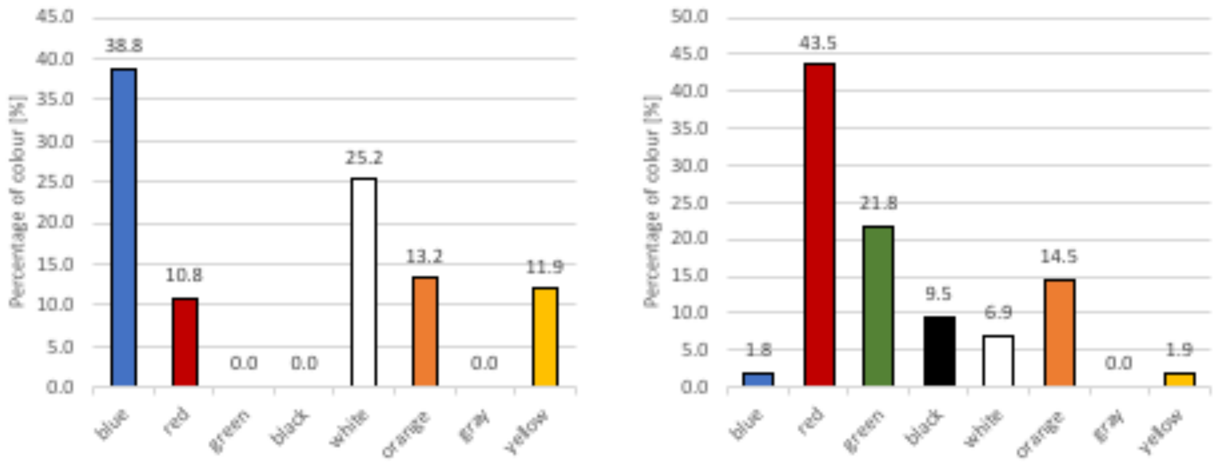


Figure 4. Colours of logotype symbols of well-known old banks (left) and newcomers (right).

3.2 COMPARISON OF LOGOTYPE COLOURS BY THE BANK VALUES AND PRINCIPLES

The logotype colours were also analysed by the values and principles, which were listed on the internet pages of each analysed bank. The most common values were responsibility, respect, confidence and trust, honesty, discretion, excellency, integrity, loyalty and effectiveness. According to the dominant colour blue in four logotypes of well-known old banks, the communicating values through the logotypes were trust and security which were also promoted through their internet pages. On the other hand, blue is also the colour of assurance and composure, dependability, smartness and stability in performance (Brown, 2016), which could be reflected through their logotypes. Colour blue in logotypes of well-known old banks was usually in combination with gray (as just small part of the symbol or rather typography). Two of six Slovenian well-known old banks had colours red and orange in their logotypes. Colour red and orange both promote confidence, while red also promotes ambition, and orange promotes affordability, innovation and modernity (Brown, 2017) which are not explicitly stated as values of any analysed bank. Innovation and modernity are values which could not be forgot nowadays. Both colours, especially red, were used in five logotypes of newcomers. Colour red promotes power of banks, maturity (Brown, 2016a), passion and balance (Brown, 2016), especially in combination with black. In the case of colour orange, De Bortoli and Maroto (2001) emphasised that this colour could promotes cheapness, thus it could be used with certain degree of caution. Colour green was presented in logotypes of two newcomers but not in our well-known old banks. This colour is associated with initiative, wealth and growth (Brown, 2016), ethical and freshness and beside that it is associated with Slovenia by the most Slovenian citizens. Since colours of bank logotypes are often associated with their national colours (Brown, 2017), green should be more often chosen by Slovenian banks. Among all banks, only two (one well-known and one newcomer) had colour yellow in their logotypes. Although this colour represents optimism and friendliness, their share in logotypes were rather small.

3.3 Recognisability of banks according to their logotype colour

Results of the quiz by which recognition of banks was analysed according to their logotype colours are shown in Fig. 5. Although we expected, that logotypes just by the colours will be very difficult to determine, it showed up, that some of the logotypes were quite recognizable according to their colours. The most recognizable were well-known old Slovenian banks, especially those with longer tradition. Among newcomers the most recognizable were those who are more advertised in different media (especially TV) and those who were primarily Slovenian but lately bought by foreign banks.

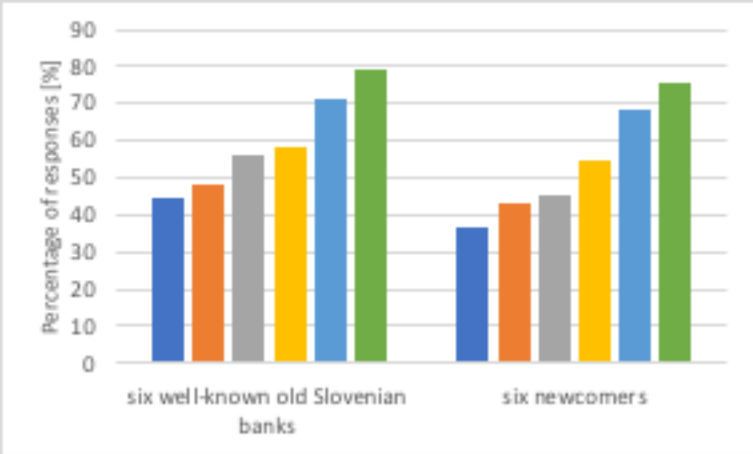


Figure 5. Percentage of respondents who recognized bank according to the colour of logotype.

4 CONCLUSIONS

Colours in logotypes of well-known old banks and newcomers follow the colour scheme made by the Towergate Insurance. Bathi (2017) stated: "Every colour counts (as long as it's blue)« and colour blue is thus "the safest" colour for the bank (Brown, 2016a). The colour blue is the most common colour also in the logotypes of banks in Slovenia. The second most preferable colour was red, however green and black were swapped. The difference in logotype colours among well-known old banks and newcomers exist, regardless if logotypes were analysed in whole or separately by the symbols or typography. Colours of logotypes correspond to the promised values and principles of banks; however, some well-known Slovenian banks could risk more with colours red and especially orange which promote innovation and novelty, both nowadays popular values. Seven banks of twelve were recognized according to the colour by most respondent (more than 50 percent) which applies that colour is an important and powerful element of logotypes.

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IMPACT OF AGE OF PIGMENT PRINTING PASTE ON PRINT QUALITY

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Abstract: *The purpose of this work was to determine the impact of the age of the pigment printing paste on the quality of printed fabric. Two printing pastes, light red and dark red, were prepared and they were printed onto a cotton fabric by screen printing technique on a magnetic printing machine Mini MDF R350 (J. Zimmer). Printing was performed at a predetermined time intervals, which were 1, 2, 3, 4, 7, 14, 30 and 60 days after preparation of the printing pastes. Printed samples were air dried and cured at 150°C in an Ernst Benz dryer. The printing pastes were air-sealed and stored in the refrigerator at the constant temperature of 8°C. The quality of the prints was monitored by measuring the color depth (K/S) and CIELAB color values of printed samples. The color fastness of the prints to washing at different temperatures, resistance to rubbing and resistance to light were measured as well. The changes of the viscosity of the printing pastes was measured on a Rheolab QC (Anton Paar). It was found out that, the quality of the prints shows minimum deviation with time and that the pastes were still appropriate for printing after 60 days.*

Keywords: pigment printing, cotton fabric, color value, color fastness, durability.

1 INTRODUCTION

Textile printing is one of the most versatile and important methods used for introducing color and design to textile fabrics. Several techniques and different colorants are available for textile printing. More than 50% of all printed textiles are printed with pigments. The main factors leading to pigment printing being so widely used are the quality of prints, application to almost every kind of fibre or mixture, and the ability to avoid any washing processes after the curing. The process is simple, economical and environment friendly [1]. A large color gamut is available. Insoluble pigments, which have no affinity for the fibre, are fixed onto a textile with binding agents in the pattern required. The pigment printing pastes consist of pigments, binders, synthetic thickeners and printing auxiliaries. The wide variety of binders and auxiliaries available allow the printer to achieve almost any requisite fastness properties. A conventional thermal curing technique is generally used to bind the pigments onto the textile surface. The heat energy starts the crosslinking of a binder, which binds the pigment particles onto the surface [1]. Flat or rotational screen printing is still the prevailed technique in the printing of pigments; however, the interest in the ink-jet printing technology is constantly on the increase [2].

Three required components of a pigment print system are pigments, binder and thickener, all of which are dispersed in water. Most of organic and inorganic pigments are used in the form of pigment dispersions. They usually contain pigment, dispersant, wetting agents, preservatives, thickener and chemicals to adjust pH. Thickeners are mostly synthetic polyacrylatic polymers and binders are most commonly acrylic copolymer emulsions [3]. Most of these components have low biodegradability and it is important to use as much of prepared paste as possible to prevent the disposal of unused chemicals. A higher amount of the printing paste can be used if the paste is stable enough to be used in a longer time interval.

The aim of the research was to determine the impact the age of the pigment printing paste has on the quality of a printed fabric. Two printing pastes, light red and dark red, were prepared and they were printed onto a cotton fabric with the screen printing technique in time intervals from 1 to 60 days. The quality of prints was monitored by measuring color depth (K/S) and CIELAB color values of printed samples and by determining different fastness properties.

2 EXPERIMENTAL

100% cotton fabric from Tekstina, Ajdovščina with the mass per unit area 156g/m^2 was used in the research.

2.1 Printing

Table 1 presents the recipe for stock paste and Table 2 the recipes for two printing pastes, for a light and a dark shade. Pigment Bezaprint Rot KGC from Bezema, Switzerland was used for printing. All chemical components of the printing pastes were a product of Minerva, Italy.
Flat screen printing was performed on the laboratory magnetic printing machine MINI MDF R 390, Johannes Zimmer AG (Austria). The area coverage of the printing paste on the cotton cloth was approximately 5 x 15 cm. The printing, drying and curing conditions are presented in Table 3.
Printing, drying and curing was performed 1, 2, 3, 4, 7, 14, 30 and 60 days after the preparation of the pastes. The pastes were kept sealed in the refrigerator at constant temperature of 8°C.

Table 1. Stock paste recipe.

Component	Quantity [g]
EUTSCHAUMER W. KONZ	4
MINERPRINTBINDER WST	150
CLEAR D/27	26
FIXATOR L/F	10
WEICHMACHER A/95	10
Distilled water	800
Sum	1000

Table 2. Printing pastes recipes.

Component	Quantity [g]	
	Light shade	Dark shade
Bezaprint rot KGC	6	20
Stock paste	994	980
Sum	1000	1000

Table 3. Printing, drying and curing conditions.

Phase	Conditions
Printing	Flat screen stencil: mesh 43 threads/cm Printing speed: 80% Squeegee diameter: 6 mm Magnet pressure: level 3 No. of passes: 2
Drying	Air drying
Curing	Ernst Benz TKF 15-M500 drier, T = 150°C, t = 5 min

2.2 Analysis

After printing the samples were kept in a dry, dark place. All measurements were performed at once at the end of all printings. All samples were conditioned before measuring according to standard SIST EN 20139:1992 at 20°C and 65% humidity for 24 hours.
Color properties were determined by a Datacolor Spectraflash® SF 600 PLUS-CT spectrophotometer, under illuminant D65 using the 10° standard observer, d/8° measurement geometry and a measurement area of 20 mm in diameter. Ten measurements were done on each sample. CIE L*a*b*, C*, h and color differences (ΔE*) were calculated using Datacolor Datamaster software.

The color strengths (expressed as K/S value) were calculated with the Kubelka-Munk Equation (1):

$$K/S = \frac{(1-R)^2}{2R} \quad (1)$$

where K represents the absorption, S the scattering and R the reflection of light.

Color fastness to washing at 40°C and at 60°C was tested according to SIST EN ISO 105-C01: 1985 (E)
Crockfastness was measured according to SIST EN ISO 105-X12:1993 on a CM-5 Crockmeter AATCC Atlas (USA). **Ten measurement were done for dry and wet crockfastness tests.**
Color fastness to artificial light was measured according to SIST EN ISO 105-B02:1999 on a Xenotest Alpha, produced by ATLAS Material Testing Technology BV (USA).
The viscosity of printing pastes was measured using the rotational rheometer Rheolab QC (Anton Paar, Austria) at 25°C.

3 RESULTS & DISSCUSSION

Figure 1 shows the viscosity of printing paste in the dependence of shear rate on the 4th and 60th days after preparation. The diagram shows a shear thinning flow behavior, which is typical for such polymeric solutions. It is clearly seen that viscosity of all printing pastes is quite similar. Neither the concentration of the pigment nor the age of the printing paste influence on the flow behavior. This meant that we could print with all pastes under the same printing conditions and we could expect the same behavior.

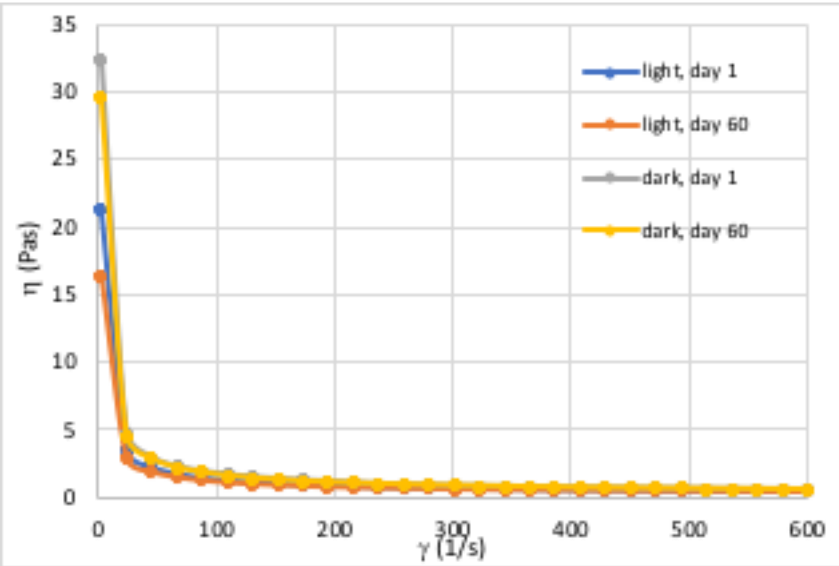

Figure 1. Viscosity (h) of printing pastes versus shear rate (g) at 4th and 60th day after preparation.

Figure 2 shows the color strength, K/S, of light and dark samples, printed at different time intervals. K/S values of dark prints are higher than K/S values of light prints. There are no differences in K/S values between samples printed at different times. We can conclude that the same color value can be obtained with the fresh or 60 days old printing paste.

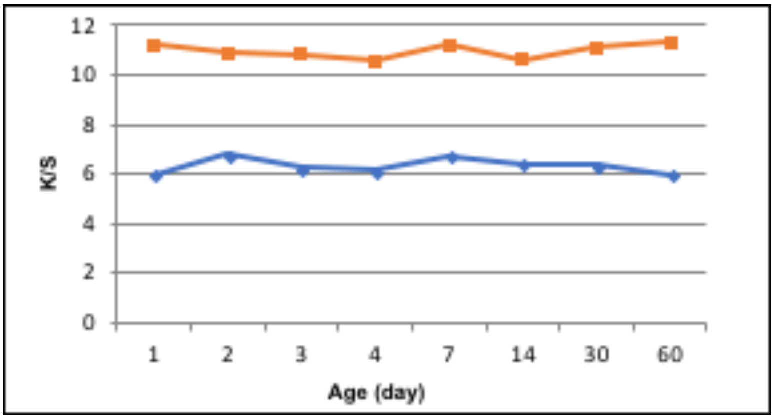

Figure 2. Color depth, K/S, of samples printed at different time intervals.

Tables 3 and 4 show the CIELAB color values of dark and light samples printed with pastes of different age. The sample printed on the 1st day represents the standard for calculation of color differences, ΔE*. At the light colored paste, most color differences are smaller than 1, which means that they are invisible for the human eye. They do not increase with the age of the printing paste. The color differences are higher at dark color printing paste, some even exceed the value 2, which is visible to human eye. Even at dark color, there is no increasing of color differences with the age of the paste. From CIELAB values, we can conclude again, that the color of the printed samples is adequate when they are printed with 60 days old printing paste.

Table 3. CIELAB color values of light colored samples.

Paste age (day)	L*	a*	b*	C*	h	ΔE*
1	44.73	60.19	30.19	67.34	26.64	/
2	44.99	60.26	29.56	67.12	26.13	0.69
3	44.99	60.23	29.54	67.08	26.12	0.71
4	45.24	60.45	29.06	67.07	25.68	1.27
7	44.88	60.53	30.29	67.68	26.58	0.39
14	45.38	60.23	29.84	67.21	26.36	0.74
30	45.00	60.90	30.06	67.91	26.27	0.77
60	44.83	60.83	30.56	68.07	26.67	0.74

Table 4. CIELAB color values of dark colored samples.

Paste age (day)	L*	a*	b*	C*	H	ΔE*
1	52.44	58.46	19.13	61.51	18.12	/
2	51.88	59.87	20.87	63.41	19.22	2.31
3	52.41	59.02	19.88	62.28	18.62	0.94
4	52.79	59.12	19.71	62.32	18.44	0.94
7	52.11	60.05	20.85	63.57	19.15	2.36
14	52.42	59.67	20.69	63.15	19.13	1.97
30	52.52	59.56	20.34	62.94	18.86	1.64
60	53.03	59.00	19.69	62.20	18.46	0.97

For the evaluation of the prints, their fastness properties are also important. They were investigated by measuring the color fastness to washing at 40 and 60°C (Table 5), the fastness to light (Table 6) and the color fastness to rubbing with the crock test (Table 7).
It can be seen that all prints have good fastness to washing at both temperatures. All values are 5, regardless the color of the prints or age or printing paste.

All fastness to light are also good. All values are between 4/5 and 5.

Crock test shows that the samples have worse wet than dry fastness to rubbing, which is normal for pigment printing. Also normal is that better values are obtained for light than for dark samples. The values do not differ according to the age of the printing paste.
The obtained values of different fastness properties appointed that the samples are equally resistant to different impacts when they are printed with fresh or 60 days old printing paste.

Table 5. Color fastness to washing of light samples at 40°C and 60°C.

	Grey scale rating for color change at washing			
Paste age (day)	Light shade		Dark shade	
	40°C	60°C	40°C	60°C
1	4/5	5	5	5
2	5	5	5	5
3	5	5	5	5
4	5	5	5	5
7	5	5	5	5
14	5	5	5	5
30	5	5	5	5
60	5	5	5	5

Table 6. Color fastness to light.

	Blue scale rating for color change at exposing to light	
Paste age (day)	Light shade	Dark shade
1	4/5	4/5
2	4/5	5
3	5	4/5
4	4/5	5
7	4/5	5
14	4/5	4/5
30	5	4/5
60	4/5	5

Table 7. Rubbing fastness.

Paste age (day)	Grey scale rating for color change at rubbing			
	Light shade		Dark shade	
	Dry	Wet	Dry	Wet
1	5	2/3	45	2
2	4/5	2	4/5	2
3	5	3	4/5	2
4	5	2/3	4/5	2
7	5	3	4/5	2
14	4/5	4	4/5	2/3
30	5	2	4/5	2
60	5	2/3	4/5	2

4 CONCLUSIONS

In the research, it was investigated how long it is possible to use a pigment printing paste in order to obtain quality prints on a cotton fabric. The period from 1 to 60 days was chosen from practical reasons. It was established that quality prints are obtained even 60 days after the preparation of the printing paste if it is properly prepared, sealed and stored in a cool and dark place. The color strengths and CIELAB values of samples printed 60 days after the preparation were the same as of those printed on the first day. The prints were equally resistant to washing, light and rubbing. The pastes kept their rheological properties and pH value.

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INFLUENCE OF OPTICAL PAPER PROPERTIES OF RECYCLED AND NON-RECYCLED PAPERS FOR DIGITAL PRINTING ON COLOUR REPRODUCTION

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ABSTRACT: *The main aim of the present research was to examine whether the papers made of 100% waste paper could replace papers made of virgin fibres as substrates in InkJet printing. We chose several different papers with different paper properties which were printed on InkJet digital printing machine. The optical paper properties (whiteness and yellowness) were measured with spectro-densitometer SpectroDens (Techkon). The test chart used in the paper contained primary (cyan, magenta, yellow and black) and secondary (red, green and blue) process colours. Quality of the reproduced colour was also measured with spectro-densitometer SpectroDens (Techkon). According to the obtained results, optical paper properties such as whiteness and yellowness are inversely proportional. Results showed that some recycled papers have even the same whiteness as non-recycled papers. The experiment shows that still recycled papers cannot be compared to non-recycled regarding reproduced colour in inkjet printing.*

Keywords: recycled paper, InkJet printing, colour reproduction, optical paper properties.

1 INTRODUCTION

The paper is still the substrate mostly used for the image reproduction in digital printing technique. Hence, knowledge of the influence of paper on print quality is needed to understand and improve the digital printing performance. Paper, which is the receiving substrate, is an important component in determining the final print quality, especially for colour printing. Paper can be described as sheet material that is largely composed of cellulosic fibers, which become joined together in a hydrogen-bonded structure as a consequence of the evaporation of water (Hubbe et al, 2008).

To ensure the best quality and productivity on digital printing, some requirements for paper properties must be met. While many types and grades of paper can be run in digital printing systems, there are a common set of characteristics and quality criteria that must be built into papers that are optimized for performance in digital printing systems – either monochrome or colour. While some offset sheets may also function, they may not perform as reliably, or produce the same print quality as papers specifically designed for use in digital printing systems (Xerox, 2004).

Printing companies participate in choosing the paper on which something is to be printed. Besides the quality of paper, environmental consideration is one of the factors that influence the choice and therefore they often choose to print on recycled paper. Demand for the use of recycled paper has increased recently. The original motivation for paper recycling was primarily economic. The intention was to use collected waste paper in the manufacturing of paper. That was primarily a concern in countries without indigenous forests, which could ensure their production of newsprint and packaging material. Today environmental concerns are the main motivation.

The primary material in the production of paper is pulp which consists of cellulose fibers. The fibers are either fresh fibers from the wood of coniferous and deciduous trees or recycled fibers from collected paper (Silfverstolpe, 2008). There are two principal types of pulp, depending on the method of the production: chemical or mechanical. Mechanical pulp is produced primarily from spruce wood, and during the production, the fibers are liberated only through mechanical processing of the wood. In the production of the chemical pulp, cellulose fibers are extracted by boiling with chemical additives. The chemical pulp consists both of long-fiber pulp from coniferous trees and of short-fiber pulp from deciduous trees.

Recycled paper is a type of paper that completely or partially consists of recycled fibers. These fibers can have very different origins and therefore also very different characteristics when it comes to being a component of the new paper. When producing graphic papers based on recycled fibers, the paper mill needs as high-quality raw materials as possible. This includes as little ink as possible to facilitate deinking, or preferably not having deinking at all. Unlike the preparation of the pulp from virgin fibers, the fibers obtained from printed recovered paper must have the ink removed. Large particles of ink that are left in the pulp will result in blemished papers with visible specks of ink. If the ink particles are less than 40 μm in size, the eye cannot resolve them

(Thompson, 2004). Recycled paper also includes a large proportion of the paper from chemical pulp, which produces the strongest fibers (Silfverstolpe, 2008). The concerns with recycled paper are usually about the fiber qualities. However, the increasing demands and improvements in technology have been perfecting the recycled paper quality, as well as driving the cost to be in the same range compared to the virgin fiber paper (Wingkono et al, 2011). It is said that recycled paper is more expensive then non-recycled paper. It is wrong because the recycled paper has aligned with conventional paper prices in recent years due to the increase in demand, refinement of the papermaking process and the significant reduction in energy and water necessary to make recycled paper compared to conventional paper (Jurič et al, 2013).
In previous research (Grilj et al, 2011; Jurič et al, 2013), it has been proven that there is a difference in prints on recycled and non-recycled papers in electrophotography. Therefore there was an idea to investigate further whether there is a possibility that recycled papers could replace regular papers in ink jet printing technique.

2 MATERIALS AND METHOD

For this research, we used several different papers with different paper properties (six recycled and eight non-recycled papers). In Table 1 are presented papers with their names and grammage (papers marked with green are recycled). All papers were printed on InkJet digital printing machine - Canon PIXMA MP230 with the same print settings. The optical paper properties (whiteness (WCIE) and yellowness (G1925), which are quality parameters very important for the paper industry) were measured with spectro-densitometer Techkon SpectroDens using the standard observer of 10° and D50 illuminant. The test chart used in the paper contained primary (cyan, magenta, yellow and black) and secondary (red, green and blue) process colours. Quality of the reproduced colour was also measured with spectro-densitometer Techkon SpectroDens, the standard observer was set at 2° and D50 illuminant. Lab values were measured five times for each colour, and only average values are shown in the results.

Table 1. Papers used in this research,

Samples	Paper	Grammage [g/m^2]
1	Nautilus Superwhite	250
2	Nautilus Superwhite	160
3	Nautilus Superwhite	70
4	Nautilus Universal	250
5	Nautilus Universal	160
6	Nautilus Universal	70
7	HP mat	220
8	HP semi gloss	220
9	HP high glossy	220
10	Fabriano	200
11	Fabriano	220
12	Perfect Proof Semi Matte Lite	155
13	Perfect Proof Semi Matte	185
14	Perfect Proof PhotoGloss	175

3 RESULTS & DISCUSSION

Obtained results for whiteness and yellowness of papers are presented in Table 2 and Figure 1. Based on the results, it can be concluded that the whiteness and the yellowness are inversely proportional and in strong correlation (R2 = 0.95). By increasing the whiteness of the paper, the yellowness decreases, and vice versa. Positive values of G1925 indicate a yellowish tint of paper, while negative values indicate a bluish tint of paper.

Table 2. Optical paper properties.

Samples	Whiteness - W_{CIE}	Yellowness – G_{1925}
1	114,44	-13,56
2	112,42	-12,36
3	107,40	-13,16
4	77,63	0,84
5	74,13	1,22
6	75,44	-1,67
7	109,56	-8,62
8	112,34	-12,43
9	115,33	-14,01
10	129,34	-19,31
11	129,21	-19,77
12	99,79	-7,96
13	97,70	-6,38
14	103,51	-7,78

It is clear that recycled papers (samples 4, 5 and 6) have the smallest whiteness (and greatest yellowness), but the first group of recycled paper (samples 1, 2 and 3 – Nautilus Superwhite) can counter non-recycled papers. Fabriano papers (samples 10 and 11) are the whitest with the smallest yellowness.

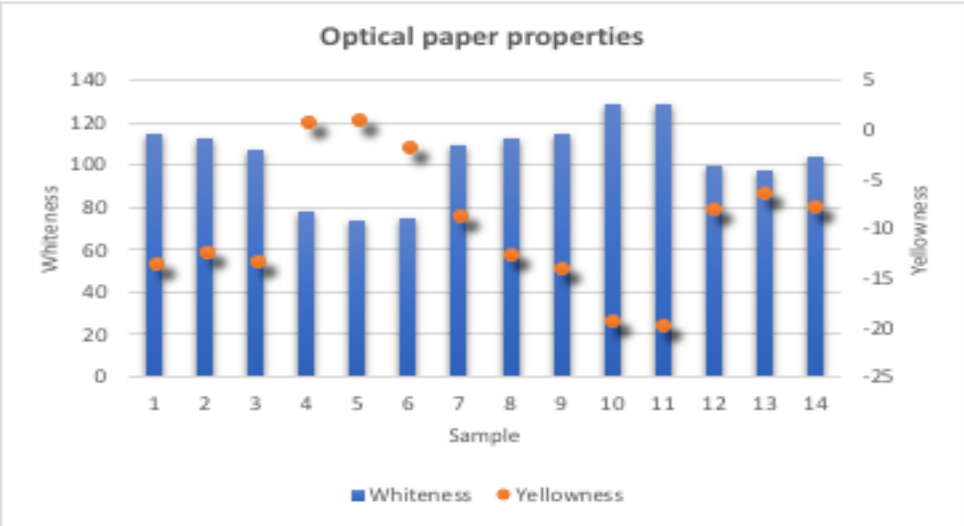

Figure 1. Optical paper properties of samples used in the experiment.

In Figures from 2 to 8 are presented colorimetric values (L*a*b*) of primary and secondary colors. Based on the results, it can be noted that there is a difference in the printed colour on recycled and non-recycled papers. Smaller lightness is obtained for cyan and yellow on recycled papers, while reddish tones (magenta and red) are darker on recycled paper. For black, green and blue, the lightness values are more or less the same, the only difference is noticed on Fabriano papers (samples 10 and 11). Chromatic values (a* and b* coordinates) differ in all colors between different groups of papers.

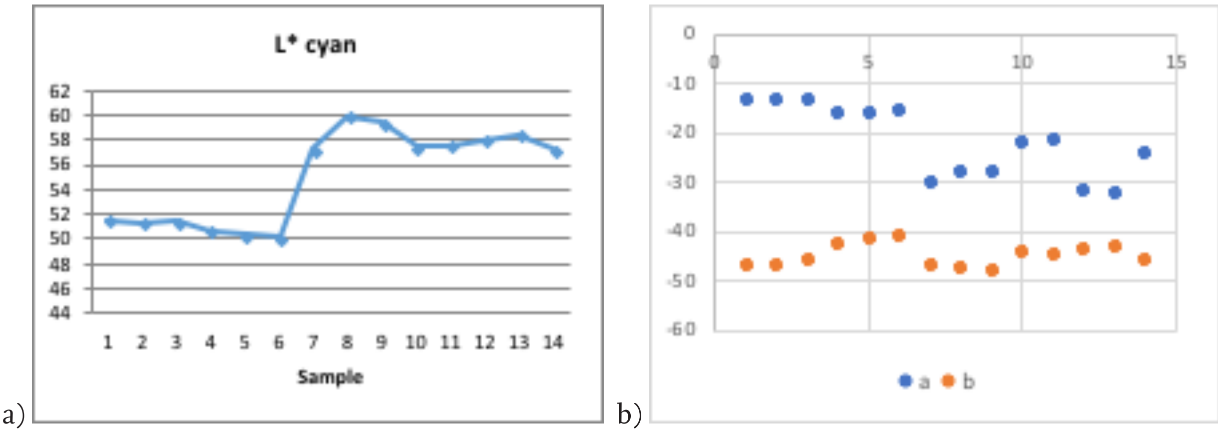

Figure 2. Lab coordinates for cyan, a) L* values and b) a* and b* values.

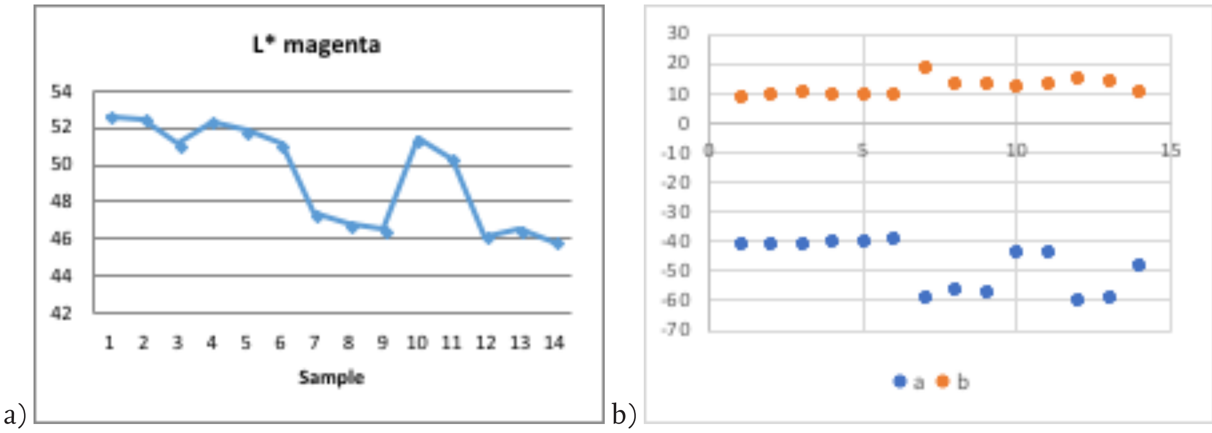

Figure 3. Lab coordinates for magenta, a) L* values and b) a* and b* values.

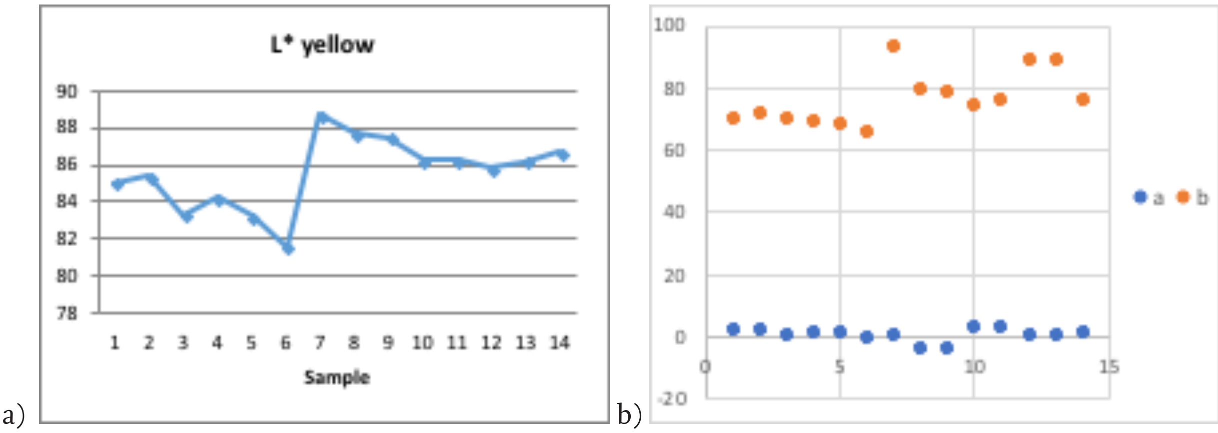

Figure 4. Lab coordinates for yellow, a) L* values and b) a* and b* values.

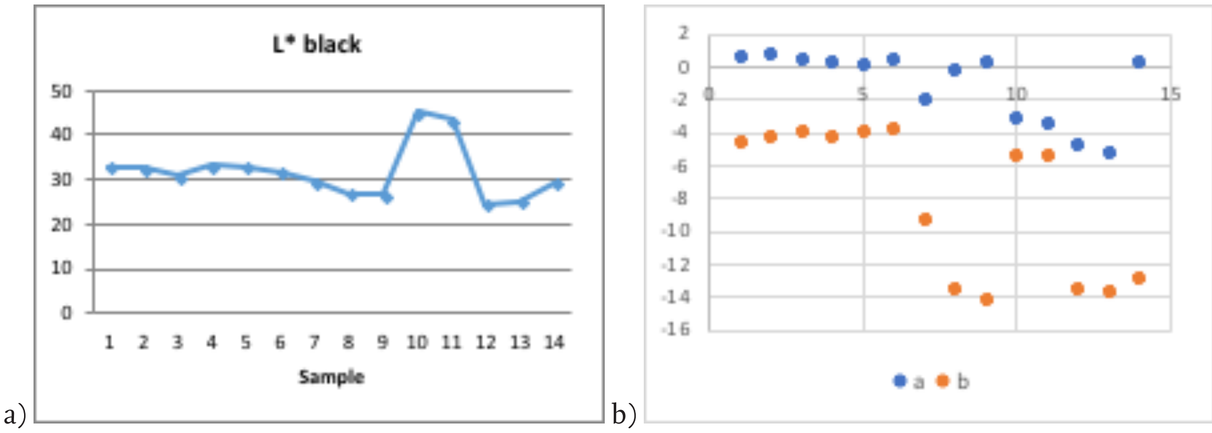

Figure 5. Lab coordinates for black, a) L* values and b) a* and b* values.

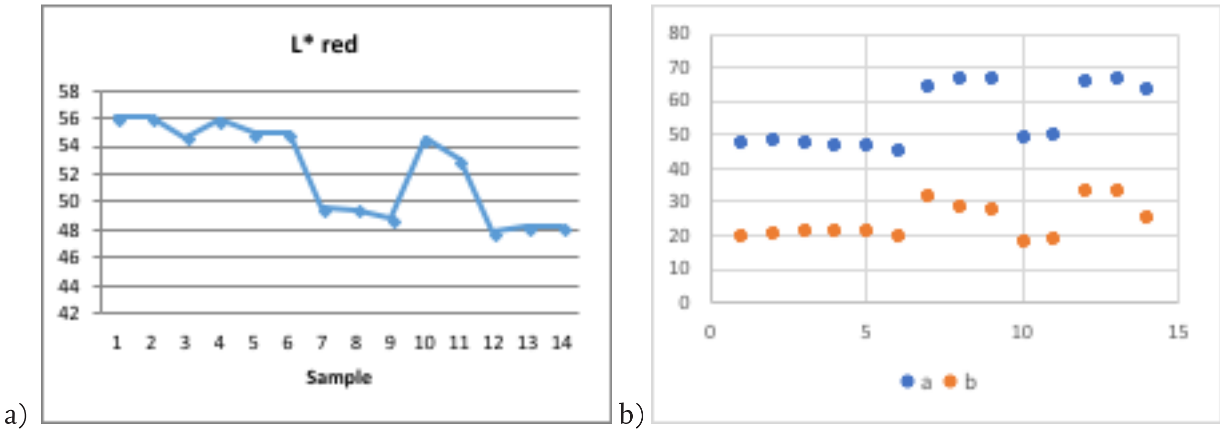

Figure 6. Lab coordinates for red, a) L* values and b) a* and b* values.

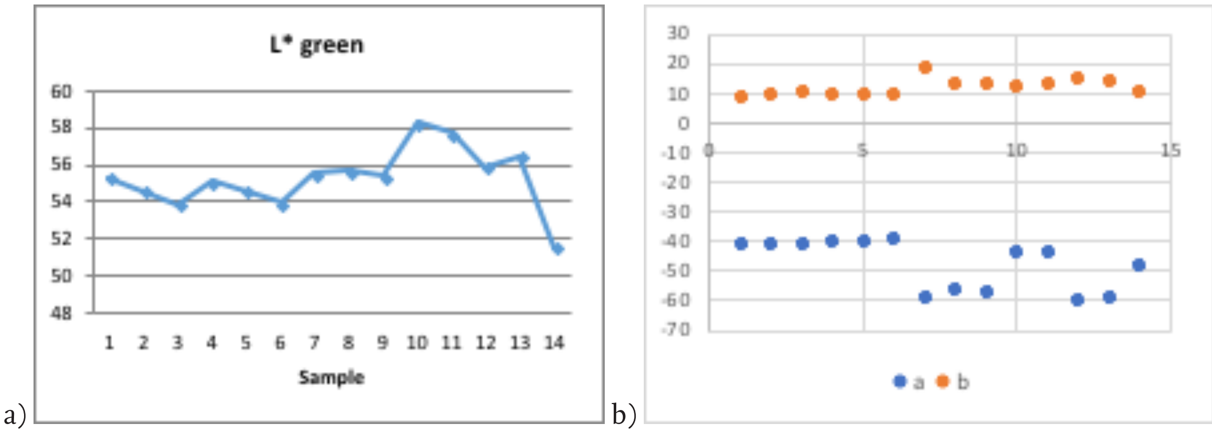

Figure 7. Lab coordinates for green, a) L* values and b) a* and b* values.

a) b)

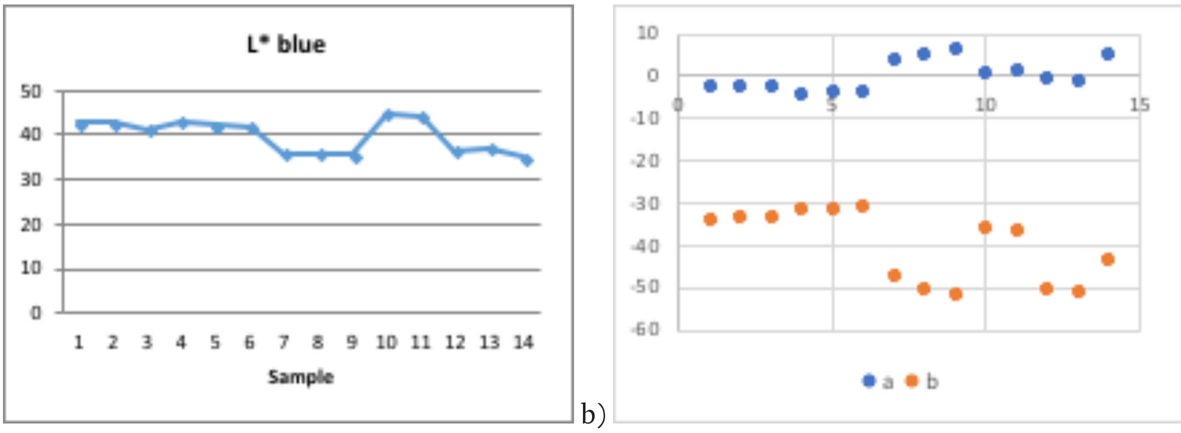

Figure 8. Lab coordinates for blue, a) L* values and b) a* and b* values.

4 CONCLUSIONS

Recycled papers are slowly becoming more and more used for printing and could replace nonrecycled papers for less demanding and lower quality prints. We were interested in whether there was a difference in the optical properties of recycled and nonrecycled papers, and whether these properties affect the final quality of the digital prints (inkjet). According to the results, some recycled papers have the similar whiteness as regular papers, while for some recycled papers whiteness is much lower, and the yellowish is larger. But the printed colour varies considerably on these papers, regardless of their similar optical properties. Some tones are brighter (cyan and yellow) while the other (magenta and red) are darker which are printed on recycled papers. Also, there are major differences in the chromaticity of primary and secondary colours. Therefore, based on the results obtained, it can be concluded that recycled papers can not yet be replaced by recycled material if the colour reproduction and the quality of the printed colour are significant.

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POLYLACTIC ACID FIBRES CONTAINING FLUORESCENT PIGMENTS

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ABSTRACT: *Fibres are globally considered as dynamic, highly developing materials. Research is currently engaged in the study of special fibres, which have interesting properties. This work is focused on the characterization and study of light and thermal stability of PLA fibres containing yellow fluorescent pigment. Spectroscopic and colorimetric measurements were used to characterize and study sample stability. Samples were found to be more subject to light aging; with significant color changes and fluorescence disappeared completely after 4 days. Changes in the PLA structure using FTIR spectroscopy were not observed.*

Keywords: fibres, polylactic acid, fluorescent pigment, colorimetry, spectroscopy.

1 INTRODUCTION

Fibres are generally considered as dynamic, highly developing materials. Materials made from natural and chemical fibres have a wide use in all areas of life. Synthetic fibres are resistant to atmospheric influences and are inexpensive therefore mass production of these materials contributes to accumulation of the waste in environment, in the better case in landfills. The solutions of these serious environmental problems require replacement of the synthetic polymers by biodegradable polymers and polymers from renewable resources (Sin, 2013). Research is currently engaged on the study of special fibres, which are interesting from the point of view of their properties (biodegradability, nontoxicity, security). Such fibres are used in the manufacturing of protective or children's clothing and in various medical applications. This work is focused on the characterization and study of light and thermal stability of polylactic acid (PLA) fibres with different contents of fluorescent pigments.

2 EXPERIMENTAL

The yellow fluorescent pigment RADGLO EA – 30: Chartreuse (0.1 – 0.8 wt. %) was added directly to the polymer matrix (PLA) in order to prepare fibres with multifunctional properties containing the pigment directly in its structure. The pellets of PLA were mechanically mixed with pigment and mixture was used for undrawn PLA fibres preparation by classical spinning from melt at the temperature 190°C using a laboratory pilot line. The undrawn PLA fibres were drawn on the drawing ratio 1.5.
Two types of accelerated aging – light aging in the Q-sun Xenon test chamber (type Xe-1-S light intensity at 420 nm: 1.1 W/m^2; illumination 89000 Lx; black point temperature 65°C, window glass filter, light intensity in the region 300 – 800 nm approx. 494 W/ m2) and thermal aging in the dark at 80°C - were used to study the light and heat stability of the prepared samples [2].
UV Vis spectra of samples were monitored by UV Vis spectrometer CE3055 (Cecil Instruments). Original reflectance (R) spectra were transformed into optical density (O.D.) using Eq. (1):

$$O.D. = -\log R \qquad (1)$$

The FTIR spectra were measured with the FTIR spectrophotometer Excalibur Digilab FTS 3000MX, USA, using the ATR adapter with diamond window.
The colorimetric coordinates of samples (L*, a*, b*) were obtained by means of Spectrophotometer Spectrodens (Techkon, illumination D50, standard observer 2°). CIE L*a*b* system was used to evaluate the color changes. Value L* represents the lightness of color spot, chromatic coordinates a* and b* range from green to red and from blue to yellow colours, respectively.
The total color difference was calculated from Eq. (2) (Hunt, 1995),

$$\Delta E^*_{ab} = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \qquad (2)$$

where values DL*, Da* and Db* are the differences between relevant values attributed to aged and non-aged samples.

3 RESULT & DISCUSSION

3.1 Characterization of samples

Two spectroscopic methods (UV Vis, FTIR) and colorimetry measurements were used to characterize samples as well as to study the effects of accelerated aging [1]. Figure 1 shows FTIR spectra of PLA fibers with varying contents of fluorescent pigment RADGLO CHART EA-30. As the pigment was added in very small amounts, the spectra correspond mainly to PLA. In the FTIR spectra of PLA typical bands at 2960 – 2880 cm^{-1} (-CH_3, -CH_2, -CH group), 3590 – 3650 cm^{-1} (-OH group), 1720 – 1740 cm^{-1} (-C = O group) can be observed. The absorption bands of the pigment are visible only at 2855 and at 1600 cm^{-1}, where a slight increase in absorbance with increasing pigment content can be observed. UV Vis spectra of PLA fibers with various content of pigment are shown in Fig. 2. Since the PLA is white, it absorbs only in the UV range (235 and 300 nm). In the UV Vis spectra the maxima at 335 and 430 nm and the minimum at 310 nm increase with the increasing pigment content (Figure 2).

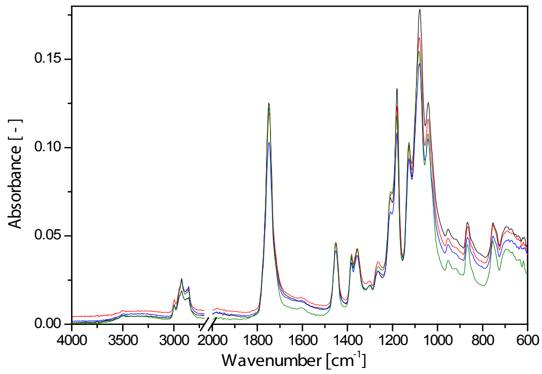

Figure 1. FTIR spectra of PLA fibres with various pigment concentration (0.1 wt. % red line, 0.5 wt. % blue line, 0.8 wt. % green line, without pigment black line).

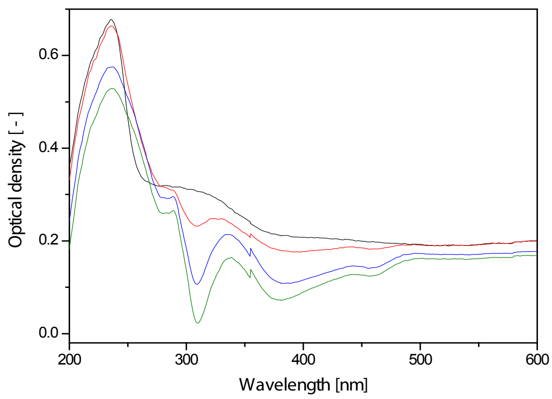

Figure 2. UV Vis spectra of PLA fibres with various pigment concentration (0.1 wt. % red line, 0.5 wt. % blue line, 0.8 wt. % green line, without pigment black line).

Colorimetric coordinates L*, a*, b* were also measured on all samples (Table 2). With the increasing pigment content, the values of the coordinates L*, a*, b* were changed. PLA had the L*, a*, b* coordinates typical for white, but when the pigment was added, the coordinate L* (darkening of the samples) and the coordinate a* (shift to green) decreased, while the coordinate b* increased (shift to yellow). (Panák, 2008)

Table 1. The colorimetric coordinates L*, a*, b* of samples with various pigment concentration

Pigment content [%]	L*	a*	b*
0	96 ± 4	1.2 ± 0.9	1.5 ± 0.5
0.1	63 ± 4	-10.1 ± 0.7	9 ± 2
0.5	65 ± 2	-23 ± 1	29 ± 3
0.8	66 ± 2	-28 ± 1	37 ± 2

3.2 Light and temperature stability of samples

Subsequently, the color stability of the pigmented fibres was analysed. The samples were subjected to light and thermal aging, the changes were evaluated by UV Vis spectroscopy and colorimetry.
After 3 days of accelerated light ageing (Q-sun chamber) the significant changes in UV Vis spectra were observed (Figure 3). In pigment free PLA fibres (Figure 3A), after the first day of light aging, the absorbance in the visible region of the spectra increased, indicating a darkening of the sample. In UV Vis spectra of pigmented samples (Figure 3B), the peak at 430 nm decreased and at the same time decreased the minimum at 335 nm associated with the disappearance of fluorescence due to pigment degradation. Based on the above mentioned, we can assume that even the sample with the highest pigment content (0.8%) did not show fluorescence after the first two days of accelerated light aging.
Colorimetric measurements (Table 2) showed that during light aging of pigment free PLA fibres the coordinate L* decreased (samples darkening), the changes of coordinates a* and b* were negligible, their values are in the area of achromatic colors. In samples containing pigment we observed the increase of the coordinate L* (samples fading) and a* (green loss) and the significant decrease of the coordinate b* (yellow loss), which is associated with significant decoloration of samples, as evidenced by the high ΔE*ab values, which increase with increasing pigment content.

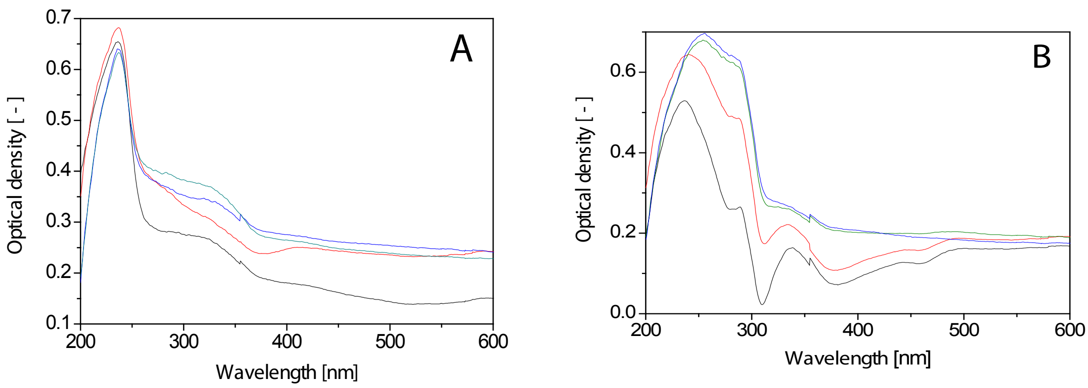

Figure 3. UV Vis spectra of pigment free PLA fibres (A) and PLA fibres with 0.8 wt. % of pigment (B) during light ageing (1 day red line, 2 days blue line, 3 days green line, unaged samples black line).

The samples were subjected to thermal aging without light access, where the aging time was 28 days. During thermal aging much smaller and slower changes than during light aging of samples (except PLA without pigment) (Table 1) were observed. Changes of the shape of the UV Vis spectra were small, and the “minimum” at 310 nm remained present, although with time decresed (Figure 4). Thus, we can assume that fluorescence of pigmented fibres under thermal aging decreased, but did not disappear. During light aging in the Q-SUN chamber the fluorescence of the samples with pigment content of 0.8 wt. % completely disappeared after 2 days, the effect of thermal aging was significantly smaller.
In the case of pigment-free fibers, the more significant color changes (mainly the L* coordinate decrease) were observed at thermal ageing (80°C) as at light ageing, with the presence of the pigment in the amount of 0.1% already increased the PLA thermal stability.

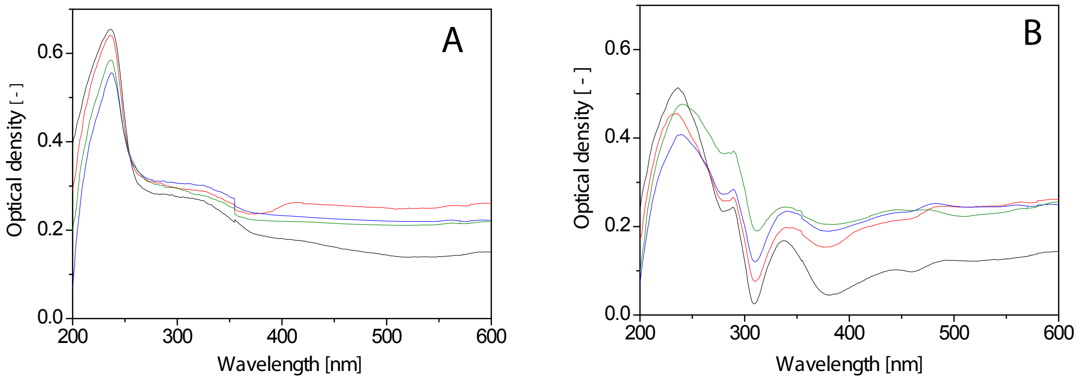

Figure 4. UV Vis spectra of pigment free PLA fibres (A) and PLA fibres with 0.8 wt. % of pigment (B) during thermal ageing (1 day red line, 3 days blue line, 28 days green line, unaged samples black line).

Table 2. Comparison of color changes of PLA fibers with pigment due to light and heat aging

Pigment content [%]	DEab* after 3 days	
	light ageing	thermal ageing
0	15.2	42.7
0.1	14.8	10.1
0.5	36.7	5.0
0.8	47.5	7.1

After four days of light aging in the Q-SUN the samples were stored and after one year their characteristics were re-measured. Subsequently, they were light aged for 7 days. During storage and additional aging, there were no significant changes in the FTIR and UV Vis spectra. So we can say that the most important changes occurred during the first days of aging.
In colorimetric measurements of the samples, which were after 3 days of light ageing one year stored in dark and subsequently aged for seven days in the Q-SUN chamber, there were no significant changes in the coordinates L*, a*, b* and ΔEab* values are in the range of measurement errors.

4 CONCLUSIONS

In conclusion, the color stability of PLA fibers with fluorescent pigments is significantly influenced by light, as all samples were significantly decolorised and lost their fluorescence after 3 days of accelerated light ageing (corresponding approximately to 3 years of natural ageing), whereas the color changes achieved after 28 days of aging at 80 °C in the dark were much smaller and fluorescence decreased only about 50 %. Potential modification of fluorescent pigments could be increase its stability in PLA fibers.

ACKNOWLEDGEMENTS

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PREVENTION OF STARCH DEGRADATION IN PAPER MAKING PROCESS FOR RECYCLED PACKAGING PAPER

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ABSTRACT: *In this report were observed the possibilities of prevention of starch degradation in papermaking processes for corrugated paper production by using zinc-based product that inhibits amylase enzyme. The examinations were carried out at zero and 24 hours' downtime of the paper suspension. The consumption of the amylase enzyme inhibitor additive was 0,5%; 1%, 1,5% and 2% of o.d.f. Laboratory paper samples (90g/m²) were obtained. Dewatering time, turbidity and conductivity were determined. Starch amount was measured using iodine staining. The investigated strength properties were - burst strength test index, compressive strength test index and tear index. The results show positive effect of the enzyme inhibitor over the dewatering effect and turbidity of the white waters together with constant strength properties. Most interesting is the result for the starch concentration in the white waters, which are in the range of 0,05% even after the 24 hours' downtime of the paper suspension.*

Keywords: recycling, paper, starch, enzyme inhibition, corrugated packaging, strength .

1 INTRODUCTION

The demand for packaging and container boards has grown both globally and in Europe in the past few years. The annual demand is expected to grow at about 3-6% in emerging markets and with 1 % in Europe over the next five years and will amount to almost 115 million tonnes of converted material by 2019 (Smithers Pira, 2015). Global demand for container boards will continue to increase due to the increase online shopping and trading with a significant market share. At the same time, board manufacturers are looking for opportunities to decrease the production costs and to improve lightweightening of the paper together with environmental and sustainability requirements without compromising the most critical quality parameter – strength.

The papermaking process consists of several major steps: stock preparation, sheet forming, pressing, drying, and surface finishing (Maurer, 2009). Starch is an important component of many paper grades. Starch consumption by weight in papermaking and paper conversion processes ranks third after cellulose fibre and mineral pigments. Starch is used as a flocculant and retention aid, as a bonding agent, as a surface size, as a binder for coatings, and as an adhesive in corrugated board, laminated grades, and other products (Vrabic Brodnjak, 2017). The major starch sources are corn, potato, waxy maize, wheat, and tapioca. Refined starches are supplied in powder form or as slightly aggregated pearl starch. Unmodified (native) starch is rarely used in the paper industry, except as a binder for laminates and in the corrugating process. Most starches for use in papermaking are specialty products that have been modified by controlled hydrolysis, oxidation, or derivatization (Maurer, 2009). When choosing starch for paper production there are some important aspects such as: application requirements for starch, dispersion of starch, environmental aspects of starch, and use of starch in papermaking furnish, is it for surface sizing of paper or as a coating binder, as adhesive in paper conversion or in newer specialty papers Starch analysis in paper is having the same importance as the other wet-end or surface chemical additives (Neimo, 1999).

It is also well known that the typical composition of the main paper industry microflora consists of aerobic bacteria and anaerobic bacteria, which are two types, spore forming and non-sporulating, fingi – moulds and yeast and algae – blue-green or green (Blanco, 1996). Due to this favourable conditions preventing or reducing deposits in pulp and paper making processes is having significant importance for the overall papermaking runability together with the need of increased savings. One opportunity for preventing or reducing deposits in pulp and paper making processes is by including a cyclodextrin during or after pulp formation in an amount effective for preventing or reducing the deposits (US 2006O124266A1).

Actual trends in papermaking concern on the use of recycled fibres and minimizing effluent volume by closing water circuit. Beside environmental and economic advantages, both trends can lead to serious problems in papermaking processes due to contaminants introduced with recycled fibres and their accumulation in closed water system. A key factor to avoid disturbances in the papermaking is to prevent the accumulation of detrimental compounds. In this respect, first it is necessary to find out methods to characterize and control the effects of chemical additives for different papers grade.

Amylase is an enzyme produced by many bacteria and fungi. The α-amylase belongs to a family of endo-amylases that catalyses the initial hydrolysis of starch into shorter oligosaccharides through the cleavage of α-D-(1-4) glycosidic bonds (Souza, 2010). This enzyme breaks down starch polymers into smaller sugars which can be seen as high COD values in process waters and increased microbial activity due sugar nutrients (Fig.1). Significant improvement of the enzyme inhibition could be achieved by appropriate microbiological control followed by starch stabilization which stopes the enzymatic degradation of starch. Retention and strength management to retain starch and boost strength and productivity is also beneficial.

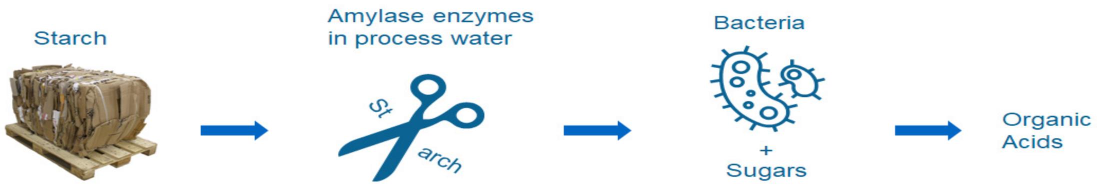

Figure 1. Starch in papermaking process.

Two different mechanisms occur while using enzyme inhibition additive, one mechanism inhibits the existing amylase activity and the other mechanism prevents the production of new amylase by microorganisms, giving a synergistic impact (US 9278874 B2). A special amylase enzyme inhibitor prevents the enzymatic degradation of starch polymers, and fine-tuned synthetic polymer program ensures that this secondary starch is retained within fibres (Fig.2). Less starch degradation means less pH drop and that more starch is present with the recycled fibres (Thorn, 2009). Other benefits are improved runability due to stable wet-end chemistry as well as optimized retention, better dewatering ability of paper suspensions, improved turbidity of the white waters, increased strength properties and more efficient and sustainable raw material usage due to improved yield of starch and reduced need of added starch.

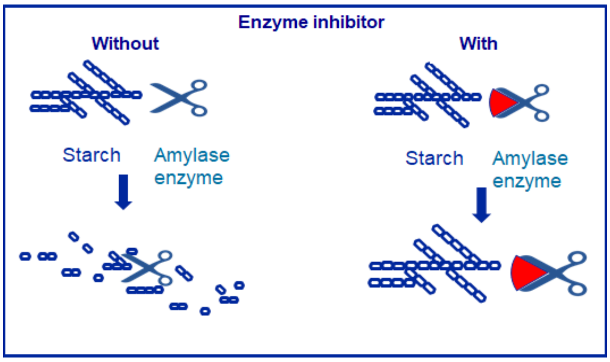

Figure 2. Starch in the paper suspension.

In this report were observed the possibilities of prevention of starch degradation in recycling and papermaking processes for corrugated paper grades production by using zinc-based product that inhibits amylase enzyme, which has benefits both on paper suspension properties and paper strength properties of the produced paper grades. All the examinations were carried out at zero and 24 hours' downtime of the paper suspension.

2 EXPERIMENTAL

The used raw material was secondary fibre material for the production of testliner for corrugated cardboard grades delivered from DS Smith Bulgaria SA. The secondary fibre material was prepared in laboratory conditions by hydropulper and the end refining degree was 35°SR. Paper slurry contained the regularly used chemical additives for the production of the corrugated liner paper grades: Carboxymethyl Cellulose - 16 kg/t, Starch - 30kg/t and Retention Additive - 0,136l/t. As enzyme inhibitor was used Fenno Spec 1200, delivered by Kemira. It is a zinc-based product (zinc sulphate 28-30%, zinc chloride <=0,58%) that inhibits amylase enzyme. As retention additive was used Fenno Pol K 2130T - modified poly acryl amide with cationic charge, delivered by Kemira.

The amylase enzyme inhibitor additive was used at consumption of 0,5%; 1%, 1,5% and 2% of o.d.f. Paper suspensions were prepared in accordance with the following order of adding the components:

1. Only pulp (P)
2. Pulp and 0,1% retention additive (PR)
3. Pulp, 0,5% Feno Spec 1200, 0,1% retention additive (0,5% FS)
4. Pulp, 1% Feno Spec 1200, 0,1% retention additive (1% FS)
5. Pulp, 1,5% Feno Spec 1200, 0,1% retention additive (1,5% FS)
6. Pulp, 2% Feno Spec 1200, 0,1% retention additive (2% FS)

Dewatering time (T700) of the resulting paper suspensions were determined followed by measuring Turbidity, NTU acc. ISO 7027 and Conductivity, μS acc. ISO 7888 of the white waters. The refining degree was determined by the Schopper Riegler Value ºSR, acc. to ISO 5267-1/AC: 2004. The dewatering time was determined by Shopper Riegler apparatus (Germany). The measuring conditions are the same as for determination of beating degree but the central vertical out-pipe is closed. The concentration is 0.2% (2g o.d.f in 1000ml water). In the current experiment the dewatering time was measured for 700ml filtrate. Starch amount was measured using iodine staining. For determining the starch concentration in the white waters, the absorbance of the iodine in the white waters and in the three standardized starch solutions, were determined by using UV/Visible Scanning Spectrophotometer UV 3300 PC of BIOBASE Co., Ltd, by the method of standard calibration curve and the concentration of the starch in the white waters was determined in percent starch. All paper samples were prepared on paper laboratory machine (Rapid-Kothen, Germany) acc. ISO 5269-2:2005, with a grammage of 90g/m^2, with drying conditions of - 96°C and duration of 7 minutes. The investigated strength properties of the obtained paper samples: burst strength test index (BI) according to ISO 2759:2014, compressive strength test index (SCT) accord. to ISO 9895:2008 and tear index (TI), accord. to ISO 1974:2012 were analysed in the standard atmosphere at 23 °C of temperature and 50% of relative humidity.

3 RESULTS & DISCUSSION

Usually, the dewatering time gives us indirect information about the flocculation ability of the paper suspension together with the drainage ability. The accelerated dewatering and increased retention as a result of flocculants effect means purer waters in paper mill as well. After preparation of each pulp mixture, the dewatering time has been measured (Fig.3). As it is seen from the chart, the dewatering time is improved for all paper suspensions, compared to that from secondary fibre material only (P).

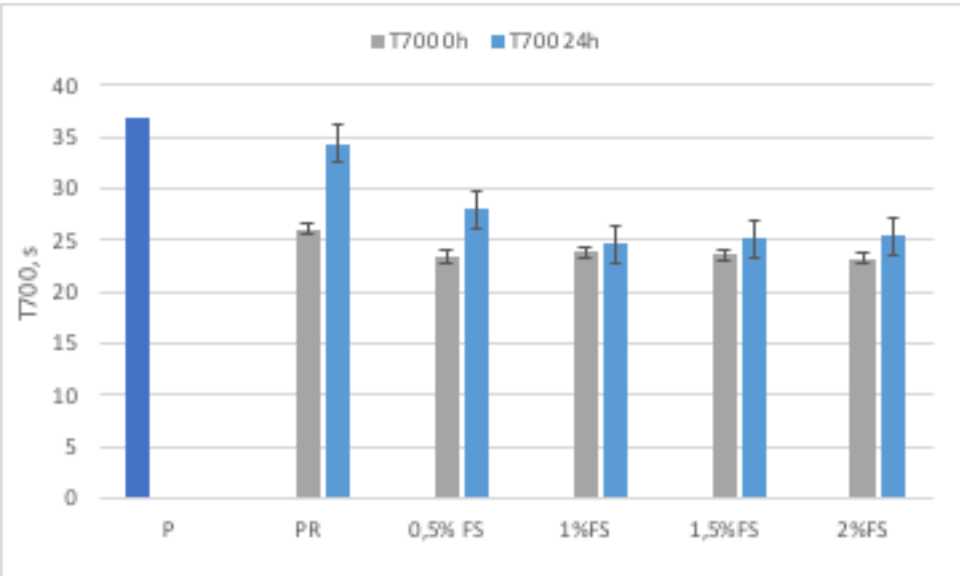

Figure 3. Dewatering time T700, s of the paper suspensions.

Adding of retention additive (PR) improves the dewatering ability with 10 s, but best result at 0h downtime was observed for the paper mixture with 0,5% of o.d.f. enzyme inhibitor (0,5%FS). Increasing the FS consumption from 1% to 2% had no significant effect and dewatering time is practically unchanged. The tendencies after 24h downtime of the paper suspension are different. The dewatering of suspension consisting only retention additive aggravated significantly with about 8 seconds, but still had better dewatering than that of pulp only.

Paper suspensions consisting Feno Spec 1200 were with improved dewatering time. At 0,1% consumption 700 ml filtrate was obtained for less than 25s and this result is only 1s higher than that at 0,5% FS at 0h downtime of the paper suspension. The optimal FS consumption regarding the dewatering time, both at 0h and 24h downtime is 0,1% of o.d.f. The improvement of the dewatering time probably is due to the synergic effect of the retention additive and the zinc based additive, which has also positive charge 9not so strong in electricity as Al3+) and acts as a coagulant.

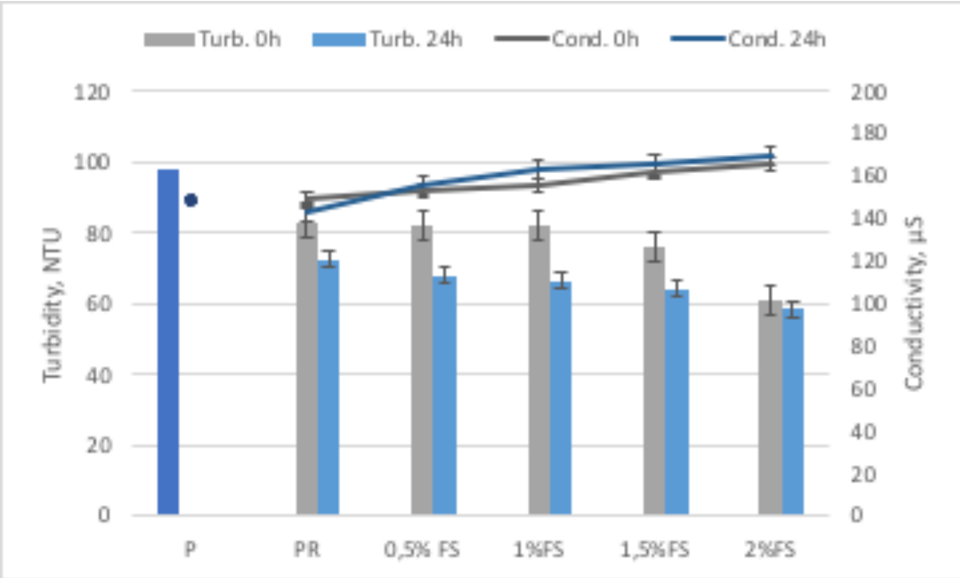

Figure 4. White waters turbidity, NTU and conductivity, µS.

Measuring the electric conductivity gives an indication of the total concentration of electrolyte in the liquid phase, while the turbidity indicates indirectly the overall retention effect. Regarding the turbidity and conductivity of the white waters, the results which are presented in Fig. 4 are interconnected. With increasing the enzyme inhibition additive from 0,5%FS to 2%FS the turbidity is decreased, while the conductivity is increased and this effect is bigger while using paper suspensions directly after its preparation. At 24h downtime the clarification effect is not that strong. It is visible from the chart, that consumption of 2% Fenco Spac 1200 is sufficient for inhibition of the amylase enzyme and results before and after the paper suspensions downtime are very similar. The curves for the conductivity before and after the suspensions downtime are very close and presence of FS increased the white waters conductivity, both at 0h and 24h suspension downtime due to the increased retention of fines, starch and inorganic substances.
As shown in Table 1, as the concentration of the enzyme inhibitor increased and at 24h suspensions downtime, the starch concentration in the white water decreased. Because fresh starch was not used and the studies were conducted only with the starch in available secondary paper, which is 30kg/t, the amount of starch in the white waters ranged from 0.04-0.05%. Results show that the effectiveness of the additive used can be judged with great accuracy only when fresh starch is incorporated. These experiments are provided in the next stage of the study, along with industrial experiments.

Table 1. White waters adsorption and starch concentration.

Starch, %	Adsorption	Adsorption	P	PR	0,5%FS	1%FS	1,5%FS	2%FS
0,03	0,173							
0,04	0,244	0h	0,396	0,319	0,318	0,314	0,311	0,31
0,05	0,35	24h	-	0,269	0,285	0,284	0,286	0,285

The obtained results for the strength and dynamic parameters of the investigated laboratory obtained paper samples are shown in Fig.5 and Fig.6. Before the testing process paper sheets were conditioned at temperature of 23 °C ±1 °C and relative humidity 50% ± 5% for 24 hours. Bursting strength is particularly important for packaging papers, as it determines how much pressure paper can tolerate before it ruptures. The results for the burst strength test - burst index (BI, kPa.m²/g) and tear strength - tear index (TI, mN.m²/g) are shown in Fig. 5. It can be seen that both parameters are relatively constant. Burst index is more sensitive with regard to the downtime of the paper suspension, which is probably due to the decrease of interfiber bonds, mainly hidrogen bonds togeter with increase in the mobility of the paper structure elements and the increase in the flexibility of the fibers themselves as a result of the inhance starch and overal retention. The tear resistance determines the force applied during the tearing procedure. It indicates the behavior of paper and it is important for packaging papers, where the toughness and shock absorption are very important factors. Tear index is more stable and after 24h of papersuspension downtime the results are practically unchainged but still slightly higher than the zero sample (pulp without any additives). This parameter depends primarily on the strength and nature of the fibers themselves, that's why the influence of the amount of additives and the downtime of the paper suspension is insignificant.

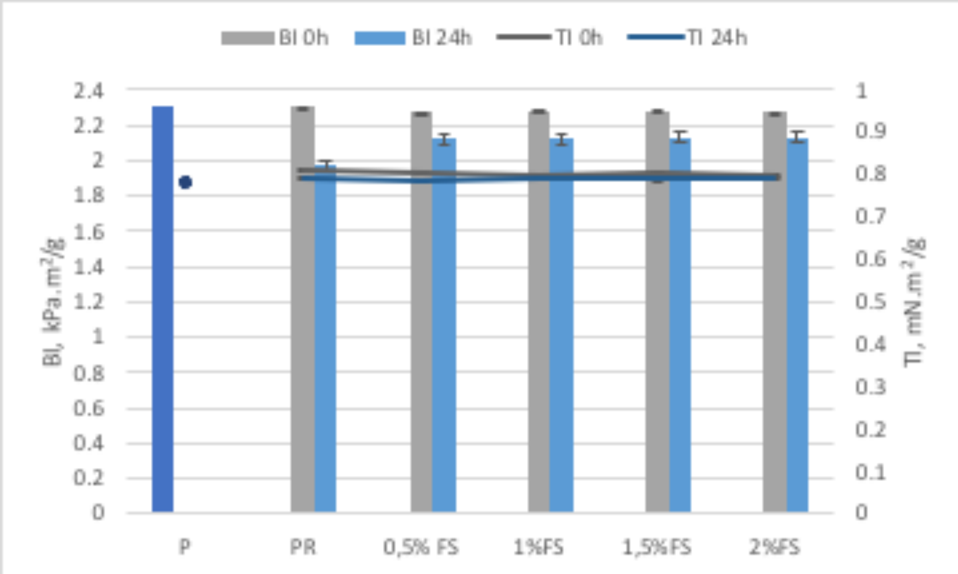

Figure 5. Burst index and Tear index of the paper samples.

In the short-span compression test (SCT) the compressive strength of paper in compression mode is determined. Because only a very short length of paper (0.7 mm) is used in the test, greater account is taken of the load-bearing fiber portion of the material than with the traditional test methods (ring crush test, corrugated crush test or linear crush test).

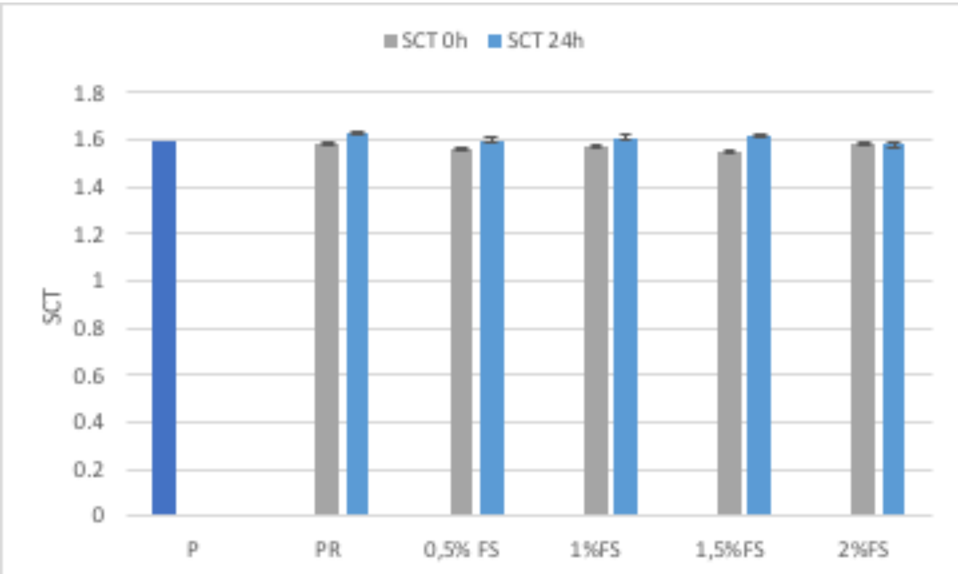

Figure 6. SCT of the paper samples.

Determination of the compressive resistance has now become established as an alternative to the ring crush test. The effect of the enzyme inhibition additive over the compressive strength test index (SCT) before and after the paper suspensions downtime is shown of Fig.6. The SCT parameter for the investigated paper samples is with constant values. The presence of Feno Spec 1200 has no negative strength effect.

4 CONCLUSIONS

The amylase enzyme inhibitor prevents the enzymatic degradation of starch polymer and the results from the paper suspension analysis show positive effect of the enzyme inhibitor over the dewatering effect and turbidity of the white waters. Investigated strength and deformation properties of the obtained paper samples are constant before and after 24 h of paper suspension downtime. Result for the starch concentration in the white waters are in the range of 0,05% even after the 24 hours' downtime of the paper suspension.

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Printing braille with special expandable screen printing inks

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ABSTRACT: *Printing braille and other tactile elements for blind and visually impaired is distinguished by specific characteristics, which are not always required in prints intended for normally sighted. For achieving good readability and tactile recognition of prints adequate height of prints, size and dimensions of braille and other tactile elements, suitable printing material and printing ink need to be fulfilled. Last but not least a proper, suitable printing technology needs to be selected. This paper presents results of the conducted research in which braille was printed with screen printing technique using two different 3D expandable water-based printing inks.*
Concluding from the results of the research we could establish that good readability and tactile recognition can be achieved with printing only in one layer if we choose the proper 3D expanding printing ink with smaller microspheres and modify the screen printing mash in a way that it enables the deposition of thicker layer. Analysis has also shown that better durability and quality of prints needs to be achieved by addition of thin coating varnish layer.

Key-words: braille, blind and visually impaired, tactile elements, screen printing, 3D expandable printing inks.

1 INTRODUCTION

Each printing process possesses its certain specifics and demands for achieving proper quality, readability and aimed content recognition, which consists of several factors. Printing braille is probably one of the most complex printing methods. It is intended for a group of people whose specific needs dictate their way of perception. Preparing all printing material and selecting proper technique is therefore complex.
Braille and other tactile elements are nowadays printed with different printing techniques, most often by embossing and UV ink-jet printing, though in some cases other techniques are also used (e.g. flexo printing, thermo-vacuum technique, screen printing etc.) (Chang, 2012; Kukec, 2015; Urbas, 2016; Zhang, 2011). Achievement of specific characteristics – adequate height of prints, dimensional ratios of individual elements (Braille, International Council on English, 2013; Deutsches Institut für Normung e. V., 2009; Fajdetič, 2015; Slovenski inštitut za standardizacijo; 2014) demand accurate – precise printing in several layers, where printing surface of printed braille as well as other tactile elements needs to be smooth and rounded (without sharp edges), is very time consuming. Beside mentioned, printing substrate needs to have specific properties. Printing substrate should have higher mass (grammage) (between 100 and 300 g/m^2) and thickness for preventing mechanical damages (folds, cracks etc.) and surface abrasions, also it should possess relatively high smoothness for achieving easier tactile reading and preventing damages of fingertips. Though embossing is not using printing ink/s, inks of other printing techniques need to offer smooth, soft and touch-pleasant prints that during reading do not cause abrasions and fingertip skin injuries. Namely, UV inkjet printing often offers hard, rigid prints of braille and other tactile elements, while embossing frequently causes either during the production (if unsuitable printing substrate is being used) or during it use (reading) cracking of the tactile surface. In both cases prints are therefore not preferable for reading by blind and visually impaired.
Due to the fact that specific dimensions of braille and other tactile elements need to be considered, prints made for blind and visually impaired, compared with the prints indented for normally sighted, are much larger and due to the used printing techniques (e.g. embossing) and readability requirements mainly printed only one sided (Kukec; 2015). Therefore, efforts have been made in trying to find a suitable technique, which would enable one layer both sided printing that would enable all demanded specifics of prints intended for blind and visually impaired (Fajdetić, 2015; Kron, 2004; Kukec, 2015; Urbas, 2016).
This paper presents a study in which modified classic screen printing technique that allows, with certain modifications of screen printing form, one-layer printing with the use of special 3D expandable printing inks. The use of these special 3D expandable inks reduces the consumption of the printing ink and printing substrate, as well as the amount of work, which leads to saving money and time. In some cases, the use of these special inks enables a possibility for printing braille not only on one but on both sides of paper format.

2 MATERIALS AND METHODS

2.1 Materials and printing method

The main goal of our research was to produce tactile recognizable prints, which would follow the standard specifications for braille and other tactile elements with the use of modified conventional screen printing technique.
For that purpose, two special 3D expandable screen printing inks have been used – Admiral (indicated as ADM) and Minerfoam SR (indicated as MFSR) (both Achitex Minerva S.p.A., Italy), which, if applied and treated properly on selected printing substrate provide stable, adequately high and recognizable tactile prints. Printing inks contained of printing base with microspheres that consisted of a thermoplastic polymer shell and liquid core. Liquid core under certain conditions (according to the producer, temperature around 150 °C and 3-minute exposure) expand and therefore increase the thickness of prints. The size of microspheres, according to the manufacturer range from 5 to 10 µm (Achitex Minerva, 2014).
Printing was performed manually using a screen printing PET mash with density of 32 threads/cm and monofilament diameter 100 µm on coated cardboard Kromopak (Količevo Karton, d.d., Slovenia), with grammage of 260 g/m^2. In order to ensure a sufficient transfer of the printing inks to the printing substrate the screen was coated with 10 layers (one on the inside, nine on the outside) of photoemulsion.
Selected braille text was printed on coated cardboard with smooth surface for easier tactile readability in one and in two layers. The printing ink ADM was applied in two layers (wet on wet method), while MFSR was printed only in one. Drying and expansion conditions of both selected printing inks differed slightly – ADM printing ink was directly dried and expanded for 3 minutes at 130 °C, while MFSR was firstly dried for 45 seconds in the drying tunnel at 100 °C and later expanded for 3 minutes at temperature of 150 °C.
For achieving higher printing paper smoothness and improved durability of prints some printed samples were coated with a thin one (1L) or two layers (2L) of water based Suncoat 9260/55s matt varnish, using the same screen printing mash. Varnish was dried for 135 seconds at 100 °C in the drying tunnel.

2.2 Testing methods

For conducting the results of printing braille with selected 3D expandable printing inks firstly the analyses of printing material were performed (grammage, thickness, surface structure). Later, height of prints – braille dots was measured with micrometer and SEM analysis (e.g. Scanning electron microscope) and measurements were compared. For assessing the shape, surface structure and quality of prints SEM and OM (optical microscope) images were investigated. Printed braille was also tested with blind and visually impaired, where prepared prints were given to a group of 10 blind people which gave us their opinion on readability and tactile recognition of prints.

3 RESULTS AND DISCUSION

The research of the printing substrate – coated cardboard showed that its grammage was 263,90 g/m^2 (slightly higher than defined by the producer), while its average thickness measured with micrometer was 0,434 mm and 0,521 mm measured with SEM. Both values were used later for the calculation of printed braille dot height (calculated braille dot height = height of print – thickness of printing substrate). Image analysis has shown that the printing substrate in average had relatively smooth surface, though it was on certain areas a bit uneven (Figure 1).

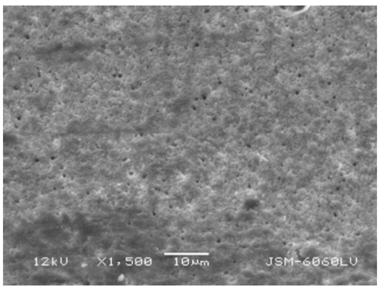

Figure 1. Surface of coated cardboard printing substrate (SEM; 1.500× magnification).

Dot heights measured with micrometer and SEM (image analysis) are showed in Table 1. Heights that are measured by the micrometer are as expected significantly lower, due to the fact that micrometer compresses the samples during measurements with the load of 0,5 kg in the area of 1,0 cm^2. Comparing the samples coated with or without varnish can see that better results are achieved in samples coated with two layers of varnish (2L) making them more resistant to pressure. SEM measured values of thickness were much higher showing same trends of results as with micrometer.

Table 1. Measured thickness of prints and printing substrate on micrometer (M) and SEM together with calculated braille dot height.

Sample	Thickness of prints [mm]		Thickness of printing substrate [mm]		Calculated braille dot height [mm]	
	M	SEM	M	SEM	M	SEM
ADM	0,500	0,882	0,434	0,521	0,066	0,361
ADM-1L	0,539	0,894			0,105	0,373
ADM-2L	0,553	0,907			0,119	0,386
MFSR	0,524	0,971			0,090	0,450
MFSR-1L	0,566	0,983			0,132	0,462
MFSR-2L	0,570	0,995			0,136	0,474

SEM image analysis has shown that printed braille dots differ according to the used printing ink (Figure 2). On dots printed with both ADM and MFSR printing inks the mesh structure of the used screen can clearly be seen. Even the expansion of the microspheres in the printing ink did not completely diminish the effect.
Later application of one or two layers of the water-based varnish slightly smoothened the clear filament lines on the prints though they can still clearly be seen. Though we have to emphasize that the SEM imaged were taken at 70× magnification and that the effect is not visible when being observed without the magnification (Figure 3).
Impression of the screen mash was more visible in the samples printed with ADM printing ink, which we contributed to the fact that MFSR possessed larger number of smaller microspheres which expanded evenly and therefore filled the surface more uniformly. Smaller expanded microspheres also adhered better to the surface of the printing substrate.

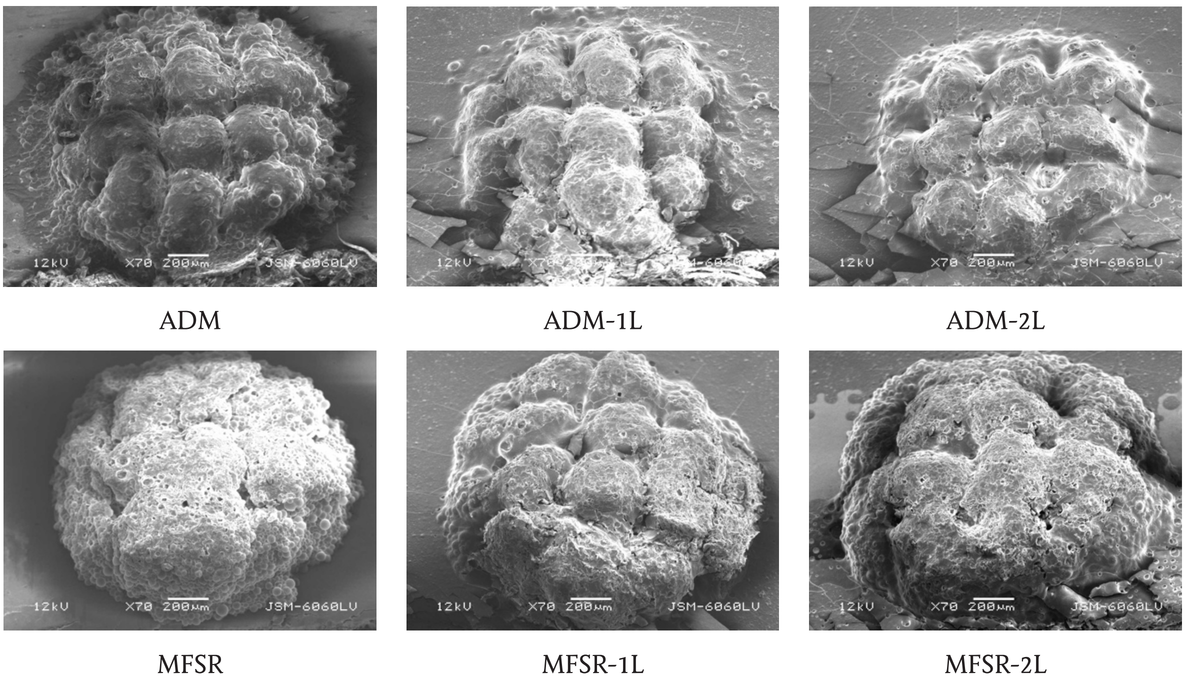

Figure 2. Surface of printed braille dots with ADM and MFSR printing ink coated with one (1L) or two (2L) layers of water-based varnish (SEM; 70× magnification).

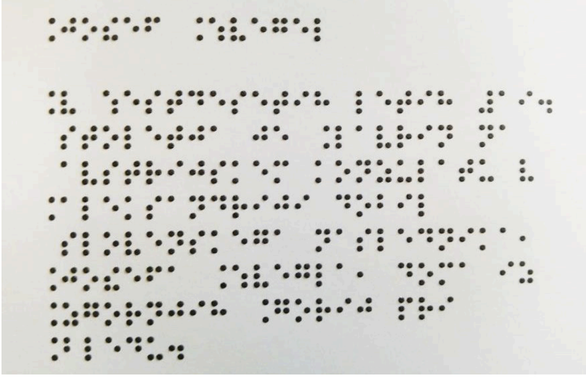

Figure 3. Printed sample in braille with selected text.

Printed braille samples were tested with blind and visually impaired, which gave us the feedback on readability and tactile recognition of prepared braille prints obtained with both selected printing inks. All interviewees were able to read the printed text though the readability was slightly worse it the case of ADM printing ink. They liked the smooth and soft surface of prints and no one detected the impressions of the screen mash in braille dots. Final conclusion was that the samples, coated with one or two layers of varnish enabled smoother and easier tactile fingertip transitions during printing where even the smoother surface of the printing substrate was recognized.

4 CONCLUSIONS

Results have shown that with both selected special 3D expanding screen printing inks ADM and MFSR we can achieve very good results – adequate height and sharp shape of the printed braille dots and suitable tactile impressions of the printed surface. Interestingly, higher prints of braille dots were achieved with MFSR printing ink, which was applied in only one and not two layers as ADM. Therefore, we can conclude, that by using this kind of 3D expandable printing ink with smaller microspheres we can enable the lowering of the printing costs and spent time of production. Beside mentioned we have concluded that using varnish as a coating layer increases the durability of prints. Testing in practice with blind and visually impaired showed that the tactile surface seemed smooth despite of its rough surface shown (impressions of screen mash in prints) in image analyses.
Results of the research have proved that with the use of modified conventional screen printing and right selection of special screen printing ink we can enable simple, fast and primarily economic printing of braille, that is adequate to prints produced by embossing, and satisfying to touch.

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SCIENTIFIC ILLUSTRATIVE DESIGNS IN GRAPHIC PRODUCTS

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ABSTRACT: In this research, the definition of illustration, presentation of its characteristics and wide range of usage are presented. It was important to briefly describe the development of illustration in Slovenian space and to mention its most influential illustrators (Gaspari, 2017).
Because the brand creates the visual presentation of their products or services, we can witness realistic illustrations being a better choice, compared to photographic material. In conclusion, illustrations of diverse styles can drastically improve the aesthetic look and recognisability of the product. The aim of our research was to present the wide usage of illustration, meaning and influence of illustrative design in graphic products and design a graphic image presented on an educational product, with the addition of realistic illustrations. The end result is a graphic image product with the addition of realistic illustrations of a selected animal as well as an interactive prototype design.

Keywords: illustration, scientific illustrations, design, reindeer, graphic product.

1 INTRODUCTION

Quality illustrations are meant to convince the spectator in this case that they are more informative and articulate than photographs. Graphic products appear as accompanying objects in our everyday life, each differentiates from another in purpose of usage, physical and graphic design (Rupel, 2013). Beside the product's quality services, graphic design or visual appearance also play a very important role. Addition of illustrations in graphic image can most certainly provide or enhance its uniqueness and recognisability. As with other forms of painting or art, visual arts are also important in illustration: line, color, light and shadows, shapes, structure, typography and composition. A quality illustration can be very simple or complex, drawing or painting, realistic or abstractly colored. Therefore illustration of an author differs from the illustrations of other authors, although they are of the same motive and areas. The wide usage of illustrations in graphic products were researched and were later narrowed down to usage of only realistic illustrations.
Realistic illustrations are often found on products for educational purposes, but can also appear in the role of advertisement on products in various markets (Gošnik Godec, et al., 2005). That can often appear on packaging's, mostly on packaging of food industry products (Hodges, 2017; Poynor, 2017).
The practical part covers the process of designing a board prototype as an interactive graphic product for client ZOO Ljubljana, Slovenia, with the addition of illustration with an educational role for a selected animal-reindeer. The process from the design of concept up to final prototype product version is described and presented. An extensive research regarding the selected animal was necessary for accurate illustrations. At the same time it was important to select the right material for the printing quality, process and for the interactive prototype.

2 EXPERIMENTAL

Traditional drawing included the largest part of our research. A series of illustrations had to be made until the illustrations, which could be suitable for use, has been made. Illustrations were made on photo, colored carton with Faber Castell color pencils. After the selection, the illustrations had to be digitized and processed (Adobe Lightroom, Adobe Photoshop and Adobe Illustrator) for proper use on the graphics products. The final part of the task was also aimed at the graphic design of the entire product, which besides the illustrations also contains the necessary graphic elements that gave the product a whole. Since several illustrations of the reindeer were produced in the process, a thematically complementary product was also produced, with general educational information content.

3 RESULTS & DISCUSSION

In cooperation with the ZOO Ljubljana, the concept of a graphic product, where the included illustrations would have the main importance for education, have been designed. The purpose of the work was to create a prototype of an interactive table as a graphic product that the ZOO will need for the animal – reindeer introduction. Initially, it was necessary to design and agree on the conceptual concept of the board, which would provide the audience with interactivity and information of an educational nature. Figure 1 and 2 present detailed illustrations of some body parts of the reindeer.

Figure 1. Illustration of a reindeer eye.

Figure 2. Illustration of a reindeer leg.

It was necessary to understand the proportions and correct the reindeer from the aspect of anatomy. With the colorings, it was necessary to give the appropriate texture to the reindeer, and at the end, notice the difference between the sharper horns and the softer figure of the animal. Figure 3 presents the illustration of whole animal, after several studies.

Figure 3. Illustration of the reindeer.

The end graphic product, with reindeer illustrations is complemented by a quarter-cut round plate (Figure 4), which had to be adequately graphically solved. The panel and the end product was written in Slovenian language due to demands of the ZOO.

Since the panel covers a large area, an additive with an inadequate solution could spoil the product or reverse the illustrations of the bottom panel. Since the panel rotated, the only option was, that the panel would not be empty, using a texture. In order to feel a separate surface immediately, there is a slight contrast in color between the plates. The pattern formed is in a hazy blue and brown color, enough to give a slight contrast to the lower plate. The pattern on the panel is consequently in circular shapes, and an arrow is added to supplement the product, which gives information about the rotation and its direction as a clockwise direction. The shape of the panel had to be cut with the cutting machine through the contour.

Figure 4. Graphic product-prototype with included illustrations in Slovenian language.

4 CONCLUSIONS

For the Ljubljana ZOO Ljubljana we have created a prototype of an educational interactive board that will provide visitors an information, for educational purpose about their animals. Because the illustration is a type of fine arts, the inclusion of realistic illustrations of the selected animal gives the product a higher value. For the entire concept of the product, we started with the client in the foreign literature and produced a prototype, where the graphic elements complement the product, give it interactivity and illustrations to give the product higher value. The prototype is made of corrugated cardboard and plate. The graphic image in the cardboard is laminated on the substrate as a label, but on a plate it was printed with digital printing technique.
We have produced a thematically complementary product, offering a general education on the selected animal, thus providing the basis for the training of specific characteristics and it's presented with the product of the horn cycle.

ACKNOWLEDGEMENT
The authors would like to thank ZOO Ljubljana for cooperation.

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SELECTING THE TRADEMARK COLOUR DEPENDING ON THE COMPANY'S BUSINESS AREA

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ABSTRACT: *The paper investigates the influence of colour on a trademark design in regards the company's profile or business area. The aim was to assess the influence of colour on consumer's attitude and to test which colour best matches particular business area. The trademark design should meet certain criteria in accordance with the company's commercial milieu. Different colours have different effects and, therefore, only appropriately defined colour should be used for specific company trademark. Hence, tests in this study were designed to help determine which colour is appropriate for a particular area of business.*

Keywords: colour, trademark, business area, semantics.

1 INTRODUCTION

A trademark is a noticeable sign used by an individual, business organization or other legal entity to identify their products and distinguish them from competitors. The trademark should visually illustrate the characteristics of the company it represents.

In all areas and types of graphic design, the trademark is one of the most complex projects, because the idea and the graphic-artistic solution itself should include many requirements in a simple, concise and sublimated form.

One way of differentiation of the trademark in relation to the other is the use of colour. Colour has the power to create an appropriate emotion. For thousands of years, colour plays an important role in the creation of a certain state of mind and its balance. For example, learning and treatment environments are no longer filled with cold colours; now they are mostly coloured with colours that stimulate the mind.

As a powerful form of communication, the colour is irreplaceable. By using different colours for a product or logo, different reactions can be caused. Colours can send subliminal messages, which play a key role in success or failure of the product.

The problem of selecting appropriate colours, depending on, and in accordance with the activities of the company, can be resolved by examining the psychological effects of colour on consumers. The colour experience varies depending on the age of the respondents, so it has been decided that the focus groups should include students, as more research has shown that the colour affects young people more than the elderly. This is especially true when it comes to marketing and the choice of colour for a product. The business fields covered by this research are medicine, electronics, transport, construction and food industry. For the colour palette, primary and secondary additive colour mixing were selected.

2 EXPERIMENTAL

In order to examine theoretical claims in the modern context, an internet survey in the form of a simple web application was conducted. The test contained a trademark design, a company name and a colour palette. The company's area could be determined by its name, while the trademark design was such as not to reveal any association. The respondents were instructed to observe black and white trademarks and determine their colour from the pallet in accordance with their preferences.

The business areas covered by this research are medicine, electronics, transport, construction (civil engineering) and food industry. The colours used are the red, purple, blue, green and yellow-orange, covering the primary colour range. Each colour is offered in three shades. The font used for all trademarks is also simple, without any additions that could be associated with the business area, so that the focus is exclusively on colour.

There were 130 participants in the experiment. Out of 130 results, 123 were processed, as 7 of the participants provided contradictory results. Of the 123 participants, 64 were graphic design students, while 59 had no background in graphic design. As colour has a greater impact on young people, the focus group was respondents aged 20 to 25.

Figure 1. The appearance of the test that was used in the survey.

As shown in Figure 1, the names of the companies are changed, while the logo and font remain unchanged.

Figure 2. Different trademarks for business fields:
medicine, electronics, transport, construction and food industry.

3 RESULTS & DISCUSSION

First, graphics with all colours are displayed individually, so that it can accurately see which colour prevailed for a particular business area. After that, the shades of the same colour were grouped.

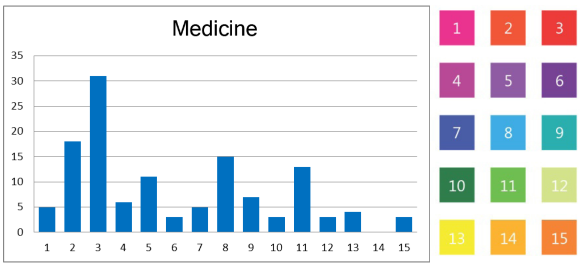

Figure 3. Results for the area of medicine.

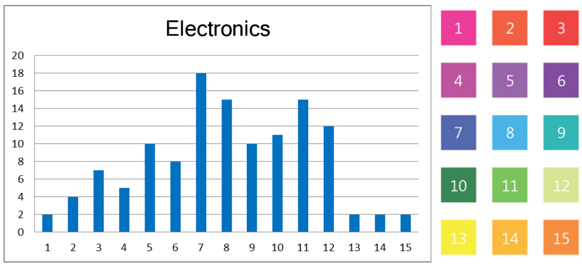

Figure 4. Results for the area of electronics.

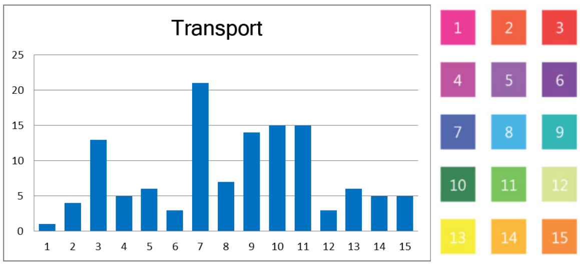

Figure 5. Results for the area of transport.

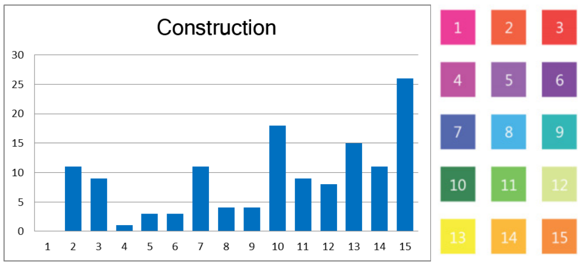

Figure 6. Results for the area of construction.

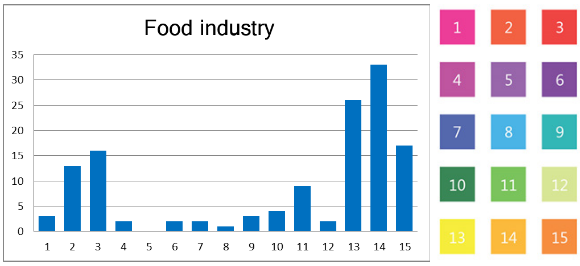

Figure 7. Results for the area of the food industry.

Based on the results of all the tests, the following results were obtained: for medicine, the association is red, for electronics blue and green, for transport blue, for the construction yellow-orange, for the food industry orange.

The results of the tests carried out by persons engaged in or related to the graphic design are as follows: for medicine red and blue, for electronics blue and green, for transport blue and green, for the yellow-orange construction, for the yellow and orange food industry. The results of tests performed by participants who are not related to the design are: for medicine - red, for electronics - blue and green, for transport - blue and yellow, for the construction - yellow-orange and yellow and orange for the food industry.

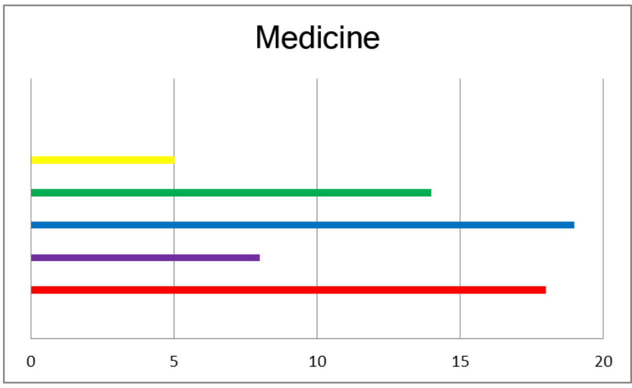

Figure 8. Answers of the participants related to design for the field of medicine.

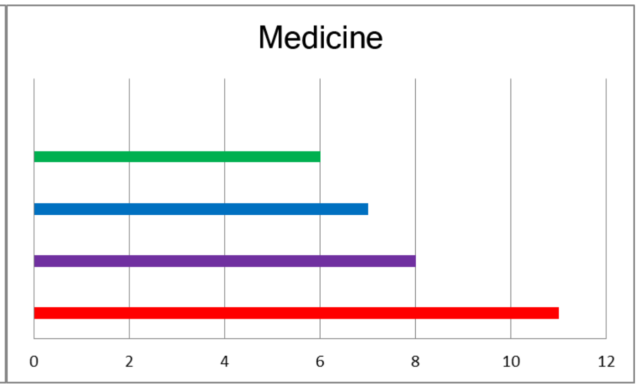

Figure 9. Answers of the participants with no background in design for the field of medicine.

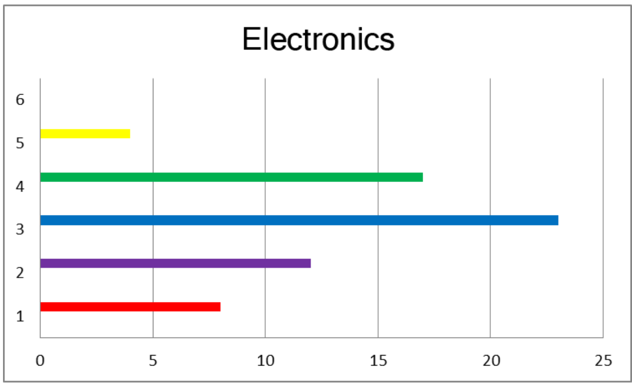

Figure 10. Answers of the participants related to design for the field of electronics.

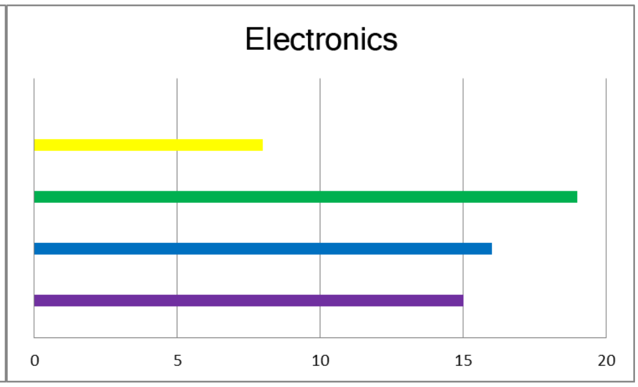

Figure 11. Answers of the participants with no background in design for the field of electronics.

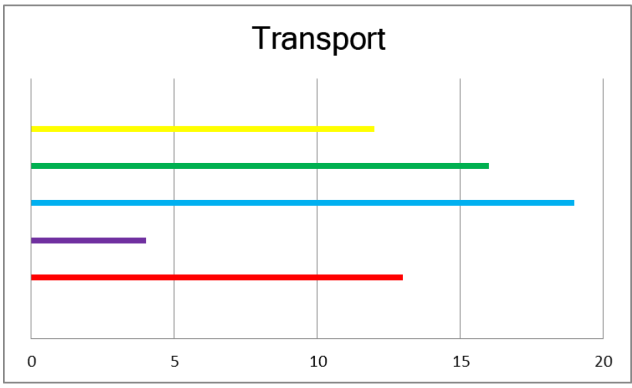

Figure 12. Answers of the participants related to design for the field of transport.

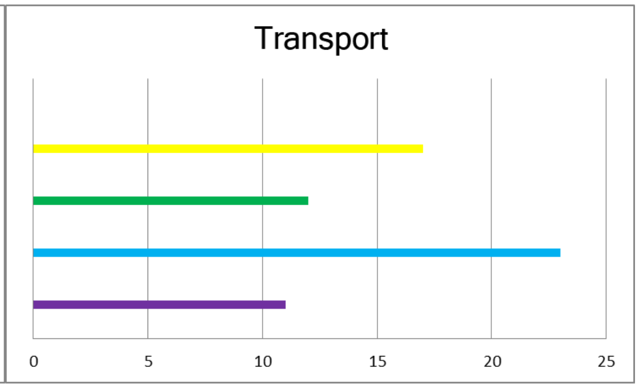

Figure 13. Answers of the participants with no background in design for the field of transport.

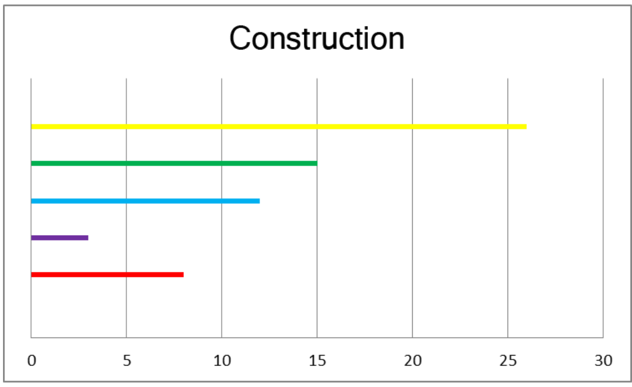

Figure 14. Answers of the participants related to design for the field of construction.

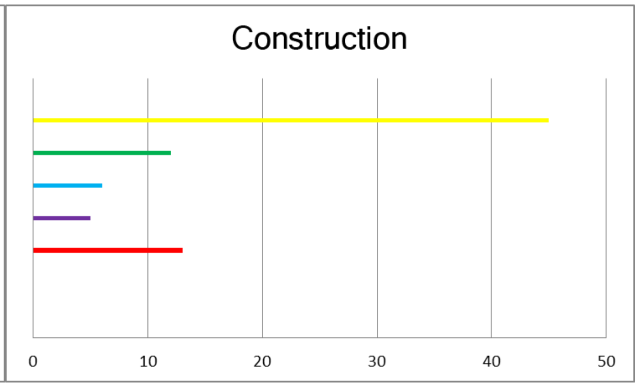

Figure 15. Answers of the participants with no background in design for the field of construction.

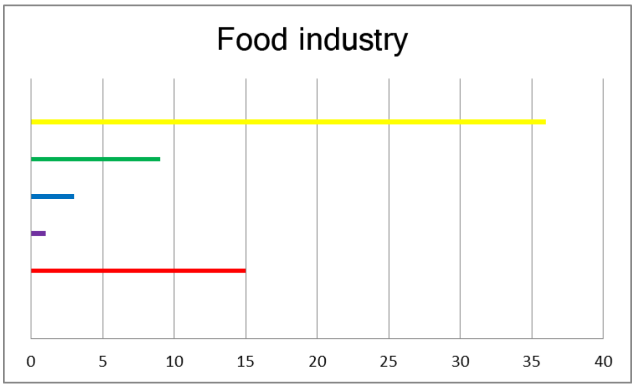

Figure 16. Answers of the participants related to design for the field of food industry.

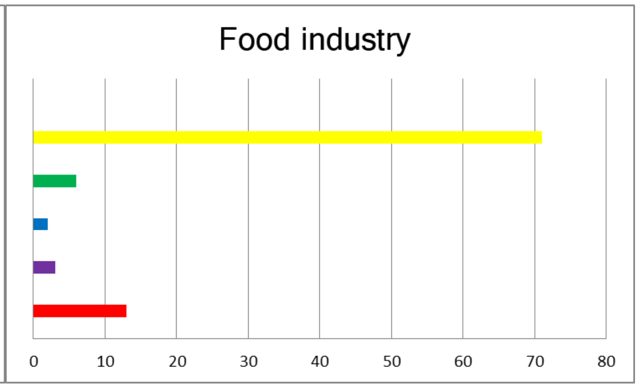

Figure 17. Answers of the participants with no background in design for the field of food industry.

4 CONCLUSIONS

Based on the obtained results it can be concluded that certain colours are associated with the certain business area by respondents. If more than one colour is needed for the trademark design, results are showing what those colours are. Also, the results show the difference between two groups of respondents. In choosing the appropriate colour for the trademark design for the specific business area of the company, designer responded differently than respondents with no graphic art background.

Colour is the basic element of many forms of communication, and a good designer needs to take full advantage of the possibilities that this huge colour range offers, to do unique works. Shape along with colour can represent a strong message. Each colour has its character and causes different associations, so sometimes even small errors in choosing the right colour can cause negative results. The same shape, trademark or logo, when displayed in different colours, can cause different effects with the viewer. The choice of colour should be carefully studied and determine which colours can be used in the certain business area, and which not.

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SELF-FOLDABLE KNITTED BAGS FOR HOUSEHOLD STORAGE OF BAKERY PRODUCTS BASED ON BIOMIMETICS

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ABSTRACT: *Textiles have multifunctional food storage potential. They can mechanically protect food against impact, they are air-permeable, washable, biodegradable, foldable, pleasant to touch and decorative. Knitted fabrics are distinguished by their stretchability and flexibility, the possibility of seamless production, high efficiency of production, possible self-folding and the possibility of complex mechanical and chemical functionalization. The use of weft knitted self-foldable structures for packaging has been an unexplored research field. The purpose of the research was to design, produce and test visually interesting, aesthetic and multifunctional weft knitted fabrics usable for household storage of baked goods/breads. Experimental work in design was inspired by natural foldable and permeable structures and based on the systematic development of 3D, textured and foldable structures with auxetic potential, made from various materials. The technological experimental work consisted of testing the foldable knitted bags for the ability to preserve the freshness of bread.*

Keywords: textiles, knitted fabrics, packaging, biomimetics, foldability.

1 INTRODUCTION

Industrial design including textile design most often draws ideas from nature. The underlying assumption in is that nature performs a function with the least amount of energy, uses the commonest materials, and is the most reliable. Biomimetics is a relatively young study embracing the practical use of mechanisms and functions of biological science in engineering, design, chemistry, electronics and so on. (Julian, 2007). Biomimetics offers competitive advantages to suppliers of materials, processes and components, and to the makers and brand owners of finished products. Product designers represent one important and welldefined channel for dissemination (Hollington, 2007).

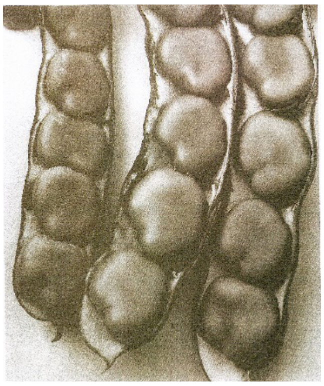

Figure 1. Beetroot peel - sparingly packaged seeds [Powers, 2000].

Nature's designs, materials, processes and structures have always inspired packaging. Packaging has a design, a shape, a structure, a concept, a finish and a decoration or print. Packaging is alongside the product, the driver to attract consumers. It is the first item the consumer sees, feels, smells, touches and (maybe) tastes. People are used to natural structures. Nature's solutions have stood the test of time. (Pointevin, 2007). One of the first and most critical roles of packaging is to contain the contents. Faced with changing volumes, numbers, sizes or shapes of items over time, nature has evolved some innovative and adaptive packaging solutions. Flexible containers are popular in nature since the size or number of the contents isn't always predictable. Flexible containers can expand and collapse. Nature therefore optimizes packaging on many scales. For example, the folding strategies from leaves have been mimiched into deployable structures for folding into the smallest space possible. These solutions could filter down to consumer application just as origami has influenced Japanese consumer packaging (Jedlička, 2009).

Efficient packaging materials and technology ensure the proper safety and quality of our food products from processing and manufacturing through handling and storage and ultimately to consumption. The polymers and materials used for food-packaging today consist of a variety of petroleum-derived plastic materials, metals, glass, paper and board, or combinations hereof. With the exception of paper and board, all of these packaging materials are actually based on non-renewable materials, implying that at some point, more alternative packaging materials based on renewable resources have to be found (Weber et al, 2002).

2 PRESERVATION OF FOOD FRESHNESS

Preserving the freshness of food is an important contribution to healthy nutrition and reducing the amount of discarded food. Food conservation including packaging is important for preserving the freshness of food. For household storage of foods, a variety of materials are used in modern times, of which textiles represent a smaller share. Textiles have multifunctional food storage potential. They can mechanically protect food against impact, they are air-permeable, thus preventing the formation of molds, they are washable and therefore repeatedly usable, biodegradable and thus sustainable, foldable, pleasant to the touch and decorative, i.e. suitable for production in different colors, sizes and shapes. Among the textiles, knitted fabrics are distinguished by their stretchability and flexibility, the possibility of seamless production, high efficiency of production, possible self-folding and the possibility of complex mechanical and chemical functionalization. Knits have been mostly used for packaging in the form of nets, produced on warp knitting machines. The use of weft knitted self-foldable structures for packaging has been an unexplored research field.

Bread is one of the most perishable food products. Its 40% concentration of water leading to a water activity of 0.96 makes susceptible to mould attacks. The micro-organisms that degrade the quality of the bread originate in the flour where they get from the cereals opportunist micro-flora, often accompanied by other microbes arising during milling or flour storing. By means of current preservation technologies and systems, the optimum duration for bread preservation on shelves is of 2-3 days (Cioban et al, 2010). Storage stability or the shelf-life of baked products could be defined as maintenance of the sensory and physical characteristics associated with freshness (Baixauli et al., 2008).

3 EXPERIMENTAL

The purpose of the research was to design, produce on an industrial weft knitting machine and test visually interesting, aesthetic and multifunctional weft knitted fabrics usable for household storage of baked goods/breads. Experimental work in design was inspired by natural foldable and permeable structures and based on the systematic development of 3D, textured and foldable structures with auxetic potential, made from various materials. The technological experimental work consisted of testing the foldable knitted bags for the ability to preserve the freshness of bread. Also, a visual analysis of the visually attractive and functionally useful packaging material for household storage of baked goods/breads was performed.
The suitability of foldable seamless knits for the storage of bread and bakery products has been studied. It was assessed by testing the antibacterial properties of the selected foldable knitted structures made from various raw materials.

3.1 Microbiological deterioration testing

First, the soil burial test according to SIST EN ISO 11721-1:2001 standard was performed for determining the resistances of foldable knitted fabrics made from various yarns to microbiological deterioration. Apart from a basic single knitted structure, a zigzag links-links knitted structure with 4 × 4 square repeating unit cell was selected. The selected yarns were made of: 100% combed cotton, 100% cotton with added polyamide filament, flax/viscose blend, natural bamboo/modal blend, carded 100% cotton, 100% lyocell, 100% viscose, wool/viscose blend, lyocell/viscose blend, lyocell/cotton blend, cashmere/polyamide/viscose and 100% wool. The time of exposure was 12 days. Afterwards the knitted samples were carefully removed from the soil. The samples were rinsed in water, sterilised by soaking in 70% ethanol at room temperature for 30 minutes and dried. Initially, the deterioration of samples was visually assessed. After that, the rate of biodegradation of the examined samples was determined by colour measurement with a spectrophotometer SPECTRAFLASH 600 PLUS (Datacolor International, USA) using the CIELAB colour system. ΔL^* values of the buried and unburied samples were determined and compared.

3.2 Antibacterial properties testing

In order to achieve antibacterial activity, Bioshield Excalibur (Izinova Ltd., Bled) finishing agent was selected, which is chemically alkyl dimethyl (3-trimethoxysilylpropyl) ammonium chloride. Its antibacterial activity is based on bio-barrier formation mechanism. Antibacterial activity of the examined knitted samples was estimated by determination of bacterial reduction according to the ASTM E 2149– 01 standard method. Bacterial reduction of the samples was evaluated against Gram-negative bacteria Escherichia coli (ATCC 25922).

3.3 Bread freshness preservation testing

To study the freshness preservation potential, two foldable links-links structures were knitted: a zigzag structure with a 24 × 24 repeat having a width of 12 ribs and a zigzag angle of 45°, and a zigzag structure with a repeat having a width of 2 ribs and the same inclination as the previous sample. The 24 × 24 structure was well folded while the 4 × 24 structure was less folded and therefore had a lesser auxetic potential. From each material and structure, three bags were made for bread storage.

White sandwich bread (Pekarna Jurčkova, Ljubljana) was chosen for testing the freshness preservation potential. When it was cooled after baking, it was cut into 2.5 cm wide slices, weighed and stored in prepared textile bags. Every 12 hours the bread samples were weighed and the percentage of the bread mass reduction was calculated (Požrl, 2017).

To test the bread freshness change during storage in textile packaging the moisture loss was determined by weighing. For packaging, materials with foldable ability and good antibacterial properties were selected: 100% liocel, liocel/cotton blend, bamboo/modal blend, flax/viscose/elastane blend and 100% bamboo cellulose viscose. In spite of good folding ability and good antibacterial properties, keratin fibers have been discarded as the reusable textile food packaging is expected to be repeatedly washable at higher temperatures while the keratin materials do not meet this requirement. For comparison, two conventional materials in which bread is stored in households were selected: a plastic bag and a sandbag paper, both from Drogerie Markt. From the testing results it is apparent that bread keeps the softness and humidity the longest if it is stored in a polyvinyl bag, but after two days it is possible to notice a change in the surface of the core. Paper bags give the worst results when storing bread because the bread is drastically dried out.

3.4 Product design

3D-knitted packaging bags have an attractive, full/compact look and good folding ability. In the folded and passive state, the bag takes up little space, especially in comparison with the bread box. Furthermore, it is decorative, washable and flexible. In the open and active state, it is well-adapted to its content regarding shape and size. The links-links weft knitted structure allows the redistribution of the volume is. Due to its ability to adapt to the content size and shape, the image of the packaging bag changes all the time.

4 RESULTS & DISCUSSION

The results of the microbiological deterioration study showed that the ΔL^* values of the foldable knitted structures were lower than for the single knitted structures. The visual assessment of the samples also showed that in most cases, the foldable knitted structures were less deteriorated than the single knitted structures. The results proved that the foldable links-links knitted structures have better microbiological resistance compared to the single structures.

According to the results, foldable links-links knitted samples from flax/viscose blend, natural bamboo/modal blend, lyocell/viscose blend, 100% lyocell, cashmere/polyamide/viscose and 100% wool were selected for further investigation.

The results showed that the selected antibacterial finish was fully effective, reflecting in complete growth reduction of the tested bacteria. On the other hand, untreated foldable links-links knitted samples exhibited rather important differences in the reduction of E. coli growth. The samples made from lyocell/cotton blend exhibited 55% reduction, the reduction of cashmere/polyamide/viscose blend was 11%, while the reduction of the rest of the samples was less than 10%. Better results for the samples made from natural bamboo/modal yarn were expected due to the original antibacterial properties of the natural bamboo fibres.

Textile bags, made from cellulose fibers, showed almost the equivalent results: they were better than paper bags and are much worse than plastic ones in bread freshness preservation. The tested bread dried the most during the first 24 hours, then the drying process slowed down. The results indicated that the bread was the least dried out in the bag made of 100% bamboo viscose. Both structure exhibit minimal moisture-retaining potential, less than 1%.

Figure 2. Knitted bag for bread storage in passive state (folded and empty).

Figure 3. Knitted bag for bread storage in active state (unfolded and full).

5 CONCLUSIONS

Foldable knitted structures are multifunctional and widely usable. They can be produced in a variety of structures, qualities and dimensions: in panels, fully-fashioned or seamless. They exhibit a supreme aesthetics and have a big potential for the use in multiple areas. Some of the foldable knitted structures exhibit auxetic properties which have lately become a subject of extensive research. Foldable knitted structures, links-links knits among them, can be considered a promising development line of sustainable hi-tech knitting technology and design, especially if combined with other technologies. The development of sustainable, re-usable and up-cyclable, genuine self-folding knitted collapsibles should be encouraged.

All tested cellulosic textile materials are suitable for bread storage. Taking into account biodegradability and antibacterial properties, it would be reasonable to make bread bags for household bread storage from a mixture of lyocell/cotton or from 100% lyocel yarn. Due to the foldability which enables the adoption of shape hape of the packaging to its content, it is recommended to use the foldable links-links zigzag structure with a larger square repeat.

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STUDY OF ACCELERATED AGING OF BLACK INKJET PRINTS

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ABSTRACT: *The purpose of this work is the study of accelerated aging of prints. This work is focused on the study of the fast and non-destructive approach to investigate the spectral changes of black inkjet prints during heat accelerated aging, which is currently interested from the point of view of forensic analysis of questioned documents. In this work, we analyzed the set of 10 accelerated aged samples printed using the office printer on the office paper. The process of accelerated aging was performed for 29 days using glass bottles closed with the Viton® sealing ring in drying oven heated to 100 °C according to the ISO 5630 – 1. The samples were measured using Near Infrared (NIR) optic fibre device and processed by the Liner Discriminant Analysis (LDA). The spectra were also measured using Fourier transform (FT) Raman device. The FT-Raman spectra were interpreted separately with regard to observing the changes and trends of spectra shapes and slopes.*

Keywords: NIR spectroscopy, Forensic science, Chemometry, Document.

1 INTRODUCTION

Ubiquitous a large number of printed documents that have to be examined in forensic to detect potential falsifications requires the fast and reliable approach to reveal the origin of the questioned documents. For this reason, numerous destructive and non-destructive methods were applied.

The method allowed repeatable and reliable investigation of black inkjet inks extracted from printouts were realized using capillary electrophoresis coupled to mass spectrometry with electrospray ion source and time of flight analyses (CE-ESI-TOF-MS) (Kula, 2014). However, for forensic aspect the non-destructive approach is required since the document in question can be analyzed by using other methods as key evidence. Non-destructive techniques like NIR spectroscopy are usually preferred since they are simpler to perform and usually require minimal manipulation of the analyzed material to preserve the integrity of the document in question (Materazzi, 2017). Infrared spectroscopy proved to be a useful technique in forensic science (Ferrer, 2017). The well-known chemometric methods play an important role in the forensic purpose of sample analysis. In particular, the NIR spectroscopy coupled in tandem with chemometrics represent the ability to study substances for qualitative and quantitative examination of the matrices (Gál 2015), (Reháková, 2017). The suitability of FT-Raman spectroscopy to investigate some black inkjet prints was described in (Oravec, 2018).

This work is focused on the non-destructive approach of spectral examination, which is currently considerably required, in forensic analysis of questioned documents.

2 EXPERIMENTAL

NIR measurements

All NIR reflection spectra were measured with an Ocean Optics fibre optics spectrophotometer consisting of Hi-Res spectrometer NIR 256-2.5 spectrometer with NIR light source HL-2000-FHSA (Ocean Optics, Inc. Dunedin, FL USA). The spectra were acquired in the range 850 – 2630 nm. Each sample was measured 9 times. The dataset was embedded in the software The Unscrambler X 10.5 (CAMO Software AS., Oslo, Norway) (Unscrambler) for following data processing and design LDA.

Liner Discriminant Analysis (LDA)

The NIR spectroscopy was combined with LDA method to classify the samples based on the time of accelerated aging. The 9 spectra of each sample were divided into Calibration set (Cal) and Validation set (Val) in the ratio of 6:3. For each sample, 3 separate LDA models were created. The selection of spectra into Val was performed in 3 different manners: the Val 123 represent first 3 measurements of the 9 in total. Val 456 represents the group of next 3 acquired spectra and Val 789 comprise the remaining 3 measurements. The Cal was varied respectively. This variation was done to improve statistical significance of the experiment.

FT-Raman measurements
FT-Raman spectroscopy of 10 samples was performed to study differences in the shapes and trends of the spectra. The spectra were acquired using Bruker FT-Raman Spectrometer MultiRAM (Bruker Optics Inc. Billerica, MA USA) with FT-Raman microscope. The device was equipped with Nd:YAG laser, diode pumped by P = 1000 mW. All spectra were acquired using device adjustment to the power of 1000 mW, 64 scans and resolution of 4 cm-1. The measuring was performed in the region 50 – 3800 cm^{-1}. The FT-Raman spectra were acquired with the OPUS 6.5 software (Bruker Optics Inc., Billerica, MA USA). The spectra were treated using manual baseline correction with OriginPro (OriginLab Corporation, Northampton, MA USA), (Origin). The two parameters of the most prominent peak (around 1600 cm-1) were recorded: the Full Width at Half-Maximum (FWHM) and the peak intensity of the band.

Sampling
In this study were investigated 10 prints of the same office printer EPSON L210 (the ink supplies reference is C13T66414A) on the same office paper (80 g/m^2). The printer was set up on normal quality and the black ink was used only. Each of the samples consists of 3 completely filled equal squares (Fig. 1) with dimensions of 1.5 cm x 1.5 cm.
The accelerated aging process was performed using closed glass bottles with Viton® sealing ring in drying oven heated to 100 °C according to the ISO 5630 – 1. Before the samples were placed into the drying oven, they were treated with the conditioned atmosphere (T = 24 °C and RH = 50%) for 24 hours. In this way, 10 samples of the different aging time were prepared. Heat treatment of the samples was carried out in constant conditions: relative humidity and temperature during 1, 3, 6, 8, 10, 13, 16, 20, 24 and 29 days. The names of the samples were derived from days of aging i.e. sample E1 was 1 day accelerated aged, E3 3 days respectively.

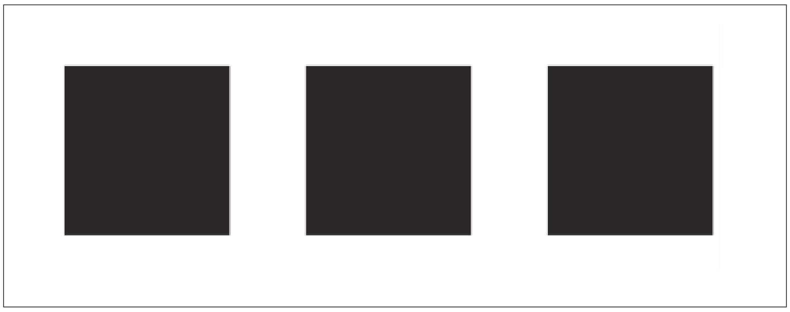

Figure 1. The view of a print file printed on the office paper.
The experiment was focused on 3 completely filled squares.

3 RESULTS & DISCUSSION

With the aim of classifying the black inkjet prints with different accelerated aging time, the analytical strategy consisting of the chemometric LDA analysis of NIR reflection spectra and the interpretation of FT-Raman spectra.

LDA analysis of NIR reflection spectra
The 90 NIR spectra were embedded into The Unscrambler to realize LDA. The aim of this method was to classify spectra from Val in the model built from Cal for each of 10 samples. The results of LDA are summarized in the table (Table 1). If the Val spectra of the examined sample were in accordance with the model (all 3 spectra of Val were right classified) than the sample was marked using “Y” symbol. If all 3 Val spectra were wrong classified, then the examined sample was marked using “N” symbol. The average accuracy of right response was 45.6%. As follows from the Table 1, LDA model is not reliable enough to classify the NIR spectra of aged inkjet prints.

Table 1. The interpretation of LDA classification.

Sample	Val 123	Val 456	Val 789
E1	-	Y	-
E3	Y	-	N
E6	-	N	-
E8	-	Y	Y
E10	N	N	-
E13	N	N	N
E16	Y	Y	Y
E20	N	-	N
E24	-	-	Y
E29	-	N	N

FT-Raman method

The FT-Raman spectra of the aged prints without baseline correction are on Figure 2 and the spectra with manual baseline corrections are on Figure 3.

The trend of intensity during aging is not certain in both cases: neither in untreated nor in baseline corrected spectra (Figure 2, 3).

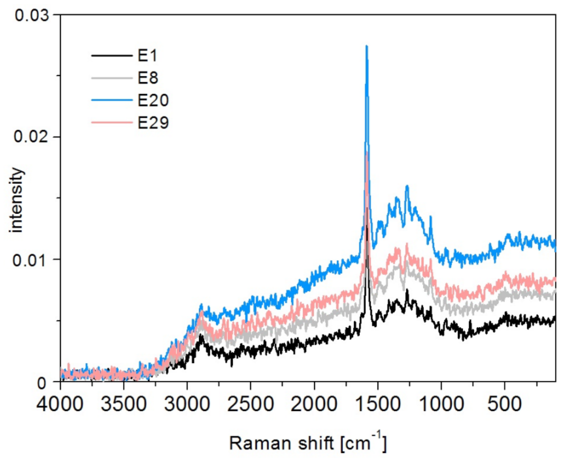

Figure 2. The FT-Raman spectra of E1, E8, E20 and E29 samples. The band of 1590 cm^{-1} represents the most prominent peak of the spectrum and belongs to the G-modes of a disordered carbon.

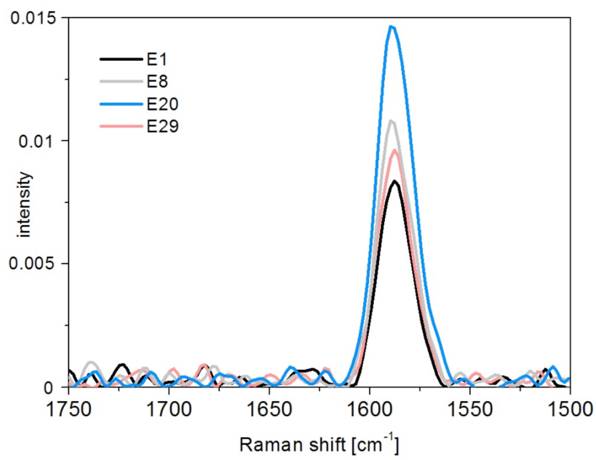

Figure 3. The comparison of FT-Raman spectra after manual baseline correction.

The investigation of prints aging using FT-Raman spectra is based on the properties of a relatively significant band of the spectrum. This strong Raman band at about 1590 cm^{-1} can arise from the G-modes of a disordered carbon. The plots of intensity and FWHM (band of 1590 cm^{-1}) against the time of accelerated ageing are on Figure 4.
The trends in both plots are not monotonic, and hence they do not allow direct classification of the unknown aged sample. However, in the combination of these parameters can be useful to distinguish which one the model sample is the best match for the unknown sample.

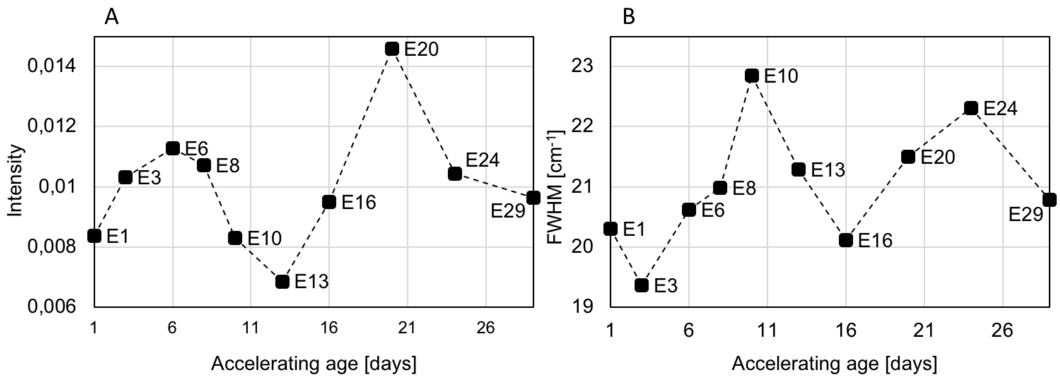

Figure 4. The intensity and FWHM of the baseline corrected FT-Raman spectra of prints during ageing.

4 CONCLUSIONS

This work is focused on the non-destructive approach of spectral examination of aged inkjet prints.
This investigation shows the interpretation of acquired spectra: the NIR spectroscopy combined with supervised classification method LDA and FT-Raman two parameters identification. In general, the trends of the spectra are not unambiguous. However, the potential to classify the samples based on similarities with the model are presented. The FT-Raman spectroscopy in tandem with NIR spectroscopy combined with LDA could be considered for applications in the forensic analysis of documents in question when the conventional methods are not effective.

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STUDY OF CHANGES OF WRITING INKS ON THE PAPER DOCUMENTS

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ABSTRACT: *Examining of writing inks is a part of analysis of documents which could help forensic experts to detect a crime. Nowadays many researches are focused on studying ink changes on the paper documents, because falsification of documents is becoming more common and more frequent.*
The most common volatile solvent in ballpoint pens is 2-phenoxyetanol (2-PHE). At the moment when the ink is deposited on the paper, alcohol starts to evaporate. The amount of 2-PHE in the extract is therefore dependent on the application time on the surface. Ink extracts can be analysed using a combination of gas chromatography with mass spectrometry (GC–MS). The time of creation of written record was identified by comparing the amount of 2-PHE in fresh samples and samples subjected to artificial aging.

Keywords: Writing inks, document, forensic examination, evaporation, 2-phenoxyethanol.

1 INTRODUCTION

Falsification and modifying of writings in documents – personal documents, checks, agreements and bills are part of economic crime.
The analysis of the ink composition as part of documents for criminological and forensic purposes is dating to 1988. In this year, the chemical analysis of the ink was the first time used on the questioned document as evidence in the court in the State of New York. This interest in examining ink naturally continued to evolve with the development of writing instruments. Analysing the age of the questioned document based on an examination of the inks present very complex process (Parciová, 2016). The degradation of the ink begins immediately after the ink has been applied to the substrate. Successive chemical reactions dependent also on the composition of the substrates and specially on the storage conditions (humidity, air flow, light, exposure to air pollutants, etc. (Menzyk, 2015).
Examining of writing inks is a part of analysis of documents which could help forensic experts to detect a crime. Nowadays many researches are focused on studying ink changes on the paper documents, because falsification of documents is becoming more common and more frequent. Analysis of individual ink components can determine if the record has changed, or if the period of the creation of document has modified (Jones, 2013). Anyway, three different actions are in progress during the degradation. The first action is a migration of dyes or pigments, the second one is a polymerization of resin and the third process is the evaporation of the volatile solvent. When writing ink is placed on a substrate, a drying process begins. This process is dependent on the composition of the ink, paper and on the storage conditions – humidity, light and thermal conditions (Cantú, 2012).

2 EXPERIMENTAL

Chemicals and materials

Samples preparation

Blue ballpoint pens used in the experiment were purchased in SEVT, a.s. Slovakia. The width tip of each pen was 0.5 mm. Inks were applied onto office paper in the form of a thin lines. The paper: First class (80 g/m^2), Mondi SCP a.s. (Ružomberok, Slovakia). The samples were stored in the at laboratory temperature (20 – 25 °C). Relative humidity during storage was in the interval 45 – 70%.

Extraction procedure

The experiment tested two series of samples. The first one was fresh written record placed in laboratory conditions (non-aged). The second one was artificially aged (the condition of ageing: 70±5 °C for 1 hour). All samples had form of 5 cm long lines written by ballpoint pen on the paper. They were cut to small pieces and put into micro-vials (2 ml). Subsequently extraction agents with an internal standard were added into samples. The extraction agent was acetonitrile (99.8%), Sigma-Aldrich® (St. Louis. MO, USA) and the internal standard was diphenylamine (DFA, ≥ 99%), Sigma-Aldrich® (St. Louis. MO, USA). Concentration of DFA was 0,0025 mg/ml.

GC–MS analysis

The solvents were analysed on a gas chromatograph – Agilent Technologies – model 7890A with mass detector 5975C (MSD) operating in the electron impact mode of ionization. Parameters of the column HP5-MS: length 30m, internal diameter 250 μm and the film thickness of the stationary phase 0,25 μm. Used thermal program: initial kiln temperature: 50 °C (±1 °C), heating 15 °C/min to 280 °C, final step: 1 min at a constant temperature of 280 °C, total length of analysis: 17,33 min, dosage amount: 1μm. The Split-less mode was used for dosing the sample.

3 RESULTS & DISCUSSION

For a detection of 2-phenoxyetanol in a fill of ballpoint pens it is necessary to know a retention time of the analysed components. Retention time is the time which flows between the feed of sample and the moment when the component leaves the column at the maximum concentration.
The chromatographic peak associated with 2-PHE should occur approximately at RT = 7.16 min (± 0,43 min) and peak for internal standard at RT = 10.65 min (± 0,61 min). These retention times are important because they are one of the main parameters to indicate the accuracy of the experiment layout (Luczak, 2002). Tables 1 and 2 show the compounds in two sample sets together with data on their retention times and peak areas.

We analyzed 2 sets of samples: lengths of 5 cm and 1 cm. A sample of 5 cm line was analyzed to optimize the setting of the device anf for better handling. The confirm of the presence of 2-phenoxyethanol was easier to detect in a larger sample. A sample of 1 cm line is the maximum quantity that can be taken from a document. At the same time, it seems that is the minimum amount from which it is possible to extract a detectable amount of 2-PHE. From a real handwriting it is possible to take the sample from various places of the signature in parts (in the total length of the line 1 cm). Basically, to determine the period of the record creation, it is necessary to take 2 cm of line on paper because 1 cm is unheated and the other cm is subjected to the artificial aging.

Table 1. Chemical compounds represented in the sample set 1.

Order	RT [min]	Peak area 10^{-6}	The name of the compound	Mole weight [g/mol]
1	7,10 ± 0,42	8,47 ± 0,12	2-phenoxyethanol	138,07
2	10,59 ± 0,51	0,78 ± 0,04	diphenylamine	169,09

Table 2. Chemical compounds represented in the sample set 2.

Order	RT [min]	Peak area 10^{-6}	The name of the compound	Mole weight [g/mol]
1	7,26 ± 0,49	3,34 ± 0,03	2-phenoxyethanol	138,07
2	10,70 ± 0,63	0,62 ± 0,01	diphenylamine	169,09

The method of calculation of the percentage dependence R was realized using equations 1-3.

$$R[\%]= ((P_w-P_s)/P_w)\ 100\% \quad (1)$$

$$P_w= (\text{Peak area } 2 - \text{PHE (non aged)})/(\text{Peak area DFA}) \quad (2)$$

$$P_s= (\text{Peak area } 2 - \text{PHE aged)})/(\text{Peak area DFA}) \quad (3)$$

On the basis of the above mathematical relations, the relevant parameters Pw, Ps and R were calculated. These parameters are shown in Table 3 for sample set 1 and in Table 4 for sample set 2.
The process of decreasing the concentration of 2-PHE in one of the aged sample long 5 cm to the non-aged sample is shown in the Figure 1. The process of decreasing the concentration of 2-PHE in one of the aged sample long 1 cm to the non-aged sample is shown in the Figure 2.

Table 3. Characteristic values for sample set 1.

Non aged sample		Aged sample				
Peak area 10^{-6} (2-PHE)	Peak area 10^{-6} (DFA)	Peak area 10^{-6} (DFA)	Peak area 10^{-6} (2-PHE)	P_w	P_s	R / %
14,24 ± 0,49	0,65 ± 0,02	0,36 ± 0,01	0,34 ± 0,01	21,98	0,96	95,65

Table 4. Characteristic values for sample set 2.

Non aged sample		Aged sample				
Peak area 10^{-6} (2-PHE)	Peak area 10^{-6} (DFA)	Peak area 10^{-6} (DFA)	Peak area.10-6 (2-PHE)	P_w	P_s	R / %
63,16 ± 0,94	3,72 ± 0,03	6,33 ± 0,09	23,38 ± 0,23	17,00	3,70	78,26

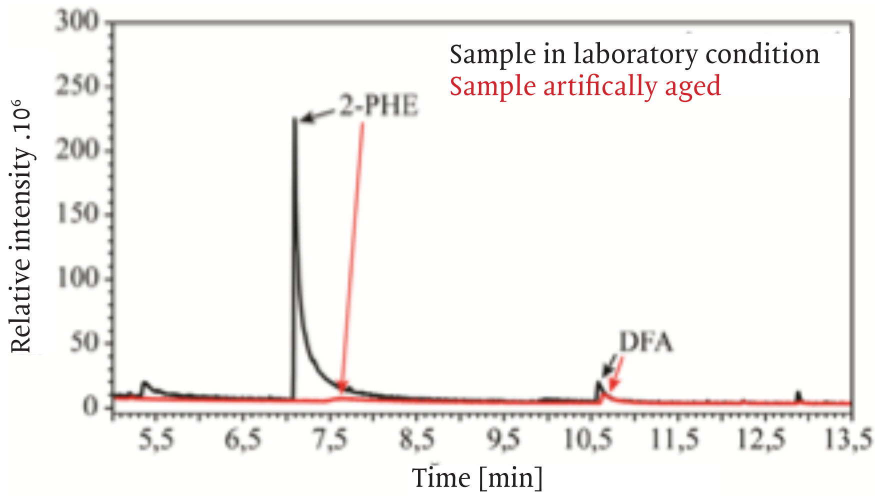

Figure 1. Chromatogram of sample from set 1 (5 cm line).

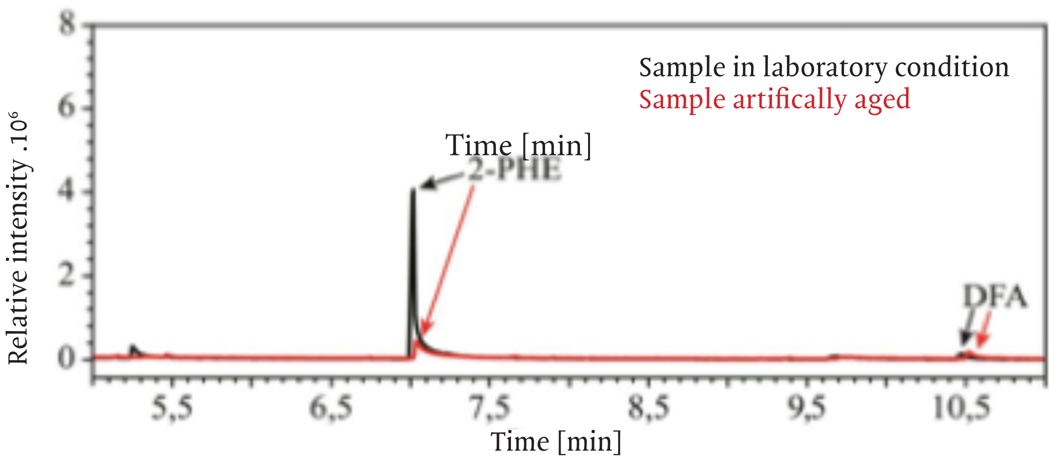

Figure 2. Chromatogram of sample from set 2 (1 cm line).

4 CONCLUSIONS

2-phenoxyetanol is the most common volatile solvent presents in the ballpoint pens. Nowadays the analysis of 2-phenoxyetanol by GC-MS is the most frequent method to determine of period of creation the record. Analysis of the period of the record creation was made by calculating the percentage dependence R, which was calculated by share of the peak area of the 2-phenoxyethanol aged and non-aged to peak area of the internal standard (diphenylamine).

Crucial findings of our experiment were:

- There is no direct relationship between R and the length of the analysed line. While percentage amount of 2-PHE (R) was 95% for the line of 5 cm length, R was 78% for the line of 1 cm length, using an equivalent amount of solvent in both samples.
- Accurate amount of analysed sample (ink line) is very important factor. We must determine the time dependence of R (considering the time pass since the ink was applied to the paper) at defined accurate amount of analysed material and specific conditions of analysis. This experiment is currently running and the results are expected in form like in the publication (Luczak, 2002):
  R < 20%: the result cannot be interpreted (writing is older than 18 month / did not contain 2-PHE)
  R > 20%: record is probably younger than 18 months.

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SYNTHESIS, COATING AND EVALUATION OF ANTIMICROBIAL MICROCAPSULES ON PAPER

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ABSTRACT: *An antimicrobial formulation for coating of papers, based on microencapsulation technology, was developed. Essential oil of Cymbopogon citratus (citronella oil) was microencapsulated by complex coacervation of gelatine and carboxymethylcellulose, and by in situ polymerization of melamine-formaldehyde prepolymers with a polyacrylic acid modifier. Both methods resulted in a container type pressure-sensitive microcapsules with a distinct liquid core and solid wall. Minimal inhibitory concentrations of non-activated citronella oil microcapsules were determined for Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa and Saccharomyces cerevisiae. The in situ polymerization microcapsules had better suspension stability and formulation properties, and were more appropriate for the coating process, due to smaller microcapsule dimensions. Pressure-activation tests of coated papers suggested the possibility of a prolonged use with gradual release of citronella oil at repeated pressures. The research will continue to optimise the quantity and/or type of antimicrobial active substance to reach higher antimicrobial activities of coated papers.*

Keywords: microcapsules, synthesis, coating, paper, antimicrobial.

1 INTRODUCTION

Interest in the bio-efficacy of essential oils and their uses as natural antimicrobials in environmentally-friendly products has increased in recent years. Several innovations in smart packaging food systems included essential oils (Rodrigez et al., 2007; Manso et al., 2013; Atarés and Chiralt, 2016; Ribeiro-Santos et al., 2017a,b). As the components of essential oils are volatile and subject to degradation under environmental influences, different encapsulation techniques may be applied to provide protection and prolonged or controlled release: microcapsules and microspheres, nanoparticles and nanospheres, liposomes, micro-emulsions, gels and molecular inclusion (Xiao et al., 2014; Majeed et al., 2015; El Asbahani et al., 2015; Bakry et al, 2016; Rodríguez et al., 2016). The purpose of our research was to develop a pressure-sensitive controlled-release microencapsulated form of an essential oil with antimicrobial effects, which would be applicable as a functional additive in paper and cardboard secondary packaging systems for food and pharmaceuticals. After the analysis of scientific literature, the lemongrass (Cymbopogon citratus) essential oil, also known as the citronella oil (CAS RN 8000-29-1), was selected for microencapsulation (Leimann et al., 2009; Wang, 2018). The citronella oil is known for its antimicrobial properties (Naik et al., 2010) and pleasant aroma, and is widely used in food, pharmaceutical and cosmetic products, as well as a repellent and a mild natural pesticide in agriculture and horticulture. The oil consists predominantly of monoterpenes, such as citral (synonym geranial) (39-48%), neral (32-35%), mircen (11-15%) and geraniol (3-5%) (Sacchetti et al., 2005; Matasyoh et al., 2011; Bassolé et al., 2011; Fadli et al., 2016) and has a boiling point at 200°C, specific weight 0.897, and the oral LD50 for rat 7200 mg/kg (ScienceLab, 2013). In the experimental part, our research focussed on the following steps: (a) synthesis of microcapsules by two different methods – complex coacervation and in situ polymerization, (b) morphological characterisation of produced microcapsules, (c) antimicrobial testing of microcapsules, (d) preparation of formulations and coating on paper, (e) weight-activation of pressure-sensitive microcapsules on papers, and (f) antimicrobial evaluation of paper matrices and coated papers.

2 EXPERIMENTAL

A non-diluted citronella oil (Sigma-Aldrich) was microencapsulated as a model antimicrobial component by two processes taking place in oil-in-water emulsions. In the complex coacervation process, acid-treated gelatine, type A (Sigma) and low viscosity carboxymethylcellulose, type 7L (Hercules) were used as macromolecular colloids with opposite charges for the formation of microcapsule walls. In a reactor vessel with a turbine impeller the temperature was maintained at T = 50°C. Emulsification took place at 800 rpm, 10 min. To form microcapsules, coacervation was initiated by dilution with water and by lowering pH to 4.3 (2 hours, T = 50°C, 800 rpm). After cooling the system to a room temperature (1°C / min, 800 rpm), coacervate walls were crosslinked by glutaraldehyde (Acros); the process was completed after 2 hours. In the in situ polymerization microencapsulation process, melamine-formaldehyde precondensate (Melamin) and the polyacrylic acid modifier (BASF) were used. The laboratory reactor was equipped with a 1000 ml vessel, a heating/cooling system, and a Heidolph mixer with adjustable speed 0-2000 rpm. An aqueous solution of the modifier was prepared, the citronella oil was emulsified to form an oil-in-water emulsion, and a melamine precondensate was added as the wall material. The polymerisation was initiated and maintained at an elevated temperature (T = 70-80°C) for 1 hour, following by cooling to terminate the reaction. Antimicrobial effects of microcapsules were determined as the minimum inhibitory concentration (MIC) in a liquid medium on Bacillus subtilis, Escherichia coli, Pseudomonas aeruginosa and Saccharomyces cerevisiae, with 2,3,5-triphenyltatrazolium chloride (Merck) added as an indicator. The MICs were determined after 24 hours of incubation at 37°C. Microcapsule suspensions were formulated with water soluble starch or with carboxymethylcellulose (ratio 1:1 and 1:2) and coated on paper (label paper, 70 gsm, and paper for flexible packaging, 50 gsm), 2 g formulation / m^2 (for 1:1 formulation 0.086 g/m^2 citronella oil within coacervation microcapsules, or 0.275 g/m^2 citronella oil within in situ microcapsules). Pressure-sensitive microcapsule walls were activated by pulling the coated paper under a 5 kg metal weight. The morphology of microcapsules and the wall rupture after activation was examined under the light transmission microscope (LTM) and scanning electron microscope (SEM). To evaluate the coated papers, a method for the determination of aerobic mesophilic bacteria in paper was used for uncoated paper matrices, and for papers coated with microcapsule containing formulations.

3 RESULTS & DISCUSSION

Both microencapsulation methods resulted in a container type microcapsules with a distinct liquid core and solid wall. The coacervate microcapsules were larger (a diameter of 10 to 60 μm), with elastic natural polymer walls (Figure 1), while the in situ polymerization microcapsules were smaller (diameter of 1 to 8 μm), with spherical, rigid and impermeable synthetic polymer walls (Figure 2).

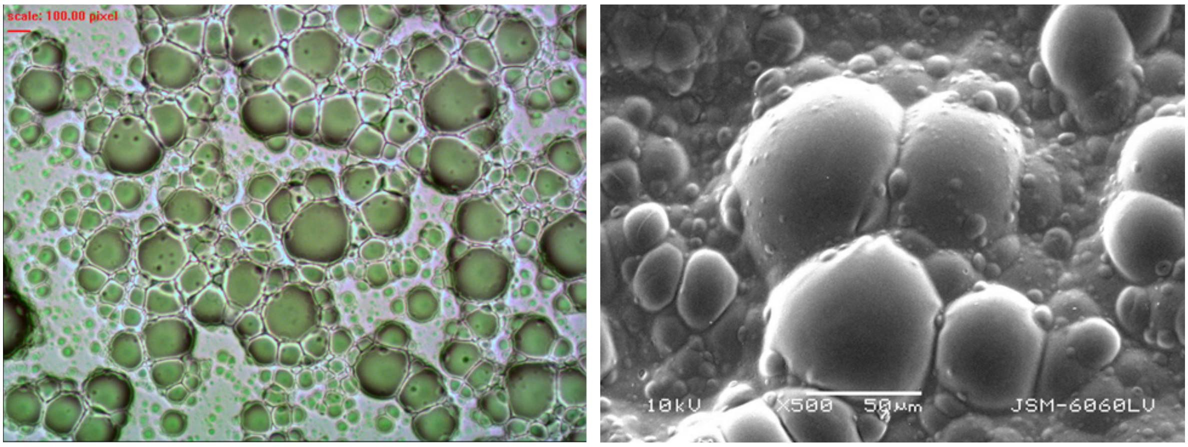

Figure 1. Coacervation microcapsules. Left LTM, 100×. Right: SEM, 500 ×.

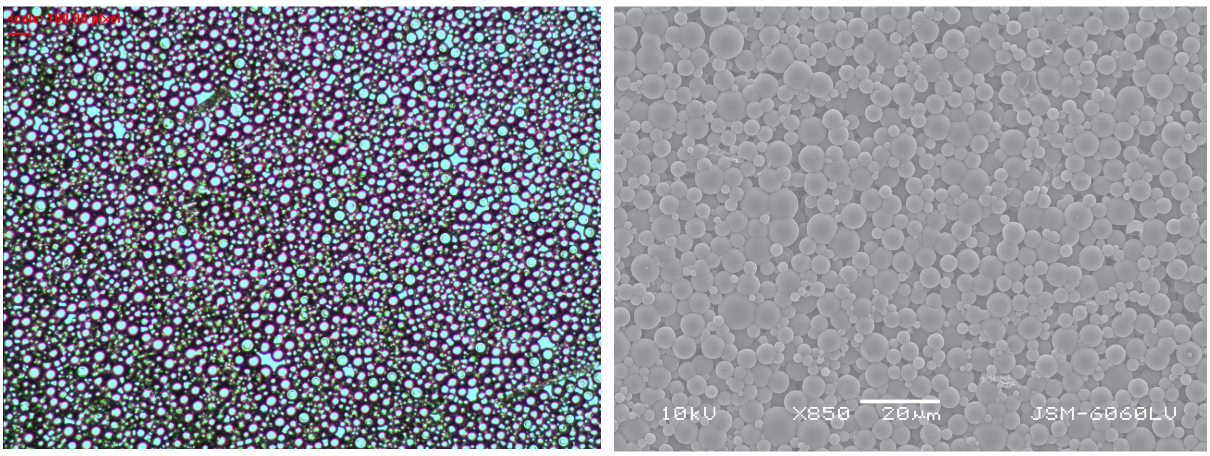

Figure 2. In situ polymerization microcapsules. Left LTM, 100×. Right: SEM, 850×.

The results of antimicrobial testing of non-activated microcapsules in a liquid medium were collected after 24 hours incubation at 37°C. The MIC values within the range 0.07%< MIC >0.014% were determined for the intact non-activated coacervation microcapsules with three tested bacterial species (B. subtilis, E. coli, P. aeruginosa), and 1.72%< MIC >0.34% was determined for the yeast S. cerevisiae. The observed antimicrobial activity can be attributed to partially permeable walls of the coacervation microcapsules. The obtained MIC values are comparable to the results by Wang et al. (2018), who produced citronella oil microcapsules with hydroxyapatite / quaternary ammonium salt of chitosan / sodium alginate walls, and determined the MIC 0.0625% for E coli and S. aureus. For E. coli and B. subtilis, the results also coincide with the literature data for the non-capsulated citronella oil - MIC 0.06% was determined by Naik et al. (2010). In contrast, in the case of non-activated in situ polymerization microcapsules, the range 1.72%< MIC >0.34% was determined for B. subtilis, and MIC >1.72% for the other three tested microorganisms. The results suggested that the in situ polymerization microcapsule walls were impermeable, and there was no residual non-encapsulated citronella oil present in the suspension. Based on these results it can be assumed that coacervate citronella oil microcapsules can be more suitable for applications with gradual release of the essential oil without mechanical activation, and the in situ polymerization microcapsules for products where a long-term retention is desired, and a planned release of active substance by a mechanical pressure. The combination of both microcapsule types could have a double effect - a slow sustained release of the citronella oil, and a planned quick pressure-activated release when used after a prolonged storage.

Microcapsules of both types withstood air drying when applied in a layer on a glass plate for LTM, and the vacuum during the SEM microscopy. In the paper coating process, the in situ polymerization microcapsules showed better formulation characteristics and were more suitable for the coating process, primarily due to smaller microcapsule sizes, better suspension stability, and formulation mixing (Figure 3).

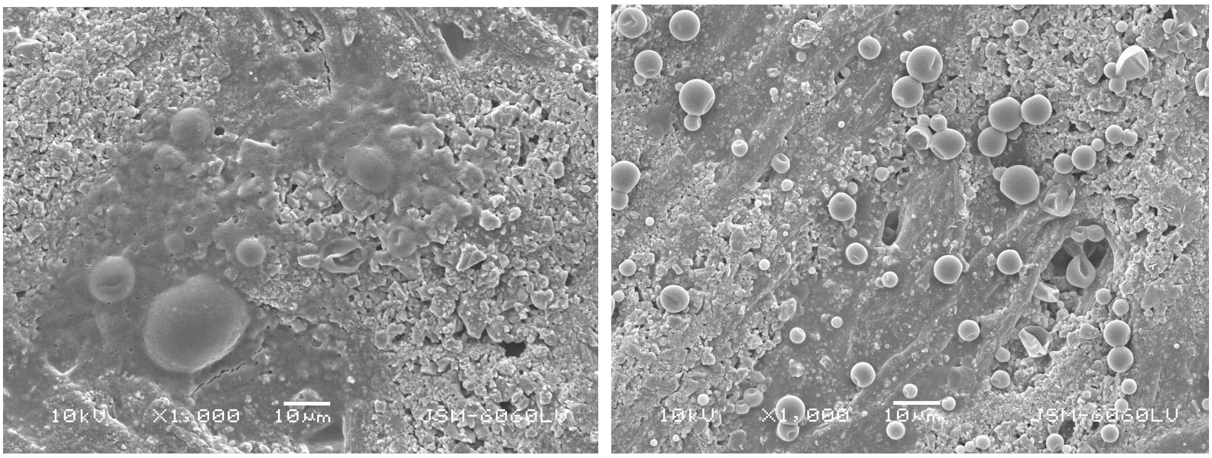

Figure 3. Coated paper with microcapsules. Left coacervation microcapsules (SEM, 1000×), right in situ polymerization microcapsules (SEM, 1000×).

SEM photographs of coated papers confirmed a partial pressure-activation of in situ polymerization microcapsules in the 5 kg weight pulling test. Microcapsules with broken walls and empty cores were visible, while some microcapsules remained intact (Figure 4). This indicated that not all of the essential oil was released from microcapsules at once, and suggested the possibility of prolonged use - gradual release of citronella oil at multiple pressures. We estimated that the mechanism of essential oil release by mechanical pressure was suitable for the intended application. However, the question remained whether the amount of released citronella oil would be sufficient for the antimicrobial effect. The preliminary antimicrobial testing - determination of aerobic mesophilic bacteria in paper on standard count agar (for E. coli, P. aeruginosa, B. subtilis) and determination of yeast on sabouraud 2% glucose agar (for S. cerevisae) revealed no significant difference between the uncoated paper matrices and papers coated with a formulation containing in situ polymerization microcapsules with citronella oil in the applied concentration range (2g of coating formulation / m^2), without or with pressure-activation. The result could be expected, as the coating 2 g/m^2 only contained approximately 0.275 g of encapsulated citronella oil per m^2, and the 1 cm2 testing sample on agar plate only contained 0.00275 g of citronella oil in microcapsules. Therefore, after the successful microencapsulation and coating step, our research will continue to optimise the antimicrobial activity on coated papers, first by increasing the amount of citronella oil microcapsules in the coating composition, and then by integrating a larger proportion of microcapsules into the paper mass during the production of paper. Another possibility is to encapsulate antimicrobial compounds with stronger antimicrobial activities, and/or to prepare mixtures of several antimicrobial compounds targeting Gram-positive and Gram-negative bacteria as well as yeasts and moulds.

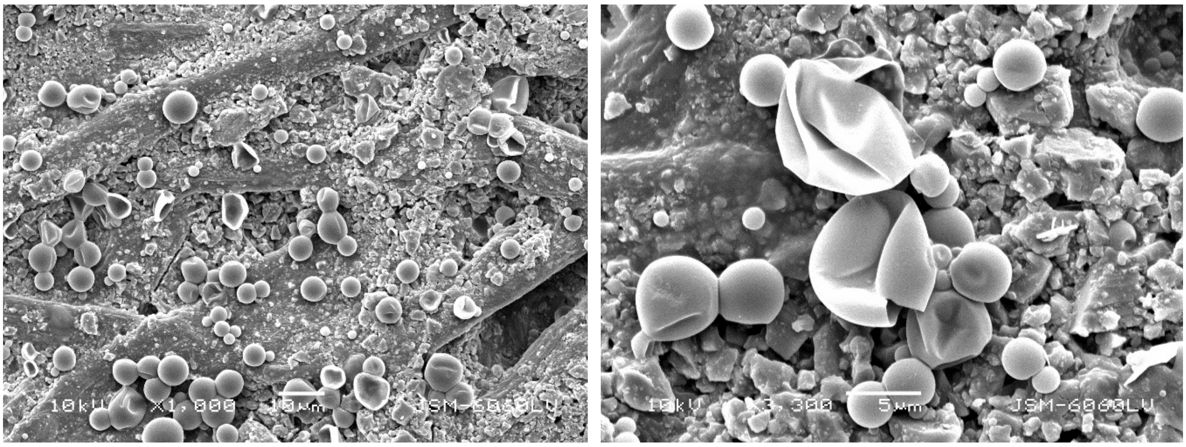

Figure 4. Coated paper with in situ polymerization microcapsules after the 5 kg weight pulling test. Left SEM 1000×, right SEM 3300×.

4 CONCLUSIONS

The aim of our research was to develop a pressure-sensitive controlled-release formulation with antimicrobial properties, to be used in packaging systems for food or pharmaceuticals. After a literature analysis, the essential oil of Cymbopogon citratus (citronella oil) was chosen as the antimicrobial compound, due to its antimicrobial activity, pleasant aroma, and applicability in food, pharmaceutical, cosmetic and agricultural products. To reduce its volatility and prolong the activity, the citronella oil was microencapsulated. Two processes were successfully applied: the complex coacervation of acid-treated gelatine and low viscosity carboxymethylcellulose, and the in situ polymerization of melamine-formaldehyde precondensates with polyacrylic acid modifying agent. Both methods resulted in a container type microcapsules with a distinct liquid core and solid wall. However, the properties differed: the coacervate microcapsules were larger (10 to 60 µm), with elastic partially permeable walls, while the in situ polymerization microcapsules were smaller (1 to 8 µm), with rigid and impermeable walls. Minimal inhibitory concentrations of microencapsulated citronella oil were determined for B. subtilis, E. coli, P. aeruginosa and S. cerevisiae. The results indicated that the antimicrobial activity depended on microcapsule type and wall permeability. Coacervate citronella oil microcapsules would be suitable for applications with gradual release, while the in situ polymerization microcapsules could provide a long-term retention and a release by a mechanical pressure. The in situ polymerization microcapsules showed better formulation characteristics (suspension stability and formulation mixing), and were more appropriate for the coating process, due to smaller dimensions. Pressure-activation of coated papers indicated that some microcapsules opened during the 5 kg weight pulling test and released the citronella oil, while a part of microcapsules remained intact, suggesting the possibility of a prolonged use with gradual release at repeated pressures during the product use. However, the amount of microcapsules or the concentration of antimicrobial agent still needs to be optimised, as the applied coating did not result in a significant antimicrobial activity, compared to uncoated papers. This will remain the goal for further research in the continuation of the project.

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TLC AND GC/MS ANALYSIS OF INK JET PRINTING INKS

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ABSTRACT: *At the moment when ink hits the printing material, the chemical structure of ink changes and several chemical processes occur, which enable fast drying or penetration of ink into the printing material. For a comprehensive understanding of the process that occurs during ink-substrate interaction, it is necessary to be aware of the components of the ink as well as the substrate. Therefore, the aim of our study was the determination of components that were needed to achieve required colour as well as what components for achieving appropriate physical and chemical properties of the printing ink were used. The thin-layer chromatography (TLC) analysis gave us the insight into the colour system of printing inks. Regardless of some limitations of gas chromatography (GC) the GC/MS chromatography enabled the overview on the additives that were added to the printing ink.*

Keywords: ink-jet, printing inks, TLC, GC/MS, chromatography.

1 INTRODUCTION

Ink jet technology is advancing rapidly. This technology can be encountered in the workplace as well as in our homes (Hudd, 2010). The interest of average end user is mostly quality print and maybe even a fastness of prints. Therefore, the manufacturers do not see the importance of spreading confidential information about components that our home ink jet printers use. The aim of ink manufacturers seems to be meeting the requirements of printer manufacturers, which is mainly limited to the physical and chemical properties of the ink (Agarwal, 2016). Consequently, they do not hesitate to replace ink components with more cost-effective components (Sharma, 2014) as long as they provide the same physical and chemical properties of the ink. At the moment when ink hits the printing material, the chemical structure of ink changes and several chemical processes occur, which enable fast drying or penetration of ink into the printing material. Meaning that identification of printing inks is complicated due to methods of application, non-transparent selection of different chemical structures, and commercial names (Lewis, 2009).

Therefore, when we observe prints, we usually do not think only about colour itself, but we should also take into consideration the printing material that accompanies the print. However, at the same time, we forget about components that were or are still present in ink.

The interest of our study was the determination of components that were needed to achieve required colour as well as what components for achieving appropriate physical and chemical properties of the printing ink were used.

Therefore, in the experimental part of our study, the determination of ink components was undertaken with a relatively simple and useful method – chromatography. The use of thin-layer chromatography (TLC) for the separation of dyes has proved to be the ideal solution due to the wide selection of stationary phases and unlimited mobile-phase mixtures (Wall, 2000). For the first, polar or stationary phase the silica gel with a fluorescent indicator on aluminium plate was selected. The second or mobile phase was chosen according to the previous tests. According to the experience of other researchers (Agarwal, 2016; Lewis, 2009; Wall, 2000) using a single solvent combination for mobile phase the complete separation of ink components will not be possible. Due to non-volatile dyes, a gas chromatography (GC) has limitations in the field of characterisation of inks (Agarwal, 2016). However, GC/MS chromatography enabled the overview on the additives that were added to the printing ink.

In the field of dye separation, we can find several analytical methods which allow more extensive understanding of ink jet ink components, each of them having specific advantages and importance in analysing printing inks. With those methods, it is possible to confirm some assumptions and find some answers to the questions that appear during experimental part.

2 EXPERIMENTAL

2.1 Printing inks

For the experimental part, products of the two ink manufacturers (Canon and Epson) were carefully selected. The conditions for selecting those two manufacturers were:
- dye based cyan, magenta, yellow and black ink jet printing inks;
- use of printing inks in desktop ink jet printers;
- printing inks should be in a liquid state.

Before the analysis, using a needle, the ink was removed out of the cartridge. The ink samples were stored in a dark and cool place in tightly closed glass vials.
Due to the sensitivity of the measuring device, the dilution of ink and methanol was required at the concentration of 1:3000.

2.2 Thin-layer chromatography (TLC)

For TLC analysis the silica with a 254 nm fluoresecence indicator coated aluminum plates (Sigma-Aldrich, DE) were used. For mobile phase we selected four different mixtures of solvents:
- ethylmethylketone:acetone:distilled water (7:5:3 v/v);
- ethyl acetate:ethanol:distilled water (70:35:30 v/v);
- butanol-2:ethanol:distilled water, (10:2:3 v/v);
- acetonitrile:distilled water (2:1 v/v).

The samples were placed as spots on a line drawn 1 cm above the bottom of coated aluminium plate and vertically placed into the glass chamber containing the mixture of solvents. The process of migration and separation occurred when the mobile phase was moving upward the stationary phase. After a certain period, the plate was removed out of the chamber and dried in the air. Under the visible light, the separated spots were marked and the retention factor (Rf) was calculated according to equation 1, where ds is migration distance of substance and dsf is the migration distance of solvent front.

$$R_f = d_s/d_{sf} \tag{1}$$

2.2 Gas chromatography – Mass spectrometry (GC/MS)

For GC/MS analysis the Agilent HP 6890 (Hewlett Packard, USA) instrument was used. As a carrier gas (mobile phase) the helium was used. The parameters for GC/MS analysis was, previously heated of the injector to the 250°C and heating chamber to the temperature of 80°C. During the analysis, the temperature in the heating chamber gradually raised (20°C per minute) to the final temperature of 270°C and maintained for 20 minutes. Only a small amount (2 μl) of the sample was required for the analysis. The final amount of sample was assessed by a split ratio of 10:1, which means that only 0.2 μl of sample passed through the GC column. The mass detector performed scanning of molecular weight from 15 to 700.

3 RESULTS & DISCUSSION

3.1 Thin-layer chromatography (TLC)

According to the previous researches (Agarwal, 2016; Lewis, 2009; Wall, 2000), the complete separation of the ink will not be possible by using only a single solvent combination for mobile phase. According to the tests of four solvent mixtures we have decided that for the first mobile phase the solvent mixture of ethylmethylketone:acetone:distilled water (7:5:3 v/v) and for the second mobile phase the solvent mixture of ethyl acetate:ethanol:distilled water (70:35:30 v/v) was used. Referring to chromatograms the retention factors (Rf) for each sample were calculated. Rf factor provided a qualitative estimation of components that were needed to achieve required colour in printing ink.
From TLC chromatogram (Figure 1) we can observe that the printing inks consist of two or more coloured components. Figure 1 shows more or less successful ink separations on the aluminium plate with the first and second solvents mixture. In the case of cyan and black printing inks, we have achieved incomplete separation of printing inks. Since the part of the ink component was kept at the starting point as well as some components had the same Rf values and were not completely separated during the process. It can be assumed that some ink components may contain a salt-based ink as the salt-forming dye is superior in dissolution stability with time and fastness properties (e.g. light and water resistance) and it is applied in combination with a basic dye

(Ono, 1994), which prevent the component to run upward over the stationary phase. Inorganic salts are often added as extenders, so different batches have the same dyeing potential (Wall, 2000). Also, for black inks another undesirable result became apparent, several components had pretty much the same polarity. Therefore, some components did not separate completely from each other during the analysis process.

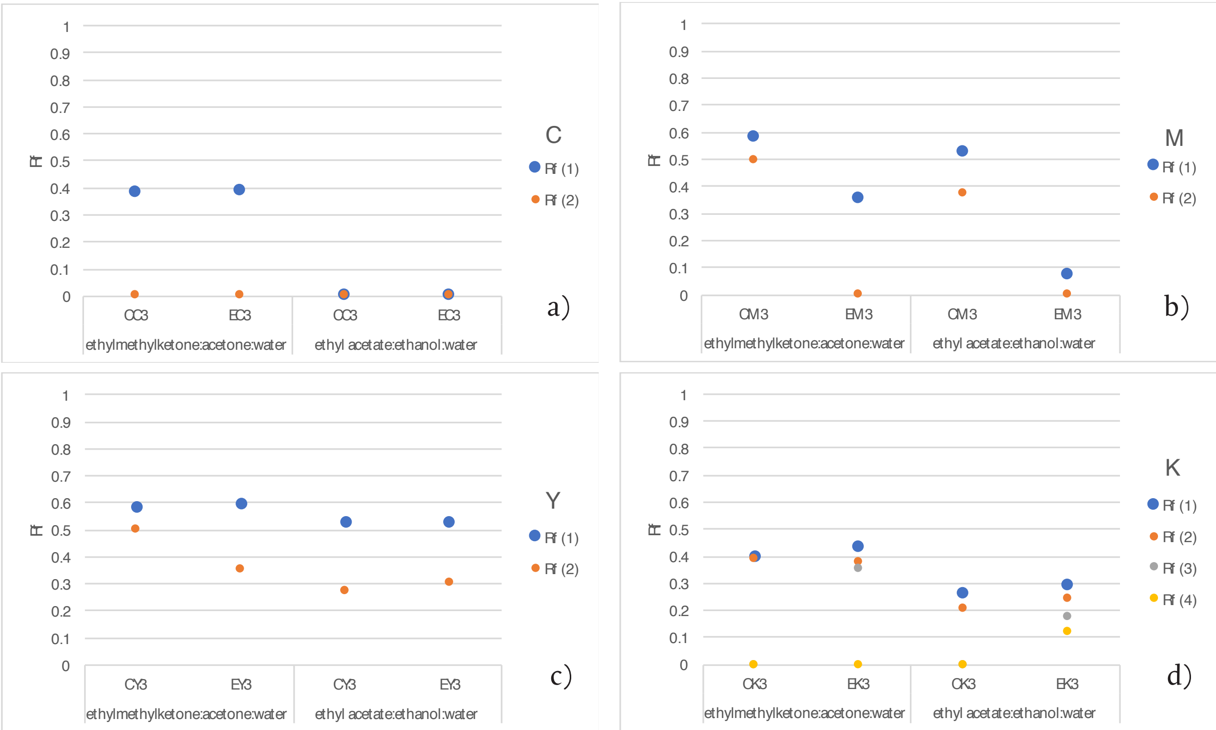

Figure 1. Display of calculated retention factor (Rf) of ink jet inks with first and second mobile phase for individual printing inks. (a) Cyan (CC3 – Canon Cyan and EC3 – Epson Cyan); (b) Magenta (CM3 – Canon Magenta and EM3 – Epson Magenta); (c) Yellow (CY3 – Canon Yellow and EY3 – Epson Yellow); (d) Black (CK3 – Canon Black and EK3 – Epson Black).

3.2 Gas chromatography – Mass spectrometry (GC/MS)

Due to non-volatile dyes, a gas chromatography (GC) has limitations in the field of characterisation of inks (Agarwal, 2016). However, GC/MS chromatography enabled the overview on the additives that were added to the printing ink. The results of GC/MS analysis revealed the insight into the ink components which manufacturers add to the printing inks to provide some specific physical and chemical properties of the inks. According to the results, the preparation of ink formulations varies according to the manufacturer as well as according to the colour. However, some components appear in both cases. We have found the following compounds of glycerol, divinyl sulfone, 1,5-pentanediol, 2-pyrrolidone, ethanol, and in some cases the presence of 2-imidazolidone as well as glycerin and triethylene glycol. Aliphatic glycols, among which is also glycerol, are in water-based inks to behave as a carrier fluid (Foucher, 1999). The purpose of alcohols in printing inks is to regulate the surface tension or to control the drying of the ink on the substrate and to improve the resistance of the prints against water (Foucher, 1999; Pekarovicova, 2015). To prevent the evaporation of water and the sedimentation of coloured components the 2-pyrrolidone (Foucher, 1999) is used. 1,5-pentanediol is used to improve curling effect (Foucher, 1999). Moreover, the presence of divinyl sulfone in the GC/MS chromatogram could be associated with reactive dyes, which are also used in ink-jet printing (Novak, 2004).

4 CONCLUSION

The analysis of different inks is useful for a comprehensive understanding of the process that occurs during the ink-substrate interaction, and it is of great interest in forensic science. Detected components can improve the understanding of the degradation process of prints with consideration of the ratio that those components contribute to the degradation process of prints.

Despite the fact that TLC and GC/MS chromatography are relatively simple methods we have obtained a significant amount of useful data on the composition of ink jet printing inks. For example, with specific improvements in the selection of the mobile phase mixture of solvents better separation of dyestuff could be achieved in the TLC chromatography process. GC/MS has proved to be an important analysing method for determination of volatile organic compounds in ink samples.

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TYPEFACE AND ECOLOGICAL DESIGN

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ABSTRACT: *Within the context of ecological design, typographers have started designing typefaces that require less ink for printing. Nevertheless, these typefaces need to be legible. The typeface Epika in three weights was made by taking into account the design rules for better legibility of a typeface, and an ecological design suggestion for spending less ink during printing. The conventional Arial typeface was used for comparison. For the purpose of the research, eight different texts were selected. The texts were printed by using the ink jet printing technology and electrophotography. We printed onto two different paper grades, i.e. uncoated office and recycled papers. The typographic tonal density of all printed typefaces was measured. The legibility of printed texts was measured with the rate of work method. The results showed that the typeface Epika had lower typographic tonal density than Arial. The texts in the typeface Epika were more legible.*

Keywords: desktop publishing, ecological design, legibility, typeface.

1 INTRODUCTION

The modern way of life represents a big burden for the nature; therefore, the importance of environmental protection is nowadays on the increase. The field of ecology was at the beginning a part of biology, and it only later became an interdisciplinary science which covers natural sciences and human behaviour that influences the world changes (Vuk, 2000). Ecology is influenced by worldwide environmental protection. When thinking about ecological design (ISO 14001, 2004; ISO/TR 14062, 2002), the solution of raw materials and materials that consume energy should be taken into consideration as well (Možina, 2006). Environmental friendliness has become a necessity in the modern way of life (Radonjič, 2008; Zakon o varstvu okolja, 2015). Furthermore, the development of ecological design is of the essence (ISO 14001, 2004; ISO/TR 14062, 2002). Within the context of ecological design, typographers also design typefaces that spend less ink during printing. Nevertheless, these typefaces need to be legible.

The communication through a page or a screen requires from the reader to translate symbols into meaning. Legibility refers to how easily this process is performed. To make reading possible, the text must be characterised by three properties (Reynolds, 1979; Možina, 2001):

- The property of visibility, so that a clear image of adequate size is received by the retina. The visibility requirements depend on the viewer's eyesight.
- The recognisability or perceptibility of letters and words making up the text. This is affected by the factors such as type style and form as well as by the reader's reading skills.
- The property of comprehensibility. Comprehension is affected not only by the content of the text but also by its visibility and perceptibility, and by the verbal capacity and intelligence of the reader.

Legibility has been studied using different methods (Reynolds, 1979; Možina, 2001), e.g. visibility, perceptibility at a distance, perceptibility in the peripheral vision, speed of perception, ocular movement, rate of work and other criteria. The rate of work is the most satisfactory measure for the legibility of a continuous text. The methods which were applied include the speed of reading aloud, the speed of reading silently, the speed of skimming or scanning the text (e.g. subjects are asked to locate specific items in the list of food ingredients or/and to locate specific target words in a text), and the rate of comprehension (e.g. subjects are asked to answer open-ended or dichotomous questions). The rate of work is also useful in studying the presentation of more complex materials (e.g. timetables and directories) (Reynolds, 1979; Možina, 2001; Možina, Likar, Muck, 2016). A large number of studies on legibility points to its importance. There is a big discrepancy in understanding what makes a text legible. However, it is possible to determine some general guidelines that can help create a legible text. There are some typographic characteristics to be observed to make a text more legible. For a small type size, it is known that the differences in stroke weight and typographic tonal density (or typographic tonality) are significant (Možina et al, 2010; Rat et al, 2011; Možina, Likar, Muck, 2016), since they influence text legibility. Furthermore, a number of other typographic characteristics needs to be observed in order to make a text more legible, i.e. distinctive character features (counter shape), x-height, ascender, descender, serifs,

contrast (stroke weight), set width, type size, leading (i.e. space between lines) etc. (Reynolds, 1988; Možina, 2001; Gaultney, 2001; Tracy, 2003). The contrast depends on the difference between thick and thin strokes of a given letter. The set width defines the width of a letter (e.g. the same typeface style and the same size can have different letter width) (Bringhurst, 2002; Možina, 2003). In this research, we focused on the designing of the typeface Epika in three weights (regular, bold and light), where the design rules for better legibility of a typeface, and an ecological design suggestion for spending less ink during the printing (Bolanča Mirković, Možina, 2009) were taken into account. We also checked the legibility of our ecological typeface in comparison with a conventional, non-eco, widely used typeface (i.e. Arial).
The purpose of the research was to determine the eco typeface legibility in print media compared with the conventional typeface. For the purpose of the research, eight different texts were selected. Attention was paid to the length of the text. We put each text into one of the two typefaces. The typefaces were 10 points in size. Moreover, the typographic tonal density was taken into consideration as it refers to the relative blackness or shades of grey of type on a page. It can be expressed as the relative amount of ink per square centimetre, pica or inch (Keyes, 1993). The changes in various type features can create variations in typographic tonal density (Reynolds, 1988; Možina, 2001; Možina et al, 2007; Možina, Likar, Muck, 2016). By using the ink jet printing technology and electrophotography (Kipphan, 2001; Kumar, 2009), we printed the texts onto two different paper grades, i.e. ordinary uncoated office and recycled papers. The legibility of printed texts was tested with the time of reading and a dichotomous question at the end of reading.

2 EXPERIMENTAL

The differences between different typefaces, used papers and printers, and legibility were researched with legibility testing and the analysis of typographic properties.

2.1 Methods and Materials

In the research, the legibility of the typeface Epika, which was designed according to the ecological guidelines, was compared with a conventional, non-eco, widely used typeface (i.e. Arial). The typeface Epika was designed with the program FontLab Studio. The test form was designed with the program Adobe InDesign and was used as a PDF file. We used two different papers, i.e. ordinary uncoated office paper (80 g/m^2), marked S1, and recycled paper (80 g/m^2), marked S2. Black prints were made with the ink jet printing technology, using the printer Epson Stylus SX425W (marked P1), and with electrophotography, using the printer HP 1018 (marked P2). The differences in the typographic tonal density of tested typefaces were measured with an image analysis (ImageJ). This software gives the opportunity to measure, analyse and provide output values, e.g. area, number of particles, circularity and percentage of coverage (National Institutes of Health, Research Services Branch, 2017).

2.2 Legibility

Different texts from the Slovenian edition of the journal National Geographic were printed in different typefaces, with different printers onto different papers. Eight different texts contained between 100 and 110 words. The observers (N = 20) were people aged between 20 and 30 years with a normal or corrected-to-normal vision. They read the texts at the same conditions of lighting measured with a spectrophotometer X-rite EyeOne, and viewing distance between 300 and 400 mm. Each observer read all eight combinations. Among different observers, the texts were presented in random order contributing the Latin square design, which was used for counterbalancing the order of the texts, i.e. to randomise the measurement process and to eliminate possible fatigue effects. Each second observer received the texts in a different order. For each tested observer, we measured the reading time.

3 RESULTS & DISCUSSION

3.1 Typeface Epika

The typeface Epika in three weights, i.e. regular (cf. Figure 1), bold (cf. Figure 2) and light (cf. Figure 3), was made taking into account the design rules for better legibility of a typeface and an ecological design suggestion for spending less ink during the printing. This typeface was designed in a sans-serif style (McLean, 1996; Možina, 2003). It has a higher x-height. Letters and digits are more open. In the contacts of strokes, we made ink traps to reduce the blackness of the characters. The strokes of the bold version of the typeface are wider by 16%, and the strokes of the light version of the typeface are thinner by 26%, compared to the regular version of the Epika typeface.

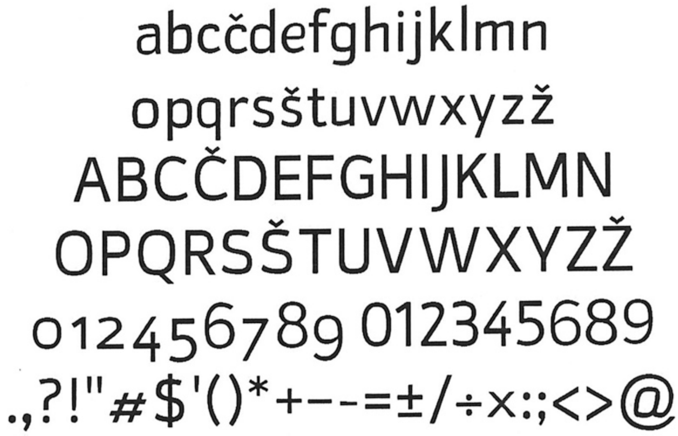

Figure 1. Regular typefaces *Epika*.

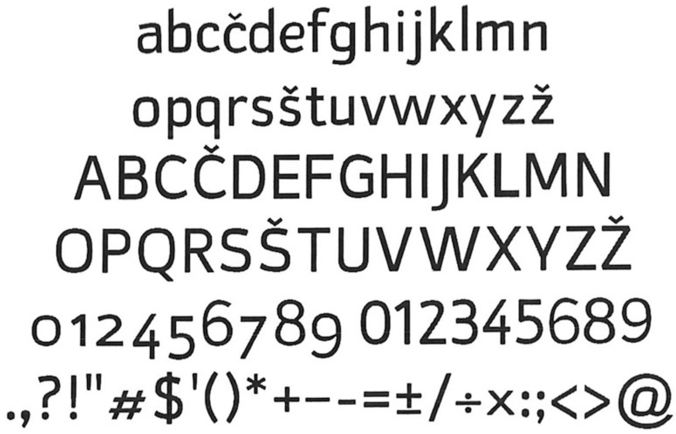

Figure 2. Bold typeface *Epika*.

Figure 3. Light typeface *Epika*.

3.2 Typographic properties of prints

The typographic tonal density (TTD) in the regular version of each typeface, 10 pt in size, on both used paper graders, printed with both printers was measured (cf. Table 1).
The results show lower TTD at the typeface Epika which results from the thinner stroke width and bigger counter size of letters. Due to the used printing technology, lower TTD was expected on the prints made with electrophotography (P2) than on the prints made with the ink jet technology (P1). The lowest TTD was observed at the typeface Epika printed on the ordinary office paper (S1) with the printer P2. There is a difference in the value of TTD between the used papers. The value of TTD is noticeably higher on the recycled paper (S2).

Table 1. Average value of typographic tonal density (TTD) of tested typefaces according to used printers (P1, P2) and used papers (S1, S2).

Typeface	TTD [%] of printed samples			
	S1-P1	S2-P1	S1-P2	S2-P2
Epika	15.72	15.81	12.35	13.30
Arial	17.69	17.92	14.15	15.00

3.3 Legibility of prints

The observers (average age 25.83 years) read different texts on both tested papers, in both typefaces and printed with both printers. 32% of observers were male and 67% female. While reading the texts, the average lighting in the room was 556.30 lux.
Table 2 shows the influence of the used typefaces, papers and printers on the speed of reading. On average, the reading speed was higher at the prints on the ordinary office paper (S1). Since electrophotography gives prints of better quality than the ink jet technology, higher reading speed was expected (P2) than on the prints made with the ink jet technology (P1). At all examples, the texts printed with the Epika typeface were read the fastest, regardless of the used papers and printers. In previous research (Možina, Likar, Muck, 2016), it was established that eco-friendly designed typefaces are read faster than the conventional ones. The interaction between lower TTD and faster reading was noticed (cf. Table 1 and Table 2). A larger counter size gave a lower TTD value and consequently resulted in faster reading.

Table 2. Average reading time of tested typefaces according to used printers (P1, P2) and used papers (S1, S2).

Typeface	Reading time [s] of different texts			
	S1-P1	S2-P1	S1-P2	S2-P2
Epika	26.80	27.91	24.13	26.89
Arial	27.69	28.75	26.40	28.15

4 CONCLUSIONS

The results of the research show that the eco-friendly designed typeface Epika is read faster than the conventional one, i.e. Arial. On the other hand, it was observed that all typefaces printed with the ink jet technology use more ink than the typefaces printed with electrophotography and that they result in lower reading speed. The typographic tonal density of the eco-friendly designed typeface is lower from the non-eco typeface. If some other eco-friendly designed typefaces along with conventional typefaces were taken into consideration as well, we would be able to give further recommendations about the usability of eco-friendly designed typefaces.

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USE OF BIOCOMPOSITE FILAMENTS FOR 3D PRINTING

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ABSTRACT: *In our researche we focused on printing with biocomposite materials based on PLA and various additives, such as (wood, hemp, and nanocellulose fibers with and without lignin). We have tested the influence on various agents such as water, oil and detergent according to the standard SIST ISO 2836: 2004 on the printed objects. The prints were also analyzed on lightfastness and thermal aging in different temperature intervals. After all mentioned analysis, colour differences were calculated. The results presented in our research showed that filaments with nanocellulose fibers were higher sensitive on water, oil, detergent than filaments with wood and hemp fibers. The similar results were achieved after lightfastness and thermal aging.*

Keywords: biocomposite filaments, 3D printing, influence of agents, abrasion resistance, thermal aging.

1 INTRODUCTION

Over the last two decades, the interest in biocomposite materials has increased in various fields as mechanics, medicine, architecture, construction, thanks to their availability, competitive quality, sustainability and environmentally friendly features.
For many years the industry has shown an interest in the use of natural fibers, for example, flax, jute, industrial cannabis, cotton and sisal for the production of a variety of end products, which are ultimately cheaper, have less weight and less negative effect for the environment (Padney, 2015).
Biocomposites are composite material, which structure is composed of two or more starting materials. The advantages of biocomposits are improvement of mechanical, chemical and physical properties after the starting materials were combined together. Basically, these materials are composed of matrix, polymer foundation often from renewable resources (mostly biodegradable), and natural fibers (biofibres) from wood, hemp, cotton, bamboo etc. General classification of biocomposites defines three main groups: porous materials, fibrous composites and articulated composites.
Material extrusion is one of the seven categories of additive technologies defined by the standard (ISO, 2015). The most widely used technologies based on material extrusion, are those with thermoplastic materials, i.e. thermoplastic extrusion.
Also, in the field of 3D printing new materials are already made from a mixture of materials, for example, wood fibers and thermoplastic matrix (Muck, 2015). Most biocomposite materials are made from natural fibers in combination with PLA thermoplastic matrix (polyacetic acid), which is also organic, and therefore biodegradable and consequently friendly to the environment (Rosainvest, 2013).
At 3D printing with biocomposite materials, there are several problems compared with conventional thermoplastics materials, but there are very little researches on the runability, printability and mechanical properties of mentioned materials (Tisserat, 2015). Besides, the review of literature also reveals the lack of researches regarding the chemical properties and resistance to selected substances of the objects printed from biocomposite materials.
In the case of wood biocomposite materials, the final properties of the printed object depend on the orientation of the model in the process of printing, the porosity of the basic filament (which increases with the diameter of the filament) and the hygroscopicity of biocomposite materials.
The tensile strength of the objects printed with thermoplastic extrusion is therefore smaller compared to the objects produced by, for example, injection molding, where high pressures improve the mechanical properties of finished products (Le Duigou, 2016).
Thus, the question arises - how the addition of natural fibers in a biocomposite material changes the final properties of the printed objects.
In addition to the basic polymer, polymer matrix and additives, which dictate the desired properties of the final printed object, the mechanical properties are influenced by compatibilizers, which contribute to better interactions between substances in composite polymer blends, and can also affect the final mechanical properties of the material (Yu, 2006).

2 EXPERIMENTAL

2.1 Materials

In our researches we focused on commercial and non-commercial biocomposite thermoplastic materials in the shape of filaments for 3D printing. All mentioned materials were based on PLA matrix.
As commercial biocomposite materials, filaments with 20% wood (PLA_wood) and hemp (PLA_hemp) additives were used. Pure PLA filament was used as a reference (PLA).
From non-commercial biocomposite three different filaments were used: PLA with 5% nanofibrilated cellulose fibers (PLA_5NCF), PLA with 5% nanofibrilated cellulose fibers and 5% lignine (PLA_5NCF_5L), PLA with 5% nanofibrilated cellulose fibers and 5% polimerized lignine (PLA_5NCF_5PL)

2.2 Methods

All samples were fabricated with ZMorph multitool 3D printer at the temperature of thermal heating plate at 80°C and extruder printing head at 195°C.

Influence on various agents
The influence on various agents such as water (tap water), oil (vegetable sunflower) and detergent (1% dish-washing detergent) according to the standard SIST ISO 2836: 2004 were tested on printed samples with dimension of 20 × 50 × 3 mm (w × l × t). Some samples were exposed to water for 24h, some to detergent for 3h and some to oil for 48h. Before and after testing the L* a* b* values were measured and at the end ΔE was calculated on the base of equation (1).

$$\Delta E = \sqrt{(L^{*2} + a^{*2} + b^{*2})} \quad (1)$$

Light resistance, lightfastness
The testing was performed using a Xenotest Alpha (Atlas, USA) source in accordance with ISO 12040 standard. The testing samples were printed with dimensions of 45 × 15 × 2 mm (w × l × t) and exposed to Xe-light for 72 h. After the lightfastness test the colour differences were determined based on the equation (1).

Thermal aging / artificial aging
Thermal aging at different temperature intervals (80°C, 110°C and 130°C) was performed only on samples printed using commercial filaments. The printed samples were 75 mm long in eprouvette shapes type 1BA according to standard ISO 527-2. After 7 days of thermal aging at each mentioned temperature intervals, the colour differences were measured based on the equation (1).

3 RESULTS & DISCUSSION

Influence of various agents
In Figures 1, 2 and 3 water, detergent and oil resistance of commercial and non-commercial filaments. For commercial three and for non-commercial two samples are presented.

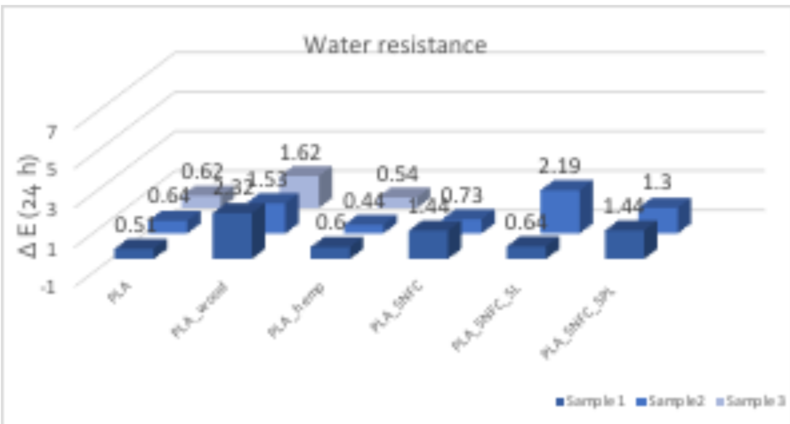

Figure 1. Water resistance of commercial and non-commercial filaments.

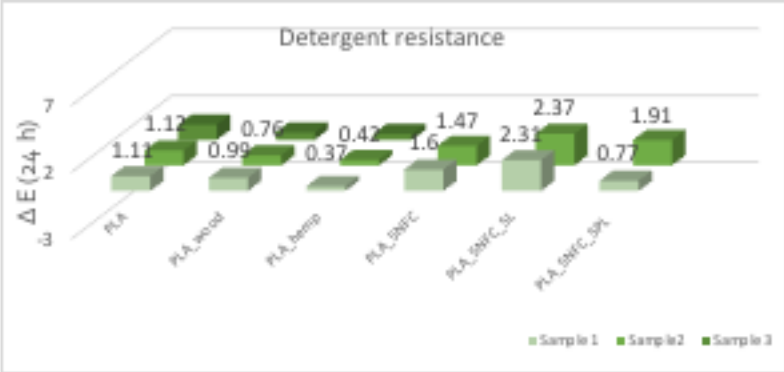

Figure 2. Detergent resistance of commercial and non-commercial filaments.

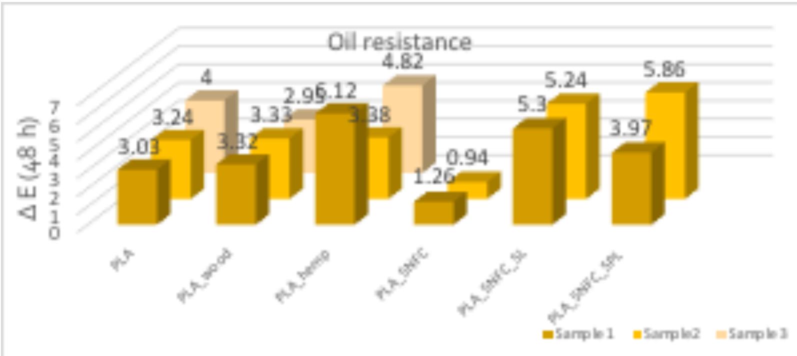

Figure 3. Oil resistance of commercial and non-commercial filaments.

All filaments, commercial and non-commercial were highly resistant to water and detergent (Figures 1 and 2). The measurements showed that samples printed with non-commercial filaments were more sensitive to water and detergent. Visible differences in colour were found in resistance to oil (Figures 3). From all printed samples PLA-wood, PLA_5NFC_5L and PLA_5NFC_5PL, the latter showed on average the highest colour changes. It is also obvious that NFC as a sole additive improved oil resistance to PLA filament in comparison to additives wood and hemp, however when it is used as an additive together with lignin and polymerized lignin the results showed obvious decrease of resistance to oily agent.

Light resistance, lightfastness

In Figure 4 light resistance of commercial and non-commercial filaments is shown.

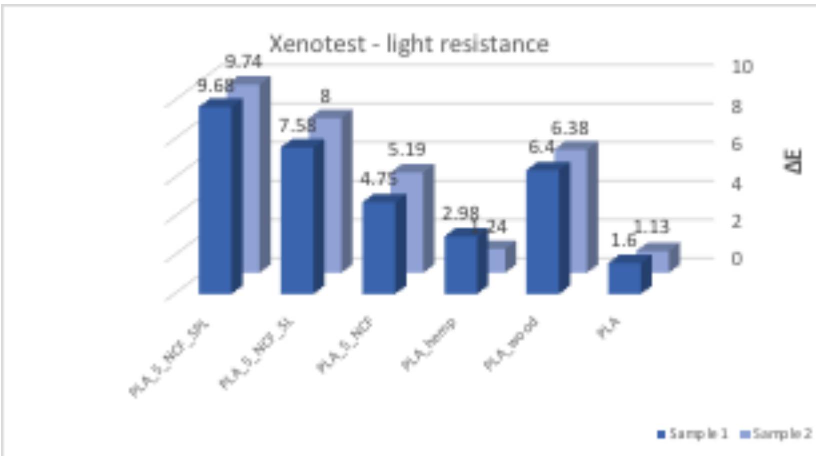

Figure 4: Light resistance of commercial and non-commercial filaments.

From the calculated colour differences it can be seen that samples printed with commercial filaments are more resistant to light than samples printed with non-commercial filaments (Figure 4). At commercial filaments the addition of wood fibers (PLA_wood) affected the colour degradation and it was very evident also with the naked eye. The measured colour difference was more than 6. PLA and the filament with the addition of hemp fibers (PLA_hemp) were more stable. Their measured colour differences vary between 1 and 3.

The results achieved after Xenotest for printed samples with non-commercial filaments showed higher colour differences with the exception of samples printed with PLA_5NFC. The final achieved colour difference was approx. 5. The value was somewhere between samples printed with commercial filaments (PLA_hemp and PLA_wood). Samples printed with filaments on the base of PLA and the addition of lignin and polymerized lignin (PLA_5NFC_5L and PLA_5NFC_5PL) showed higher colour differences. The highest measured value which was almost 10 was achieved at PLA_5NFC_5PL.

Thermal aging / artificial aging
Thermal aging was tested only on samples printed with commercial filaments. As shown on Figures 5, 6 and 7 the colour degradation correlated with increasing temperature. Samples which were 7 days exposed at 80 °C did not show obvious visible colour degradation and colour differences were measured in average from 2 to 4,43. The highest value was measured on samples PLA_hemp. After the increasing temperature up to 110 °C the samples printed with PLA and added wood fibres (PLA_wood) drastically changed the colour while samples printed with PLA and PLA_hemp filaments stayed the same as they were at 80 °C. The colour differences at samples printed with PLA_wood achieved final colour differences from 8,87 to 13,69. The highest temperature that was used for temperature aging was 130 °C. After 7 days samples didn't change only in colour, but also in their shape. From all samples, PLA_wood degradated in very high rate. The highest measured colour differences was 31,01.

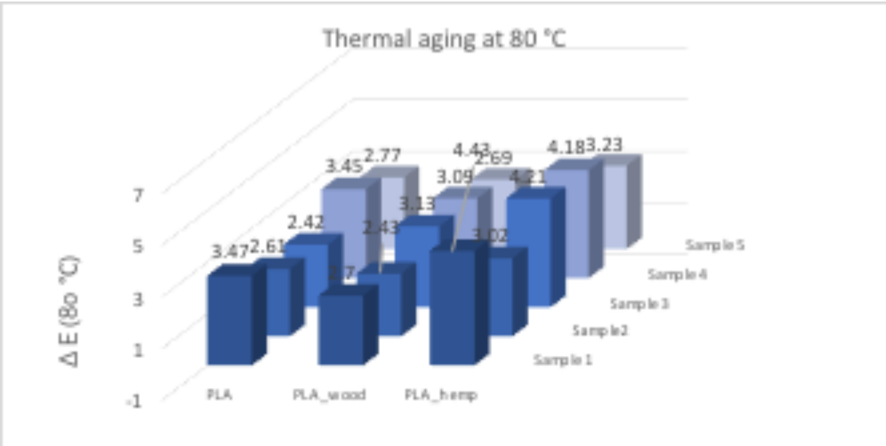

Figure 5. Thermal resistance of commercial filaments at 80 °C.

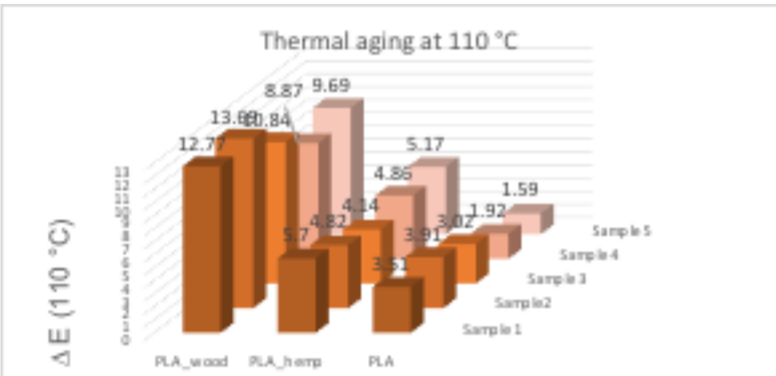

Figure 6. Thermal resistance of commercial filaments at 110 °C.

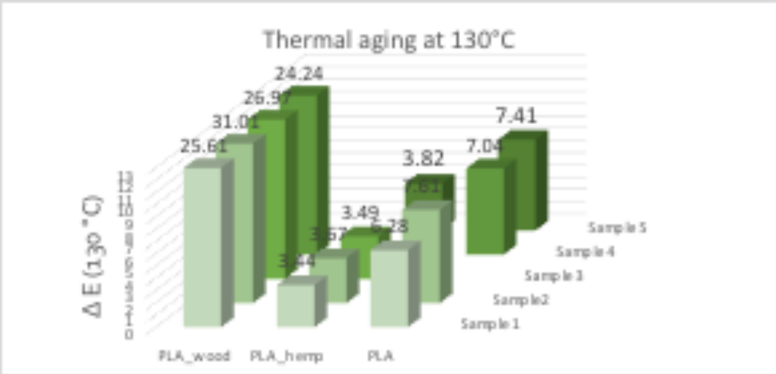

Figure 7. Thermal resistance of commercial filaments at 130°C.

4 CONCLUSIONS

On the basis of all the results we can summarize the following; if we use 3D printed items based on commercial or non-commercial filaments as final products (decorative items, toys) we have to be careful not to come in contact with oil, items should not be exposed to direct light and excessive temperatures above 80°C. In the long-term contact with oil the samples printed with filament PLA_5NFC were shown as the most resistant.

If products printed on the basis of commercial or non-commercial filaments would be exposed to light for the long period of time, the degradation of colour may occur. The most light-resistant samples were printed with PLA and PLA_hemp filament. After 72 hours of exposure to Xenon light samples printed with PLA_wood, PLA_5NFC_5L and PLA_5NFC_5PL showed visible color changes.

Elevated temperatures above 80°C greatly affected not only on colour changes, but also on the deformed shape of the samples. The highest temperature stability showed samples printed with PLA filament without any additives. It is noteworthy that additives of hemp or wood fibers greatly reduce temperature resistance.

For samples printed on the basis of PLA with added hemp fibers (PLA_hemp) the deformed shapes were more obvious than color change. The worst thermal stability was shown on the samples printed with PLA_wood filament. In conclusion the commercial filaments have proven to be more resistant to all of the performed tests than the non-commercial filaments. The addition of fibers to the basic matrix PLA mostly reduced both light and temperature resistance.

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USING UAV RGB CAMERA AS A COLOUR MEASURING DEVICE

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ABSTRACT: Today unmanned aerial vehicles (UAV) – drones – are very popular and widespread in various applications. Traditional multichannel systems for acquiring spectral images are often used only in laboratories, museums, as a part of research equipment and are very expensive and inflexible to be used on drones. Our experiments show that reconstructed spectral reflectances from RGB pictures, taken by camera-drone are quite promising, but are very much dependent on the choice of the training sets of colour chart patches. The best results are achieved when the imaging colours correspond to the training samples of the colour charts. We proved that the adoption of a drone-based camera is an efficient way to achieve good results in terms of colour accuracy, drone flexibility, ease of use, usability for a wide range of applications, way of capturing inaccessible areas where the use of commercial means of transport is not possible.

Keywords: unmanned aerial vehicles (UAV), RGB camera, spectral reflectance reconstruction, colour accuracy.

1 INTRODUCTION

Today unmanned area vehicles (UAV) – drones – are very popular and widespread in various application areas such as aerial photo and video, remote sensing, animals tracking, etc (Klemas, 2015). In a few cases drones are an indispensable part of the equipment, such as in the filming industry, military, exploration of the areas dangerous for humans - volcanoes, natural disasters: fires, floods, spillage of hazardous substances, observation of electric power lines, research of the consequences of avalanches and elsewhere (Madden, 2015).

Traditional multichannel systems for acquiring spectral images are still mostly implemented in research, such as for restoration and conservation in the field of cultural heritage, remote sensing, forestry and geology, biomedical research, quality control in industry, medicine in determining the presence of melanin and hemoglobin, astronomy, in a printing workflow with high precision color rendering (Hardeberg, 1999). They are often used only in laboratories, museums, as a part of research equipment and are very expensive and inflexible to be used on drones.

The acquisition of spectral images with a conventional spectral camera is slow, and the mobility of the equipment is poor. These reasons lead us to the estimation of spectral images from the RGB image acquired by drone-based camera. With this method, collecting spectral data of pictures is much more efficient and easier because of the RGB camera's good mobility and fast image acquiring time (Miyata, 2003).

The aim of our study was to prove that drones can also be used for effective and reliable colour measurements. Nowadays drones have the ability to use high quality cameras with very good characteristics such as large sensor size, high resolution, very good optics. By applying appropriate data filtering algorithms, such as Wiener estimation procedure, the images captured by a drone equipped with a standard 3-channel RGB camera will be used to reconstruct spectral reflectance of an imaging surface with the camera signals as an input (Cheung, 2005, DiCarlo, 2003).

2 MATERIALS AND METHODS

Our platform for capturing images consists of a quadcopter DJI Mavic Pro Platinum with 3-axis stabilized gimbal system and 3-channel RGB camera equipped with Sony Exmor 1/2,3'' sensor with 12,76 illion pixels. Despite its compact size, a drone contains (in addition to a camera) a large number of sensors and high degree of complexity, providing smart functions such as avoiding obstacles and collisions, tracking system, etc. It is equipped with 24 high-performance CPU cores, a new transmission system with a 7km range, 5 vision sensors which ensures redundancy. The maximum image size used for capturing is 4000 x 3000 pixels and the images are saved in Adobe's DNG raw format.

Starting with an acquisition the linearized camera responses have to be transformed into a high dimensional device-independent space (a spectral or multi-illuminant space). Various methods have been developed for this purpose, which can be classified into two basic categories: Target-based methods and model-based methods. The basic strategy of all these methods is to use as much information as possible of the underlying capture process. Target-based methods use captured colours with known reflectances in order to construct a response-to-reflectance transformation and apply this transformation on other captured images (Imai, 1999, Zhao, 2007, Li, 2005). The training target needs to be chosen very carefully and has to include representative spectra of the processed images. The main advantage of this class of methods is that a prior knowledge of the acquisition illuminant and device model parameters is not necessary. The main drawback is the high dependency of the spectral and colorimetric accuracy on the target choice (Mohammadi, 2004).

3 EXPERIMENTAL

In our research the estimation of the spectral image was done using the Wiener estimation method (Stigell, 2007), which was based on the use of a priori knowledge. Xrite ColorChecker Digital SG Colour Chart was attached on a neutral grey background and illuminated under 45° with Rotolight LED Anova Pro 2 Bi-Color 110° light, set to colour temperature of 3200 Kelvin (Figure 1).

Out of 140 pads of the color chart we randomly chose 93 (i.e. two thirds) patches as training samples. These patches were measured with the spectrophotomer Xrite i1Pro2 to get spectral data and also captured with the drone-based RGB camera in Adobe's DNG raw format (and transformed using Adobe Camera Raw 10.0 converter to TIFF format without compression, without colour profile attached and colour temperature set to 3200K Kelvin as set on LED lights) to get RGB data. Wiener estimation algorithm was applied to this data to get spectral estimations for selected patches.

RGB data was also acquired for the remaining 47 colour pads – test samples – for which spectral estimations via Wiener method and spectral measurements were obtained as well. Later we compared estimated and measured values of 47 test colour pads and also calculated RMSE (Root Mean Square Error), PSNR (Peak signal-to-noise ratio) and dE2000 values to see how well the estimated curves fit the measured spectral data and how pronounced are the colour differences.

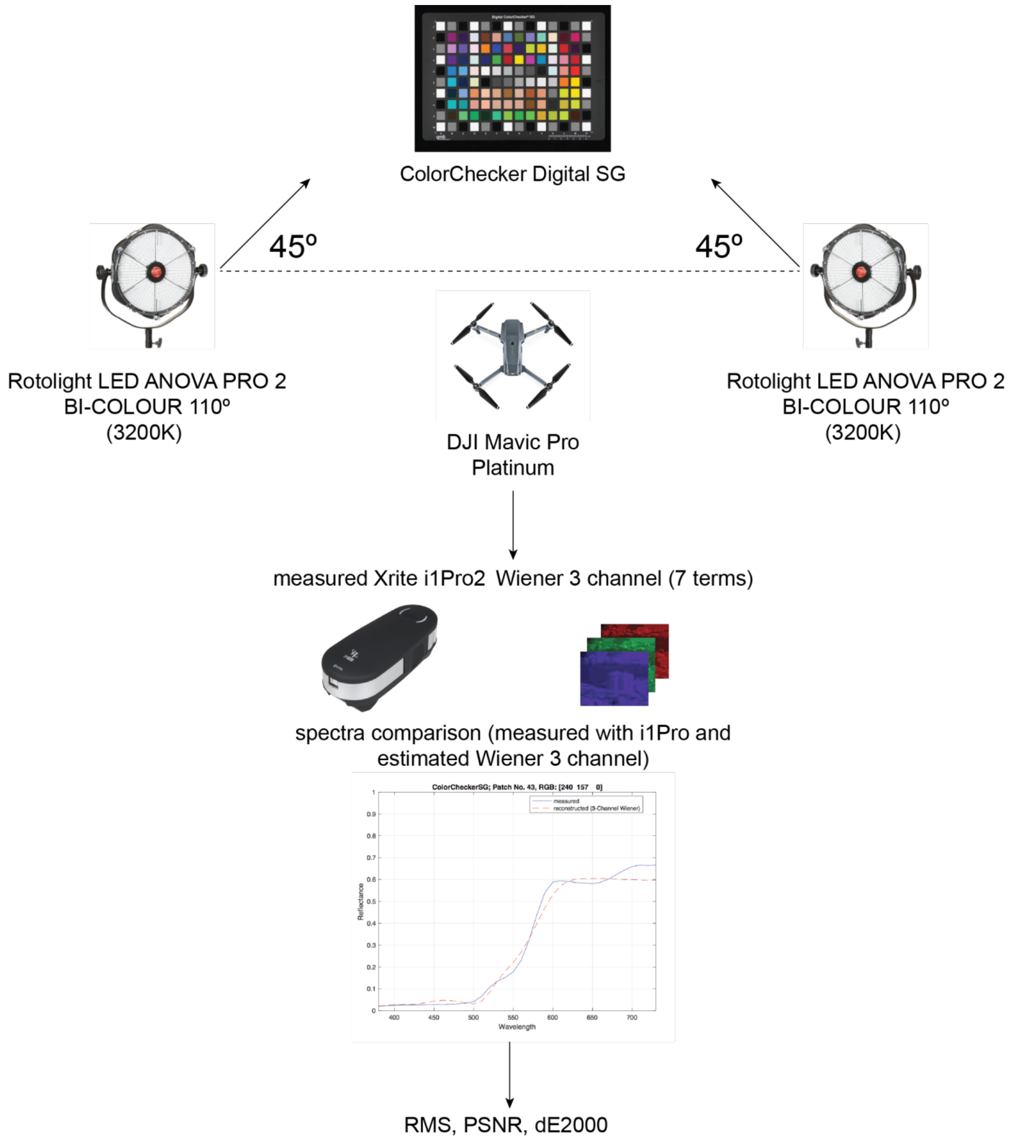

Figure 1. Workflow of the study.

4 RESULTS & DISCUSSION

4.1 Performance metrics (RMSE, PSNR and dE2000)

For the algorithm performance evaluation, we specifically calculated PSNR, RMSE and dE2000 between measured and estimated reflectance for several monochromatic, saturated and skin tones of the color chart pads (Figure 2).

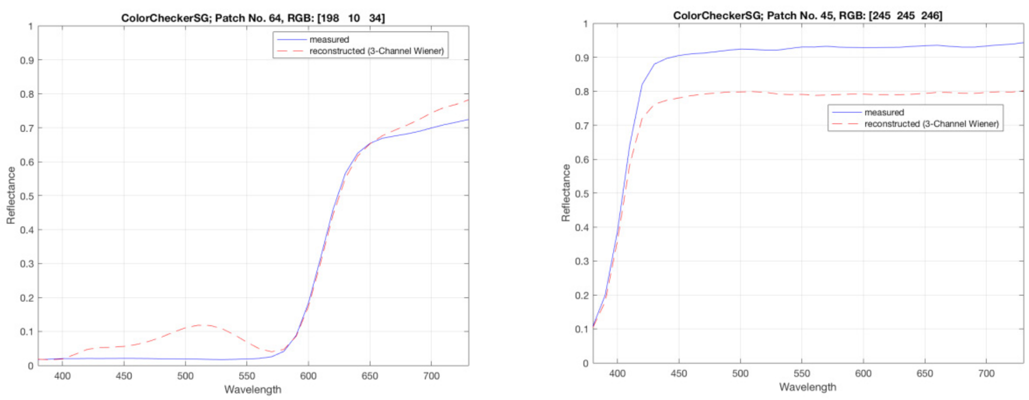

Figure 2. Patch No. 64 with the highest dE2000 (left) and patch No. 45 with the lowest dE2000 (right).

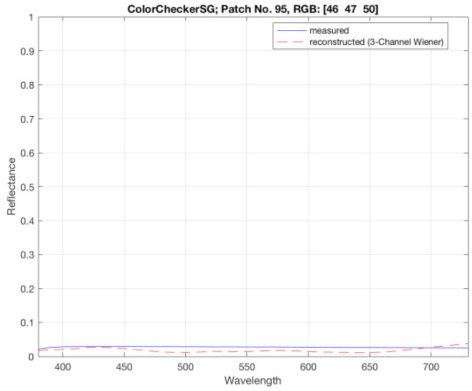

Figure 3. Patch No. 95 with the lowest RMS and highest PSNR.

When calculating CIE dE2000, first step was to compute XYZ values from measured spectra, second step was to compute XYZ values from estimated spectra of patches. CIE dE2000 formula was then applied to get CIE dE2000 color difference values. XYZ and Lab values were calculated using D50 as a light source and CIE standard observer defined in 1931 with a 2° field of view.

4.2 RMS, PSNR and dE2000 on monochromatic, saturated and skin tones

Table 1. PSNR, RMS and dE2000 values for 10 patches of ColourChecker Digital SG chart.

Patch no.	RMS	PSNR	dE2000	R	G	B	colour	
64	0,123	66,3	12,30	198	10	34		
74	0,113	67,1	11,84	255	225	44		SATURATED
94	0,062	72,3	10,89	105	167	222		
45	0,057	73,0	1,79	245	245	246		
65	0,105	67,7	5,57	205	207	210		MONO - CHROMATIC
95	0,012	86,6	9,15	46	47	50		
58	0,064	71,8	2,57	221	191	170		
87	0,086	69,5	10,67	181	125	8		SKIN TONES
97	0,037	76,8	3,79	225	185	149		
98	0,026	79,7	2,33	227	191	154		

From calculated RMS, PSNR and CIE dE2000 values it is possible to conclude that the highest dE2000 colour difference between the measured and the estimated patches occurs with the saturated colors, followed by the patches of skin tones and monochromatic patches. It is also possible to see that patches with low RMSE and high PSNR values tend to have low dE2000 colour differences.
Our experiments show that if most of the parameters are carefully controlled, spectral reflectance results are quite promising, but are very much dependent on the choice of the training sets of colour chart patches. The best results are achieved when the imaged samples' colours correspond to the training samples of the colour charts.

5 CONCLUSION

With improvements in the applied algorithm we could obtain a better performance and after optimization employed, the reconstruction method can be used in other applications as well (Shen, 2006, 2008). We proved that the adoption of a drone-based camera is a very efficient way to achieve good results in terms of colour accuracy, drone flexibility, ease of use, usability for a wide range of applications, way of capturing inaccessible areas where the use of commercial means of transport is not possible.
In our further research for better colour measurements and certain applications we could use drone with camera that do not include IR CUT filter, or use other techniques such as model based methods which are dependent on the light source and camera sensor spectral sensitivities. It would also be interesting to make

measurements under different conditions such as different light sources with various colour temperature and using different ColorCharts with much higher number of color patches.

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