https://doi.org/10.24867/GRID-2024-p53 Original scientific paper

ADDITION OF ALLANTOIN TO THE WATER DISPERSIVE VARNISH FOR CARDBOARD PACKAGING

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Abstract: *Due to its good properties, paper and paper-based materials are significant substrates in the visual communication industry. With the increased concern about plastic materials usage and their influence on the environment, the use of paper and cardboard increases. Cardboard packaging is often used as secondary packaging, and it carries visual information about the product but must have certain mechanical properties to protect the product. As cardboard deteriorates with age, it must be protected to maintain its basic function. This paper aims to investigate the influence of allantoin in addition to the water-dispersive varnish to protect cardboard during accelerated thermal ageing. For the research, the coatings including allantoin were prepared and applied onto cardboard prints. The prepared prints were characterized by their optical and mechanical properties before and after exposure to accelerated thermal ageing. Results of this research showed that the application of coatings including allantoin do not significantly influence cardboard prints, but at the same time do not provide protection in the accelerated thermal ageing. It could be concluded that including allantoin in the water dispersive varnish will not provide higher protection of prints compared to the one without allantoin.*

Key words: allantoin, water dispersive varnish, cardboard, accelerated thermal ageing

1. INTRODUCTION

Regardless of the grim predictions, the graphic industry is still growing industry. The industry's growth is dominantly due to the packaging industry, which in the period of 2023 – 2028 has predicted annual growth of 4% (Metsa board, n.d.). Even more, due to the environmental concerns and regulations (EU Commission, 2018) about plastics, paper and paper-based materials are more present in the packaging industry. Packaging has different roles including protection of goods during transport and storage. At the same time, packaging plays significant role in marketing as it has strong influence on purchasing decisions (Hurley et al., 2013). There are various methods to make packaging more attractive, consequently more appealing to customers. One of those methods is coating. Coating makes the packaging surface more appealing by making glossy or matte effect, can be spot applied or covering the whole image. Beside visual influence on the printed image on packaging, coating is also used to protect the printed image from mechanical or chemical damages caused by exposure of packaging to light, moisture, rubbing, etc. The coating should not influence the visual message of the packaging design, but studies have confirmed that there is change of the reproduction of colour due to different types of coatings (Cigula, Hudika & Donevski, 2022).
To make functional coatings, which will provide even more positives for the basic material, some additional compounds are mixed into the basic coating. In this case it is important to include compounds which will not influence the health and environmental standards of packaging, or to impact on the recycling and/or biodegradation potential of the packaging after use. For that purpose, using compounds of natural origin is of interest to researchers and producers (Fierascu, Fierascu & Chican, 2021). Having that in mind, the goal of this research is to investigate influence of allantoin onto prints coated with the mixture of commercial water dispersive varnish and various weight ratios of allantoin.
Allantoin is a compound which has origin in plants and animals and is often used in various skincare products (Martin, 2022). This compound has moisturizing effect onto skin and therefore has the potential in keeping moisture in paper and paper-based products. Moisture in paper has significant role in keeping its flexibility (Alava & Niskanen, 2006), enabling cardboard packaging formation and keeping its shape on storeshelf.

2. MATERIALS AND METHODS

For the purpose of this research samples of gloss coated cardboard with grammage of 305 gm^{-2} (UPM Finesse white gloss) were printed on a four-color offset printing press (KBA Rapida 105). Printing inks used for printing were standard process offset printing ink Novavit Supreme Bio (Flintgroup). To enable colour change detection, patches with different tone values from 0 – 100% percent with the step of 10% were defined and placed on the test print.

The coatings were prepared by dispersing allantoin particles in a commercial water dispersive varnish (Terra High Gloss Coating G9/285 by Actega). Four coatings were prepared by altering added allantoin amount to achieve weight ratio of 0, 0.25, 0.5 and 1%. The coatings were prepared by mixing water dispersive varnish with allantoin for 15 minutes by magnetic stirrer at room temperature and 1000 rpm at room temperature. Coating of the prepared prints was performed by K control coater, model 202 with the use of coating rod Nr. 3 – defined wet film thickness of 24 µm (RK Printcoat instruments, n.d.). After coating process, samples were left air dry. In the end the samples were exposed to thermal accelerated ageing for 72 hours at 105°C in a Memmert UNB400 oven. Accelerated thermal ageing is often used to simulate paper ageing and detect changes due to degradation (Małachowska, Pawcenis & Dańczak, 2021).

The prepared samples (at the beginning, after coating and after accelerated thermal ageing) were characterized by determining CIE L*a*b* colour coordinates and calculating colour change ΔE_{ab} (Mokrzycki & Tatol, 2011). For the colour measurements spectrophotometer SpectroDens (Techkon) was used. The measuring unit settings were as follows: measuring conditions M1, D50 illuminant, 2° standard observer and without polarization filter activated. Mechanical characterization of samples was performed by measuring bursting strength - Mullen test (measuring unit Lorentzen & Wettre Bursting Strength Tester SE 181) and bending stiffness according to Taber (measuring unit Lorentzen & Wettre bending tester, code 160). All measurements were performed at standard room conditions.

3. RESULTS AND DISCUSSION

Figure 1 shows influence of applied coatings on colour of prepared prints. As a reference for the colour difference (ΔE_{ab}) calculation print before coating process was used.

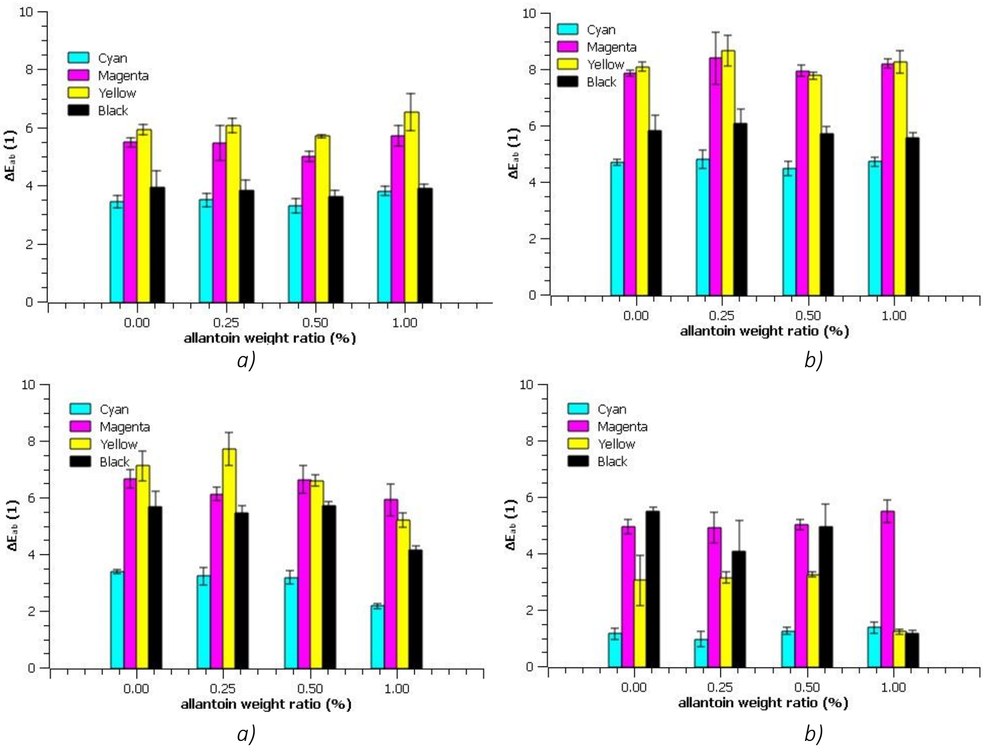

Figure 1: Colour difference on coated samples at: a) low tone value (20%), b) middle tone value (50%), c) high tone value (80%) and d) full tone

It is visible that coating process has the lowest influence on full tone of process colours while the highest colour differences are in the middle tone value (Figure 1). Furthermore, there is no influence of the allantoin weight ratio in prepared coating to the resulting colour difference.

The observed colour difference after coating process was expected as applying coating leads to darker appearance of colour (Cigula, Hudika & Donevski, 2022). Additionally, the middle tone values are the most sensitive for reproduction and often achieve the largest optical differences due to the light interaction on the surface with nearly equal ratio of surface with and without an ink film on the printing substrate. This fact is also noted in the printing standard, where middle tone values are allowed higher tolerances compared to lower and higher tone values (ISO standard, 2013).

As previously mentioned, allantoin is often used in cosmetics due to its moisturizing effect in skin care (Talakoub et al., 2008). It is expected to see a higher influence of prepared coatings on the mechanical properties of the coated cardboard. In Figure 2 and 3 one can see the results of stiffness and burst strength of prepared samples before and after accelerated thermal ageing. Please note that on the x-axe, REF means reference print, i.e. the one which was not coated.

On can see that coating process is leading to small increase of Taber stiffness, which further increases with the increase of the allantoin weight ratio (Figure 2). After the accelerated thermal ageing all samples, including the uncoated one (REF) have increased stiffness with keeping the same trend, i.e. the sample coated with the highest allantoin weight ratio having the highest Taber stiffness.

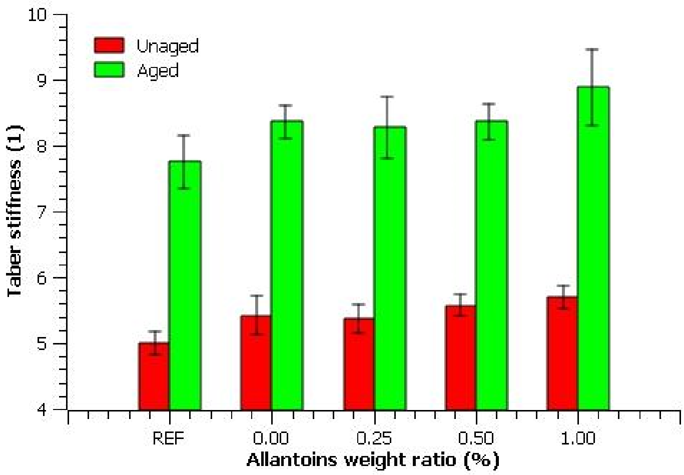

Figure 2: Taber stiffness of samples before and after accelerated thermal ageing

During thermal ageing the paper substrate is losing moisture (Alava & Niskanen, 2006) and therefore becoming more rigid, which can cause problems in packaging of products.

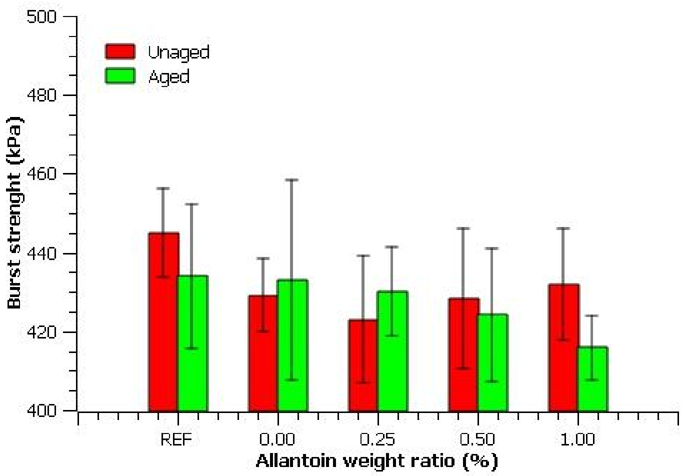

Figure 3: Burst strength of samples before and after accelerated thermal ageing

Bursting strength of samples (Figure 3) decreases with the application of coating on the surface of the print. Nevertheless, the addition of allantoin in the water dispersive varnish does not influence the burst strength. Opposite to the stiffness of the samples, accelerated thermal ageing causes decrease of the burst strength.

Although standard deviations of measurements are relatively high, it could be noted that increase of the allantoin weight ratio will lead to the decrease of the burst strength after accelerated thermal ageing. These results indicate that the coating with allantoin did not improve preservation of moisture in the paper as lower moisture in a paper material will make it more brittle (Lin et al., 2022).

In Figure 4 one can observe colour change of the paper and the process colours due to the accelerated thermal ageing. The highest colour change is on the paper and the lowest in black. The results also showed that applied coatings did not influence colour change on samples.

These results are probably caused by paper yellowing, which is common when exposed to thermal degradation (Aleksić et al., 2023) which is also confirmed by lower colour difference in yellow, while black is opaque and therefore masking the colour change of paper.

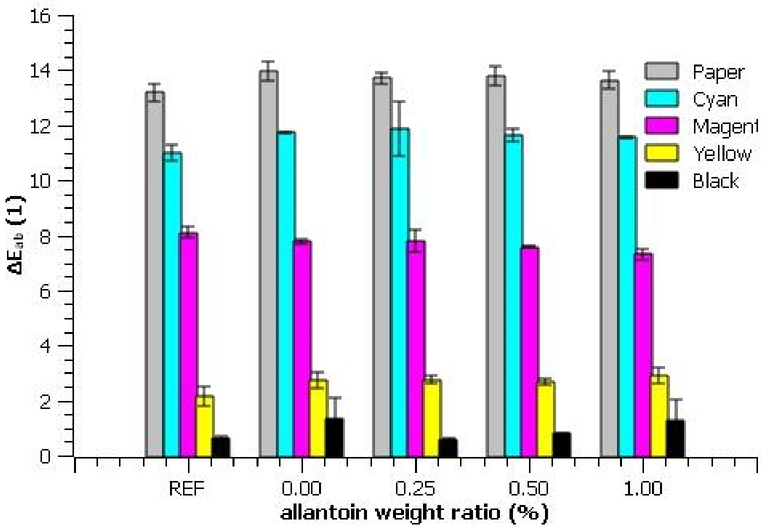

Figure 4: Colour difference of paper and full tone on coated samples after accelerated thermal ageing

The colour change of tone values aligned to the behaviour shown in Figure 4, i.e. the difference was higher in lower tone values (less surface of the paper is covered by printing ink) and lower in higher tone values. Colour difference according to the nominal tone value for black colour is shown in Figure 5. The curves are similar for other colours, although with higher differences.

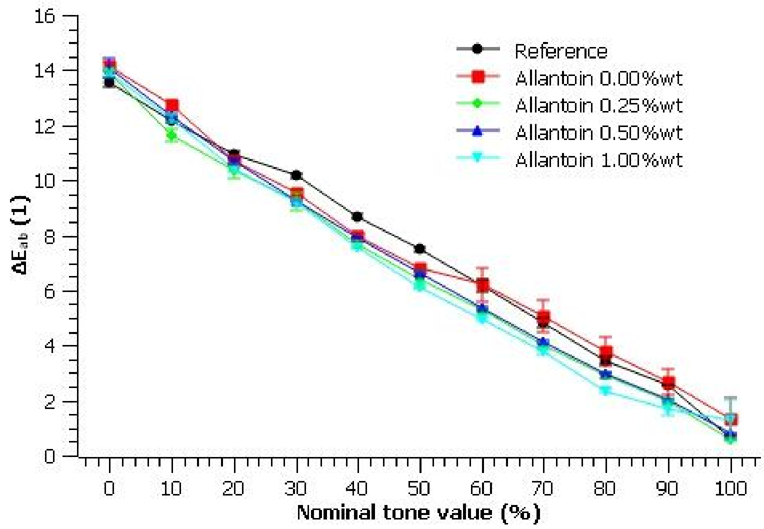

Figure 5: Black colour difference after accelerated thermal ageing depending on nominal tone value

4. CONCLUSIONS

This research was conducted to determine the influence of allantoin addition on the protective properties of water dispersive varnish applied on cardboard prints.

Results of this research showed that the application of coatings including allantoin do not significantly influence cardboard prints, but at the same time do not provide protection in the accelerated thermal ageing.

It could be concluded that including allantoin in the water dispersive varnish and applying it as an overprint varnish on the cardboard print will not provide higher protection of prints compared to the one without allantoin.

5. ACKNOWLEDGMENTS

This work was supported by the Croatian Science Foundation [grant number IP-2022-10-3864].

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