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DYNAMICS OF THERMOCHROMIC COLOR CHANGE OF PRESSURE SENSITIVE LABELS FACESTOCK MADE FROM ENVIRONMENTALLY FRIENDLY MATERIALS

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Introduction

Pressure sensitive labels (PSL), also known as self-adhesive labels, have gained great popularity due to their simplicity and user-friendly role (Medeiros et al., 2019). The PSL is an integrated part of the product packaging. It is very important that the label and the product packaging are made of the same materials and have the same structure. Such mono-material packaging enables recycling and reuse. When choosing an appropriate label material, it is important to choose an adhesive that will not adversely affect the recycling or reuse process of the product in any way (Huhtamaki, 2020). The correct selection of each part of the label is defined by various parameters. Some of the parameters are where the label will be placed and used and general information about its use such as application surface, application speed, room temperature of use and the temperature of the product itself, humidity, etc. The PSL can also provide additional value by using interesting structures, designed by a hot or cold stamping process, spot varnishes etc. It is also possible to insert RFID tags or NFC and use labels for security purposes. All materials from which the label is made depend on various external influences such as weather and storage conditions, methods and conditions of application, type of printing, etc. When printing, the surface of the substrate or the top layer of the label must have the appropriate quality. Print quality can be affected by surface structure, paper dust or discoloration of materials based on paper fibers. Optimum printing methods and techniques, appropriate inks and other auxiliary devices must be used to achieve the best appearance and purpose of the label (Marošević Dolovski, 2016).

Problem Description

This paper aims to test the functionality of one offset TC ink on the most commonly used labels and those made of biologically acceptable materials for environmental protection. Also, the influence of the shade of the facestock surface on the dynamic changes of the TC color will be examined and analyzed with spectrophotometric measurement and presentation in the CIELAB color space.

Methods

Six types of different PSL were used. Three types were made of agroindustrial by products, one is a bio-based polymer and the other two are most often used as PSL, wood-free coated on a cellulose basis. The eco-friendly labels based on agroindustrial byproducts are made from barley (B), citrus (C) and grapes (G). The reversible thermochromic (TC) ink used is a commercially available leuco dye-based offset printing ink with an activation temperature (TA) of 29°C. Before reaching the TA, the TC color is blue. By heating up and reaching the TA, the TC ink changes to a colorless state.

Results / Discussion

To examine the influence of the characteristics of the upper layer of the label and its color on the visual appearance, hue and the effect of changing the printed TC ink, the changes were monitored through CIE a*b* graph, L*T graph and spectral reflectance curves.

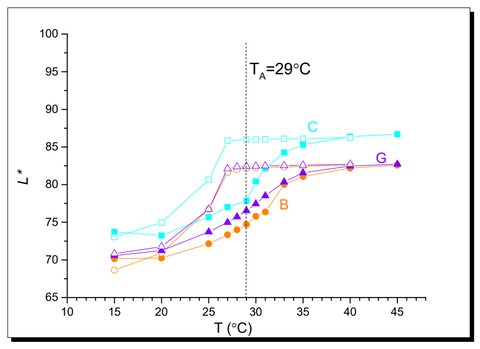

Figure 1

Hysteresis loops of all printed PSL samples during heating (closed signs) and cooling (open signs)

Based on these graphical representations, it can be concluded that during heating and then cooling, there are no equal changes in the lightness of the tested TC ink and that the reversible process is not ideal. The shape of the hysteresis for all tested samples is the same, only some small differences are observed at the hysteresis opening, i.e. at the temperature where the measurement cycle starts and ends.

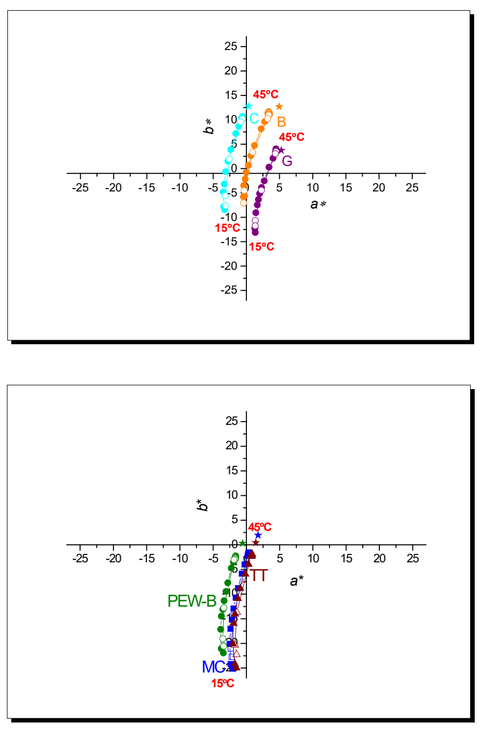

Figure 2

*TC color change path on CIE a*b* graphs during the heating and cooling process on all PSL labels*

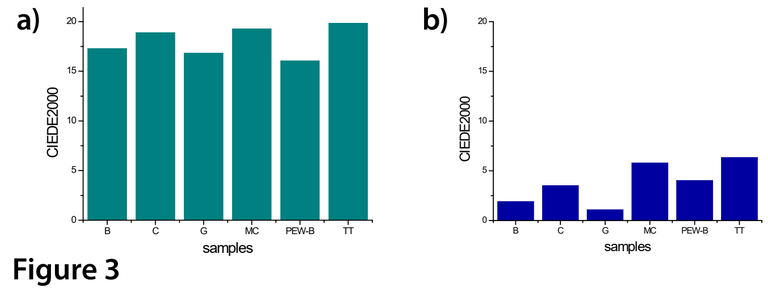

Figure 3

CIEDE2000 color difference between printed PSL samples: a) at 15°C and those at 45°C ; b) and unprinted PSL, measured at 45°C

The characteristics of the upper layer of the label and its color have a significant impact on the visual appearance, color shade and the effect of TC color change. Eco-friendly labels have a weaker TC effect compared to bio-based polymer and wood-free labels. Due to their rough surface structure, TC color have low hiding power on eco-friendly labels, which is also reflected in lower CIEDE2000 color difference values compared to smoothly structured papers with large color difference values. However, the TC effect is still clearly visible on these substrates.

Conclusion

Based on this research, it has been proven that the reversible process of TC ink is not ideal for any of the tested materials. Analyzing the results of the spectrophotometric curves, it was determined that the discoloration of the TC color is not complete in any of the tested samples and that all the tested samples have a yellowish undertone. The reason for this could be different scattering or absorption that occurs due to different optical properties of the capsule in its discolored state and the binder, i.e. as a result of incomplete transparency of the TC composite inside the capsule itself at high temperatures. This test, among other things, showed the possibilities of offset TC ink, which, despite its poor hiding power still has a significant TC effect that is visible. This is the most important factor for the thermochromic indicators on the packaging to fulfil their functional role that gives the product itself additional value.

REFERENCES

AveryDennison,. "BJ993 Fasson ®", 2022a.
AveryDennison,. "AT095 Fasson ®", 2022b.
CIE Central Bureau,. Colorimetry, 3rd Edition. Vienna, 2004.
Huhtamaki,. No simple solution: achieving sustainability means fully understanding the nuances. Future of Packaging, 2020. URL https://raconteur.uberflip.com/i/1289441-future-of-packaging-2020/13?m4= (accessed 8.26.22).
Labels&Labeling,. AWArenessTM Report Global Pressure-sensitive Adhesives Market 2021, 2021.
Marošević Dolovski, A. "Etikete i etiketiranje". Print Magazin (4), 2016.
Medeiros, D.L., Braghirolli, F.L., Ramlow, H., Ferri, G.N., Kiperstok, A.,. "Environmental improvement in the printing industry: The case study of self-adhesive labels". Environmental Science and Pollution Research (26), 13195–13209, 2019.
Tesařová, M., Krmela, A., Šimberová, I. "Digital support to external sustainability communication in self-adhesive labelling industry". Entrepreneurship and Sustainability Issues (7), 2109–2125, 2020.
Vukoje, M., Itrić Ivanda, K., Kulčar, R., Marošević Dolovski, A. "Spectroscopic Stability Studies of Pressure Sensitive Labels Facestock Made from Recycled Post-Consumer Waste and Agro-Industrial By-Products". Forests (12), 1703, 2021.

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