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Thermochromic prints on beverages packaging: The resistance of printed labels upon ethanol

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Introduction

Today, changes in the behaviour of consumers, are the cause of increased demand for different forms of packaging. In order to meet consumer expectations, packaging should be functional and attractive. Recently, intelligent packaging serves as a medium that provides consumers with the necessary information about the quality and safety of packaged goods. Thermochromic printing inks, which can be applied to a variety of printing substrates, can convey a message to the consumer by changing the colour of the print they see. The use of chromogenic colours, i.e. colours that change their characteristics due to external influences, can intrigue the customer. Thermochromic materials change their colour depending on the temperature change. Colour changes can be reversible or irreversible. Thermochromic printing inks have a rather short shelf life and poor stability. Very few studies so far have investigated the influence of different chemicals (chemical resistance) on the stability of the TC print. Jamnicki Hanzer et al. 2020. Showed that exposure of TC prints to ethanol caused severe damage to the prints and the bleeding of the colourants from the prints was also detected.

Problem Description

In this work, the chemical resistance of the prints to water and ethanol (8%, 12%, 25%, 35%, 42% and 96%.) was evaluated, as an attempt to simulate real conditions, i.e. the spilling of various alcoholic beverages on the print, i.e. the label, and to determine the effect of alcohol on the stability of the thermochromic prints

Materials and Methods

Six label papers (manufactured by Brigl & Bergmeister) were selected as printing substrates with properties given by the manufacturer and presented in Table 1.

Label type	Abbreviation	Grammage, g/m^2	Thickness, µm	Cobb 60, g/m^2
Niklakett Special	NKS	68	61	17
Niklakett Medium Fashion	NMF	70	73	17
Niklakett Premium	NP	75	64	17
NiklaSelect	NS	80	65	22
Niklakett Brilliant	NB	80	64	17
Chromolux	CHR	80	84	>8

One UV-curing thermochromic printing ink was used for printing. The used TC ink is coloured orange below the activation temperature (TA = 12 C) and changes its colour to yellow when heated above it (Figure 1). The TC ink used is reversible, i.e. the original colour is returned by heating. The assessment of the chemical resistance of TC prints was carried out in accordance with the standard method ISO 2836: 2004. Determination of print's colour change was obtained using a spectrophotometer "OceanView" and software Ocean Optics, which was additionally used for the calculation of CIELAB values, with standard observer 2° and taking into account illuminant D50. The colour of the samples was measured at two fixed temperatures (7°C and 23°C).

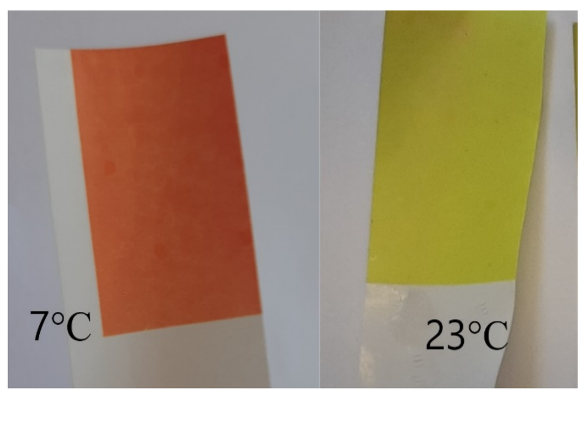

Figure 1
Visual presentation of the print colour change at temperature below TA (7°C) and at temperature above TA (23°C)

Results

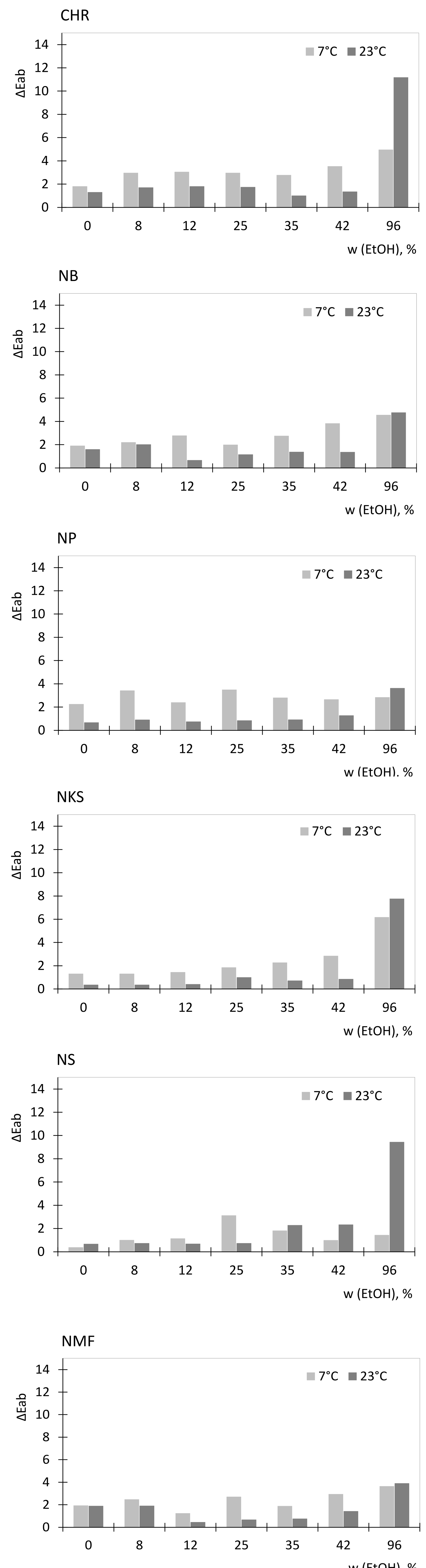

Figure 2
Total colour difference (ΔEab) of TC prints on label, measured at 7 and 23°C after their exposure to different concentrations of ethanol

Figure 2 shows the trend of colour difference increase with an increase of the EtOH concentration. At lower alcohol concentrations (8-42%), colour changes are greater at 7°C. Precisely in these alcohol concentrations, there is a higher proportion of water. This means that the stability of microcapsules is affected by water as well as ethanol. At 23°C, the colour changes are somewhat smaller, so it can be assumed that the influence of water on the stability of the yellow process colour is smaller. The high concentration of ethanol (96%) significantly affects the colour change of the print, and to a greater extent the yellow coloration of the classic process colour (measured at 23°C) than in the case when the TC microcapsules are active at 7°C.

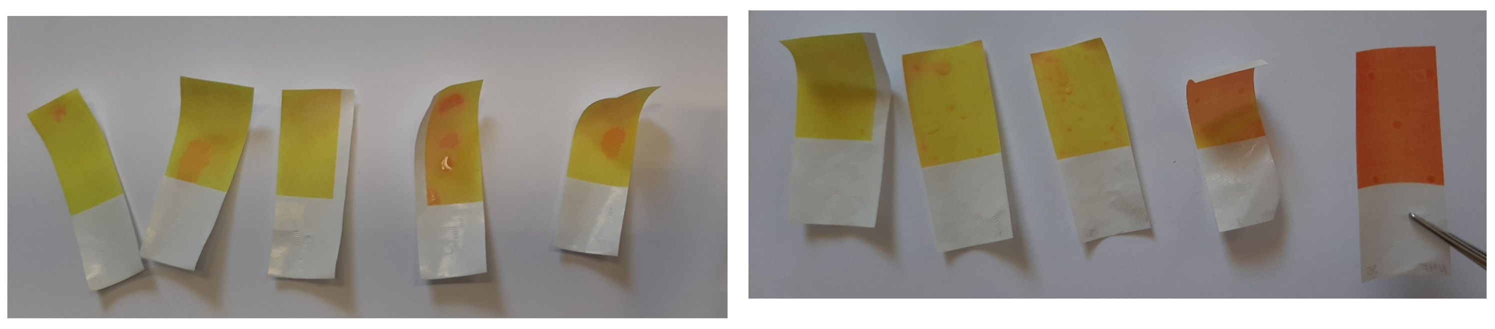

Figure 3
Change in the colour of the print as a result of the ethanol endothermic evaporation reaction on the CHR (left) and NMF (right) sample at room temperature (23±2°C) indicating a temperature below 12°C in areas where coloured in orange

When thermochromic prints were exposed to ethanol, the colour of the TC print changed from yellow to orange at room temperature. The orange colouration of the TC print indicates a low temperature (below 12°C). In that case, the sample was not exposed to low temperature even though it was coloured orange (Figure 3). This indicates that the alcohol evaporation reaction leads to an endothermic reaction, which creates a lower temperature on the surface of the print and changes its colour, i.e. a temperature lower than 12°C.

Conclusion

From the obtained results, it is evident that the chemical stability depends on the substrate on which the thermochromic ink is printed, and that with an increase in the alcohol concentration to which the thermochromic ink is exposed, the chemical stability of the TC print decreases. Moreover, it was concluded that besides ethanol, water affects the stability of the prints. The results of this test showed that when choosing a printing substrate for the printing thermochromic ink for alcoholic beverages packaging applications, the printing substrate with higher surface roughness should be considered. An additional benefit of this research was the fact that a TC print with a low activation temperature can be used as an indicator of endothermic reactions.

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