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INFLUENCE OF WHEAT PULP IN PRINTING SUBSTRATE ON THE CHEMICAL STABILITY OF GRAVURE PRINTS

Ivana Plazonić*, Valentina Radić Seleš, Maja Rudolf, Katja Petric Maretić, Irena Bates

University of Zagreb Faculty of Graphic Arts, Getaldićeva 2, 10 000 Zagreb, Croatia
Corresponding author: *ivana.plazonic@grf.unizg.hr

Abstract

Today, the global emphasis is on the importance and necessity of recycling all types of waste. In the paper industry, the waste paper has been a very important raw material for decades resulting in recycled cellulose fibres. As cellulose fibres become shorter with each recycling cycle, it is necessary to add virgin fibres to the paper pulp to achieve the required quality and stability of the formed paper. Enriching the pulp of recycled fibres with alternative non-wood fibres could be one of the environmentally friendly approaches to paper production. Wheat straw, as a by-product of globally available field crops, has imposed itself as a logical choice of alternative raw material. From the pulp of recycled fibres and from pulp admixture of 70% recycled fibres and 30% wheat fibres, laboratory papers were formed and served as the printing substrates for this study. The possibility of using such papers as printing substrates was assessed based on the chemical stability of the prints produced by the gravure printing technique with two types of inks (conventional and UV). Namely, gravure is the most common technique in printing packaging and the chemical stability of prints is one of the very important requirements in packaging printing.

Keywords: chemical stability, gravure prints, printing substrate, wheat pulp

Materials and methods

Printing substrates

Three types of printing substrates were used in this research:

- K – control sample, commercial paper from the recycled pulp,
- N – reference sample, laboratory paper from the recycled pulp,
- 3NW – laboratory paper from 30% unbleached wheat pulp and 70% recycled pulp.

Laboratory papers with a diameter of 20 cm and a weight of approximately 42.5 g/m² were formed with a Rapid-Köthen sheet former (FRANK-PTI) according to the standard EN ISO 5269-2:2004.
All printing substrates were cut in dimensions of 160 mm x 95 mm prior printing.

Gravure printing

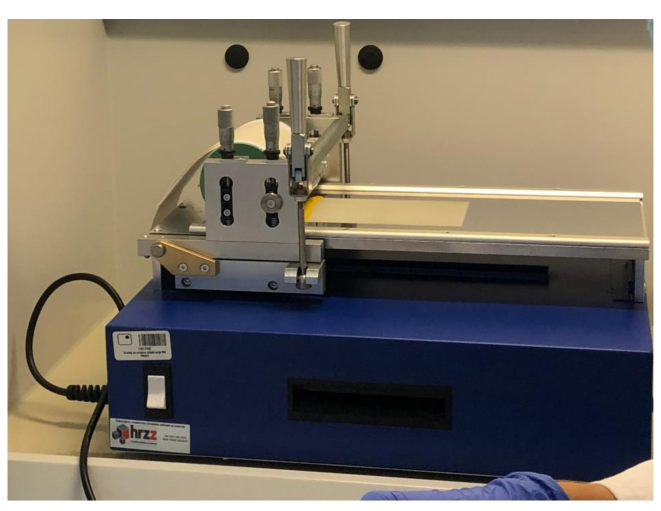

Figure 1. Printing with a laboratory device KPP Gravure system

Gravure printing in full tone was performed using a laboratory device KPP Gravure system with a 65 shore impression roller and a 100 lines/inch engraving plate (RK Rint Coat Instrument Ltd) with two types of ink, conventional and UV. Printing was done at a temperature of 23 °C and a relative humidity of 50% using Sunprop inks from Sun Chemical and Solarflex UV-curable inks from the same company. After printing at a speed of 20 m/min, the UV gravure prints were dried using a Technigraf Aktiprint L 10-1 continuous dryer with a light source output of 120 W/cm and an intensity of 60%.

Chemical stability test

All prints were cut into samples of the same dimensions (20 mm x 50 mm) and tested for resistance to chemical agents in accordance with the ISO 2836:2004 standard. Since three different chemical agents were chosen for the chemical stability assessment, it is important to emphasize that the treatment procedure and test conditions depend on the liquid chemical agent used (Table 1).

Table 1. Test conditions for selected liquid chemical agents

Test liquid agent	Receptor surface	Contact pressure	Contact duration	Drying conditions
Sodium hydroxide (NaOH)	4 Filter paper	1 kg on 54 cm²	10 min	30 min at 40 °C
Acetic acid (CH_3COOH)	2 Filter paper	1 kg on 54 cm²	30 min	30 min at 50 °C
Ethanol (C_2H_5OH)	Glass tube	-	5 min	10 min at 40 °C

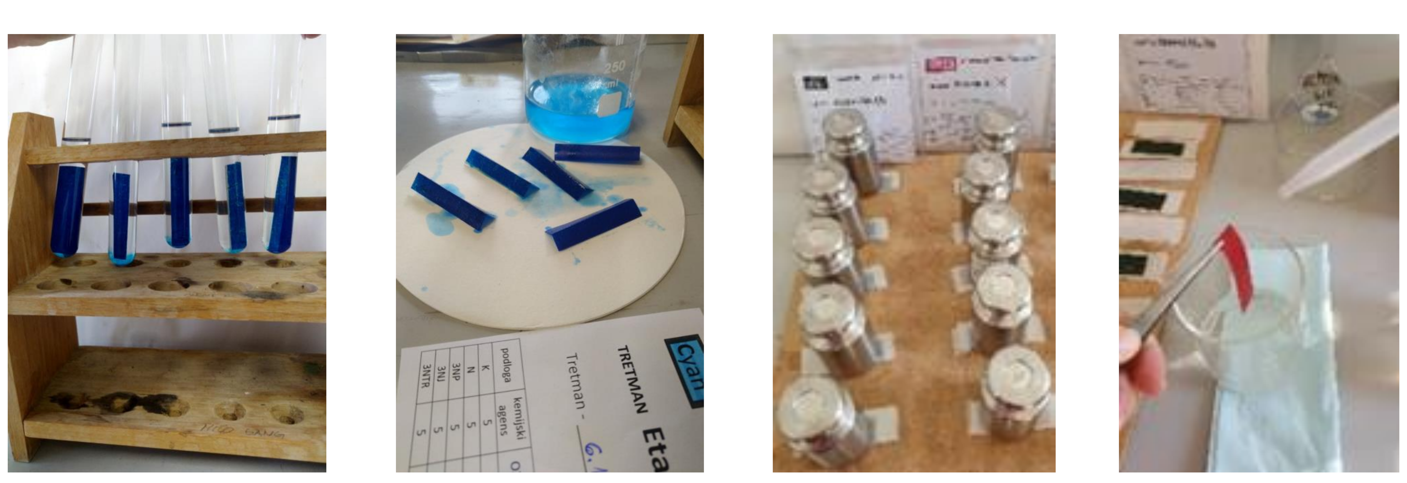

Figure 2. Chemical stability test with ethanol, acetic acid and sodium hydroxide

Chemical stability assessment

The assessment of the chemical stability for all prints was made based on the changes in optical properties after chemical treatment with various chemical agents. Optical properties were measured with an X-Rite SpectroEye spectrophotometer based on colour values in the CIE L*a*b* colour system. To calculate the difference between chemically treated and untreated samples, the Euclidean colour difference (ΔE_{00}^*) was calculated according to Equation 1, using the untreated sample as a reference.

$$\Delta E_{00}^* = \sqrt{\left(\frac{\Delta L'}{k_L S_L}\right)^2 + \left(\frac{\Delta C'}{k_C S_C}\right)^2 + \left(\frac{\Delta H'}{k_H S_H}\right)^2 + R_T\left(\frac{\Delta C'}{k_C S_C}\right)\left(\frac{\Delta H'}{k_H S_H}\right)} \quad (1)$$

According to the tolerance definition, $\Delta E_{00}^* \leq 2$ is classified as a very small noticeable difference for a standard observer, while $\Delta E_{00}^* \geq 5$ is defined as a large noticeable difference in colour that a standard observer can detect.

Results

The chemical stability of all observed prints made with conventional and UV inks in cyan, magenta, yellow, and black is discussed based on the Euclidean colour difference (ΔE_{00}^*) results presented in Figures 3-6.

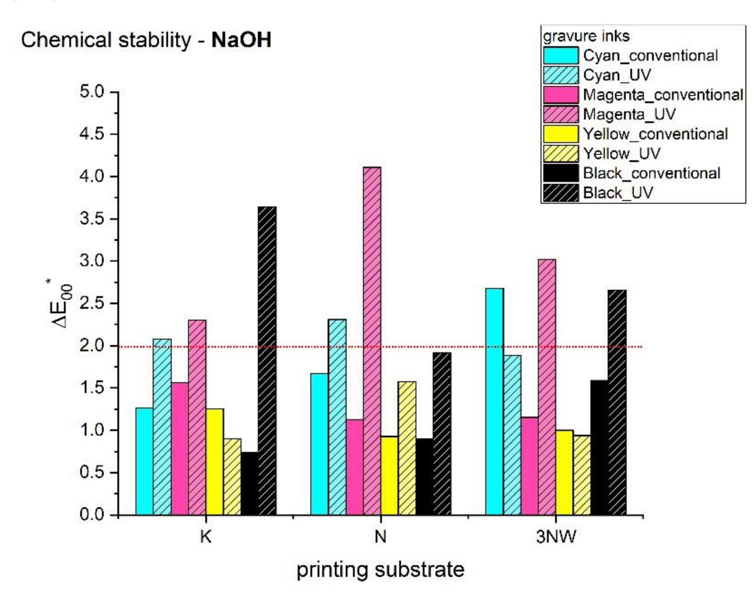

Figure 3. Colour difference (ΔE_{00}^*) of prints caused by the treatment with sodium hydroxide

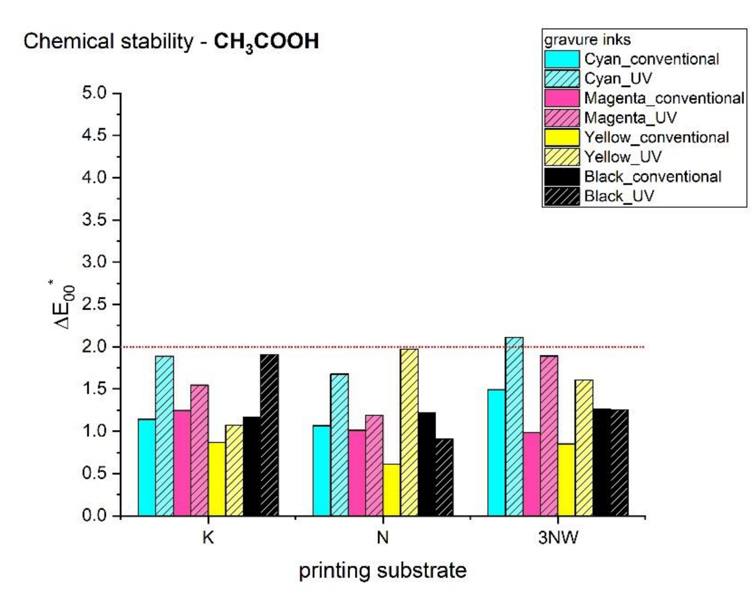

Figure 4. Colour difference (ΔE_{00}^*) of prints caused by the treatment with acetic acid

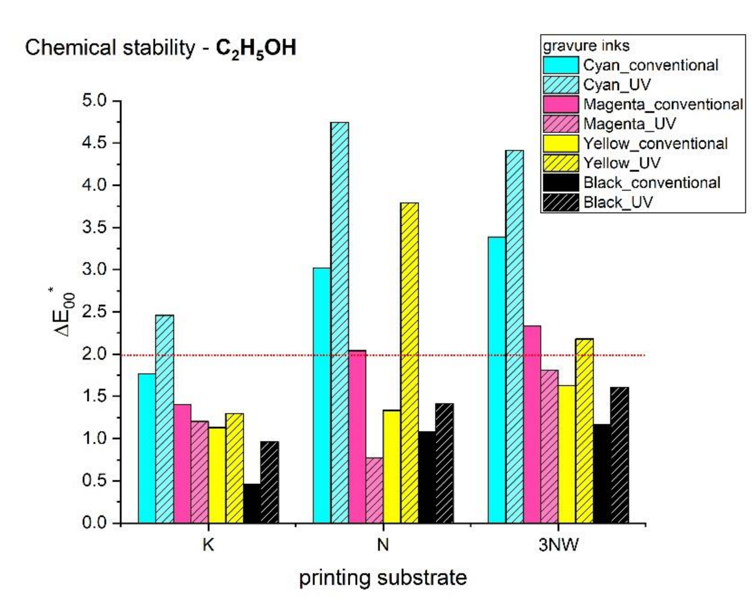

Figure 5. Colour difference (ΔE_{00}^*) of prints caused by the treatment with ethanol

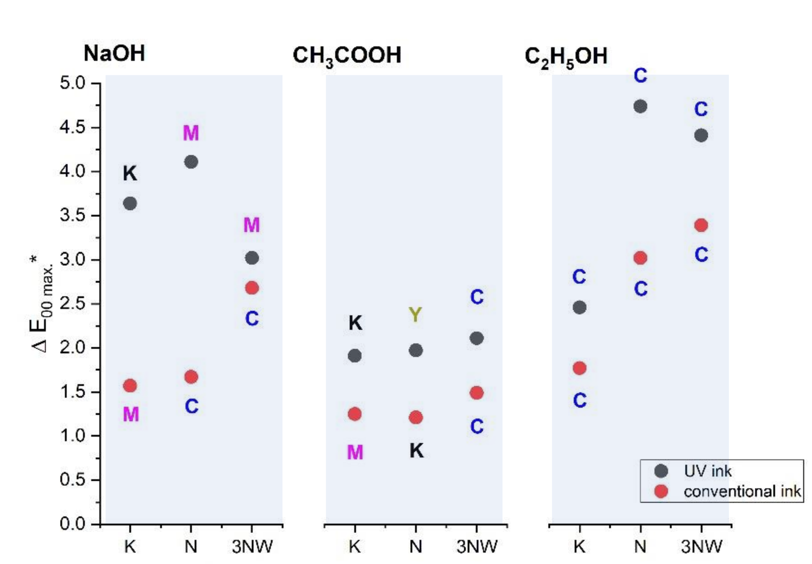

Figure 6. Maximum values of colour difference (ΔE_{00} max.*) of prints after chemical treatment

Conclusion

All results indicate that conventional inks are more stable in contact with sodium hydroxide, acetic acid or ethanol than UV inks, regardless to the composition of the printing substrate used. The greatest change in print colour was observed after contact with ethanol, especially for the cyan gravure ink. Laboratory papers made from pulp of recycled fibres and those with the addition of wheat pulp provide almost equal chemical stability of the prints, while wheat pulp in the printing substrate shows a positive influence on the reduction of the ΔE_{00}^* value for all yellow prints.

Acknonowledgement

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