GRID 2024
12. INTERNATIONAL SYMPOSIUM ON GRAPHIC ENGINEERING AND DESIGN
14-16. NOVEMBER 2024

12th GRID SYMPOSIUM

The impact of paper made from recycled and non-woody plants on the effect of fluorescent prints

Maja Strižić Jakovljević [1], Tereza Puhalović [1], Agata Radman [1], Tamara Tomašegović [1], Sanja Mahović Poljaček [1]
[1] University of Zagreb,Faculty of Graphic Arts, Zagreb, Croatia

Introduction

In the field of graphic technology and design, there is potential for replacing papers made from primary fibers with those made from recycled and non-woody materials (Teacă, 2023; Cassel et al., 2023; Kumar, 2022; Jaishwal et al., 2024; Clift et al., 2022).
Fluorescent printing inks interact well with various substrates, offering excellent fluorescent effects and anti-fake properties. This broadens their application range, ensuring durable prints with enhanced visual appeal (Dongjun, 2016). Fluorescent printing inks are classified as special effect inks, possess the ability to absorb UV radiation and re-emit photons at different wavelengths, a phenomenon known as luminescence (Jameson, 2014; Becidyan, 1995). This unique property enables them to be utilized across various applications, including decorative and packaging industries, for markings, signaling, orientation purposes, and document security (Bodenstein et al., 2019; Yook & Lee, 2013).
This study aims to assess how paper substrates made from recycled and non-woody plants influence the performance of printed fluorescent inks. The study will compare the performance of non-woody and recycled fiber papers against a reference paper made from virgin fibers, analyzing their effects on the optical properties of fluorescent inks, printed elements, and line widths. Additionally, a survey will be conducted to identify the most favorable paper substrate for designs utilizing fluorescent inks.

Materials and methods

In this research, five types of uncoated papers are used, including high-quality uncoated offset paper based on virgin fibers serving as a reference, marked as MN. Paper-printing substrates used in the research and their compositions are presented in Table 1.

Table 1 *Paper-printing substrates*

Paper-printing substrate	Grammage (g/m²)	Paper composition - fibres
MN	120	Virgin
RW	80	Recycled
NC	80	Recycled
PC	120	100% cotton
MR	118	30% hemp, 30% PCW, 40% virgin

Daylight – visible fluorescent printing ink was used for printing full tone, letters and line elements. Images of the paper surfaces and print lines on selected substrates were observed. The caliper (thickness), bulk (specific volume), density, smoothness, and water absorptiveness of the papers and spectral reflectance of the fluorescent prints were measured. A survey on 76 respondents, in order to identify the most acceptable paper substrate for designs printed with fluorescent inks.

Results and discussion

Selected properties of printing substates are presented in Figures 1 and 2.
The results of the paper smoothness using the Bekk method are shown in Figure 1. The highest degree of smoothness was measured for the RW B sample, with a value of 30.98 s. The smoothness of NC A is 30.54 s, followed by MN A (17.58 s), MR B (7.76 s), and PC B (1.98 s). The smoother side of each paper was selected for printing (marked pink in Figure 1) and analyzed in further tests.

Results and discussion

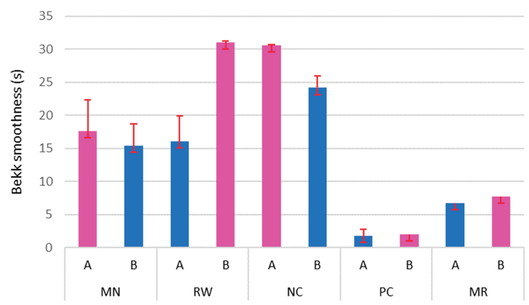

Figure 1 *The results of Bekk smoothness of the papers*

Optical properties of measured printing substates show the highest whiteness grade for the reference MN (141.2%) and PC (139.6%), followed by MR and recycled papers NC and RW (Figure 2).

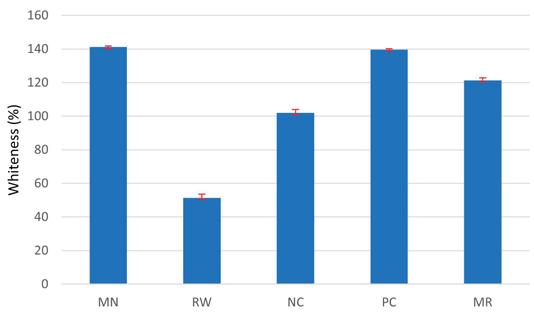

Figure 2 *The results of measured whiteness of the papers*

Figure 3 shows the microscopic images of the papers. The surface structure of the reference sample MN, a paper based on virgin fibers, is uniform and interspersed with well-interwoven fibers of different widths, with almost no impurities. The papers made from 100% recycled fibers have a surface structure made of thin fibers interwoven in all directions. Sample PC has a surface structure that is the most irregular compared to all the observed samples. Sample MR has an interwoven fiber structure consisting of hemp, PCW, and virgin fibers.

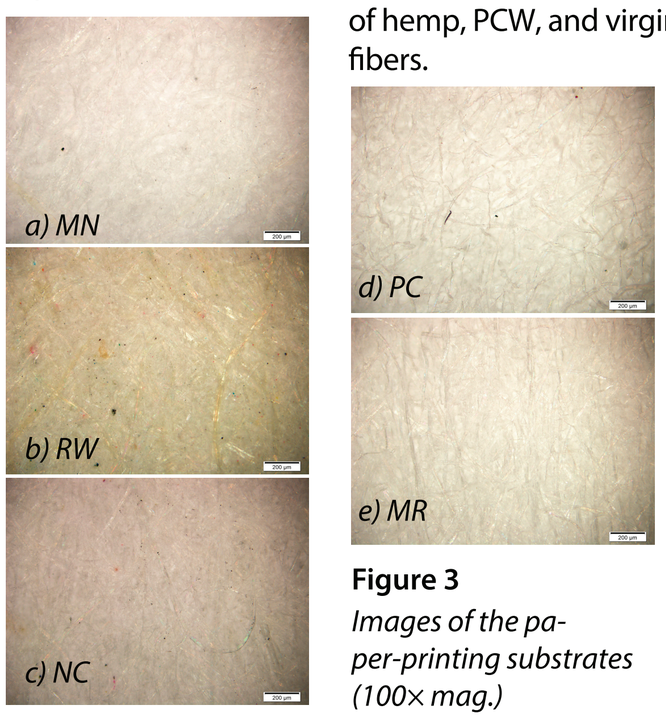

Figure 3 *Images of the paper-printing substrates (100× mag.)*

The results of measured spectral reflectance of the fluorescent prints on selected printing substrates (Figure 4).

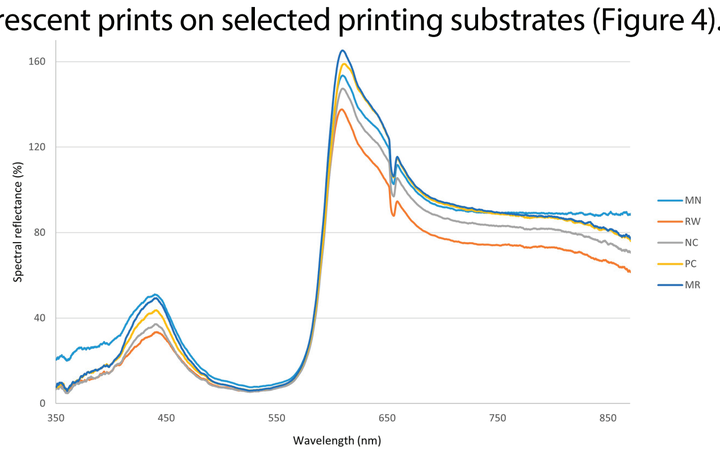

Figure 4 *Spectral reflectance of the fluorescent prints on selected printing substrates*

Results and discussion

A smaller peak at 440 nm results in spectral reflection between 32 and 50%. Spectral reflectance of fluorescent prints at 610 nm shows similar differences in the degree of spectral reflectance for all samples, with the highest peak resulting in 163 % for MR paper, followed by PC at 160 %, MN at 152 %, NC at 147 % and RW at 135%. These results are related to optical properties of the paper substrates, as well as their composition.
Figure 5 shows microscopic images of the fluorescent printed edge elements and lines on selected printing substrates. All substrates show certain irregularities in the edge elements, which was to be expected due to the type of printing technique used. The line printed on PC substrate showed the greatest smoothness of all substrates.

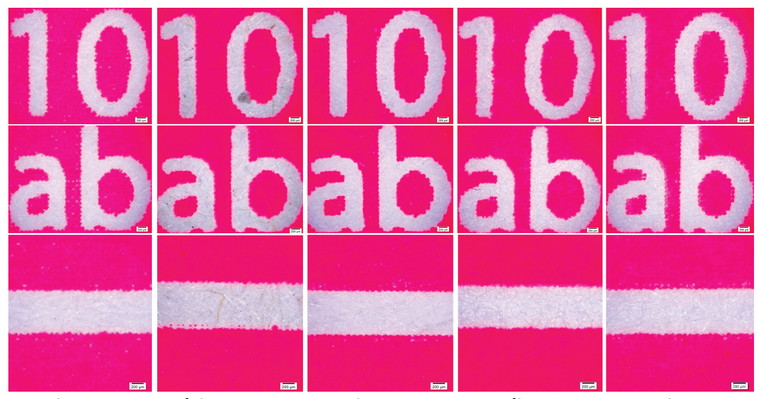

Figure 5 *Microscopic images of the fluorescent printed edge elements and lines in negative (50× mag.)*

The survey was conducted to identify the most acceptable paper substrate for designs printed with fluorescent inks (Figure 6).

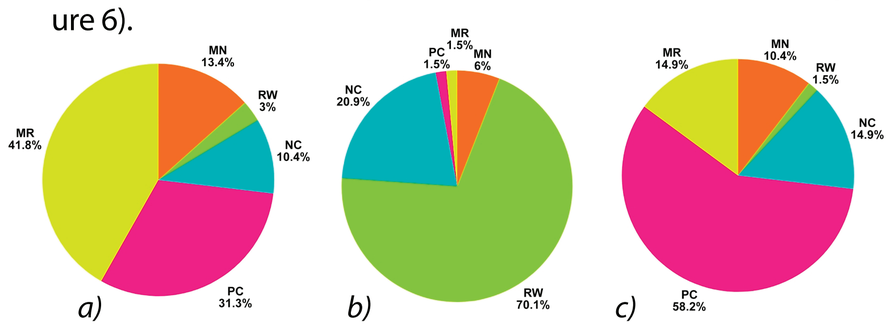

Figure 6 *The results of the research survey: a) the printing surface on which the printed element appears most noticeable; b) the printing surface on which the printed element appears to be the least noticeable; c) the solution of the printed element proposed by the respondents*

The results showed that the most noticeable fluorescent prints were observed on MR and PC substrates. No less than 70.1% of respondents identified the RW sample as the substrate with the least visible effect. 58.2% of respondents would suggest PC paper as the solution for the printed element.

Conclusion

This study determines the impact of different uncoated paper substrates made from recycled and non-woody plant fibers on the optical performance of fluorescent prints. Papers from non-woody plants, made of cotton and hemp (MR, PC), demonstrated high optical properties, including whiteness and brightness, which enhanced the spectral reflectance of fluorescent prints. Survey results supported these findings, showing a clear preference for non-woody plant-based substrates for visual appeal. Overall, cotton and hemp papers represent a promising, sustainable alternative to traditional fibers for high-quality fluorescent printing applications, with potential in packaging, signage, and security printing.