INVESTIGATION OF RECYCLING PERFORMANCE OF DIFFERENT TYPES OF PAPER PRINTED WITH UV INKS

Dogan Tutak, Irem Ilmi
Marmara University, Faculty of Applied Science, Istanbul, Turkey

Abstract: *Waste paper is an important raw material for the paper industry and pulp due to its low cost and sustainability. However, the majority of waste paper contains high volumes of printed paper, which is difficult to deink and limits their application. One of them is printed papers using UV ink. In the study; Papers of different surface structures were printed with LED-UV curable inks. Printed papers were recycled using the INGEDE method 11p. CIEL*a*b* values of the resulting paper sheets were measured; and then compared with those of the base paper. The handsheets obtained via recycling process were viewed with a microscope and the particle sizes were shown. It has been determined that it is very difficult to remove the polymerized UV cured inks from the pulp.*

Key words: Paper recycling, LED–UV ink, deinking

1. INTRODUCTION

Printed or used waste paper has become a promising raw material for the pulp and paper industry due to its low cost and conductivity to sustainable development. However, the majority of waste paper contains high volumes of printed paper, which is difficult to deink and restricts their application. (Yang et al., 2022)
Recycling waste paper requires removing printing ink from the paper through a process called deinking. (Tutak, 2018) Deinking is an important stage in secondary fiber recycling. (Meng et al., 2013) Deinking of secondary fibers involves removing ink particles from fiber surfaces and separating dispersed ink from fiber suspensions by washing or flotation.
In the deinking flotation process, the printing system used, ink, temperature, pH, bubble size, ink thickness, size of ink particles and age of printed products are the main factor of the recycling process. (Yang et al., 2022) In addition, the flotation deinking process plays an important role in the product quality and processing costs of waste paper recycling. (Yang et al., 2022)
Many difficulties are encountered in the flotation processes. One of the most important of these is the ink particle size in the flotation process. For example; the small pigment particles such as digital printing, or the difficulty of disintegration of polymerized inks in the recycling process.
Printing inks generally consist of a carrier (water, oil or solvent), colorant (pigment or dyestuff) and a binder (resin). The substrate to be used and the printing system play a decisive role in the content of the inks. (Aydemir et al., 2018) UV-curable offset printing inks have a similar structure. UV-curable inks generally consist of four main components: monomers, oligomers, photoinitiators and pigments. (Liu et al., 2020) UV-curable inks consist of monomers that are crosslinked with oligomers using UV irradiation. Monomers act as reactive dilutants and oligomers essentially replace the resinous binder (Hakeim et al., 2018) The biggest feature that distinguishes UV inks from standard offset printing inks is that they are quickly dried by a UV dryer.
UV-curable inks have a number of advantages over standard printing inks, such as high printing speeds, low VOC emissions, and good adhesion to non-absorbent surfaces. (Robert et al., 2019) In addition, the use of low energy consuming LED lamps used in recent years is also important in terms of energy saving and high productivity. (Salleh et al., 2002)
However, although the drying of the ink on the printing by polymerization provides good quality and visual advantage in printing, it causes some difficulties in the recycling process.
In this study, the effects on the recycling of coated and uncoated papers printed with UV LED ink were investigated.

2. METHODS

In this study, 140 g/m2 uncoated and 170 g/m2 coated glossy paper was used to examine the recycling performance of coated and uncoated papers. These papers were printed with UV-LED curable offset printing ink. The printed papers were prepared according to the INGEDE method 11p and the recycling process was applied. Table 1 shows the chemicals used for the recycling process.

Table 1: Standard INGEDE 11p solution formula for preparing pulp

Chemical	Rate (Dry Fiber Base)
NaOH	0.6% (100%)
Sodium Silicate	1.8% (1.3-1.4 g/cm3)
H_2O_2	0.7% (100%)
Oleic acid	0.8% (extra Pure)

Air permeability, surface roughness and CIE L*a*b* values, which will affect the recycling processes of printed and unprinted papers were measured before the recycling process. The measured values are listed in Table 2.

Table 2: Paper properties

	Base Uncoated	Base Coated
Grammage g/m^2	140	170
L*	93.15	94.88
a*	2.75	0,97
b*	-9.87	-4.48
Air permeability (ml/min)	658	0,3
Surface Roughness (ml/min)	74	0

3. RESULTS AND DISCUSSIONS

Prints were made with printing ink cured by UV-LED lamps on coated and uncoated papers. Handsheets were obtained by subjecting the printed papers to the recycling process. The measurement results on these handsheets are shown below.

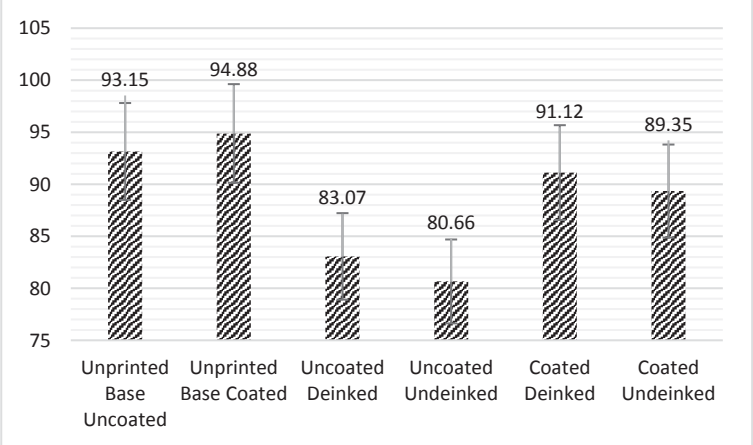

Figure 1: Comparisons of CIE L values of handsheets*

When the CIE - L* values of the obtained handsheets are compared, it is seen that the CIE - L* value of the deinked handsheets obtained from the recycling of coated papers is quite close to the base paper values. It has been determined that the CIE - L* value of the handsheets obtained from the uncoated papers is quite low compared to the base papers.
Figure 2 and Figure 3 show the CIE a* and CIE b* values. Looking at these values, it can be observed that both CIE a* and CIE b* values are quite low compared to base paper values. While the CIE a* value for the uncoated handsheets was nearly 1/5 compared to the base paper values, this ratio was determined as 1/3 for the coated papers.

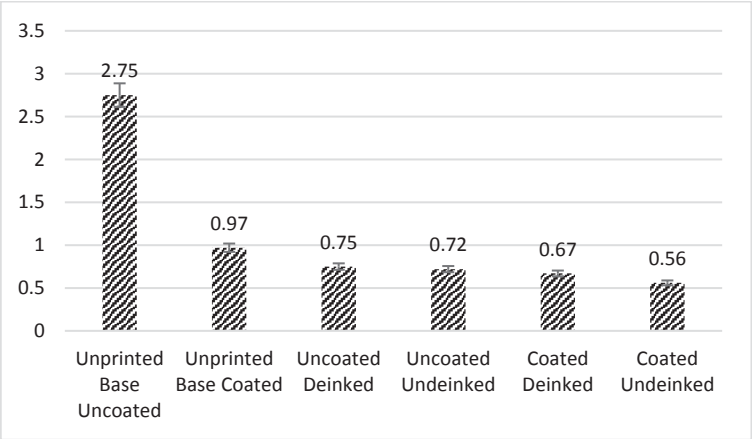

Figure 2: Comparisons of CIE a values of handsheets*

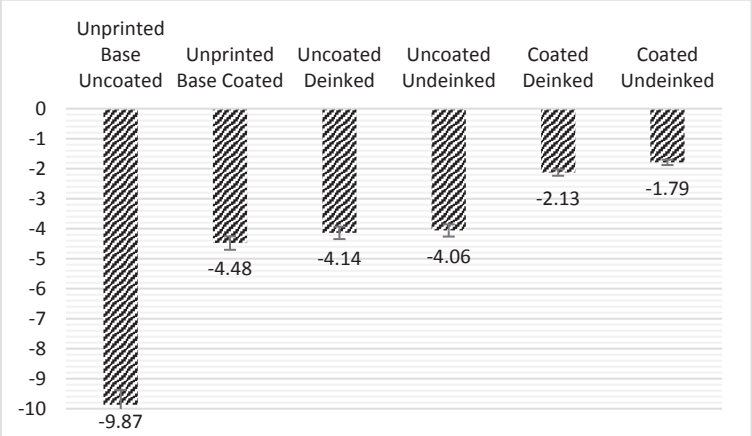

Figure 3: Comparisons of CIE b values of handsheets*

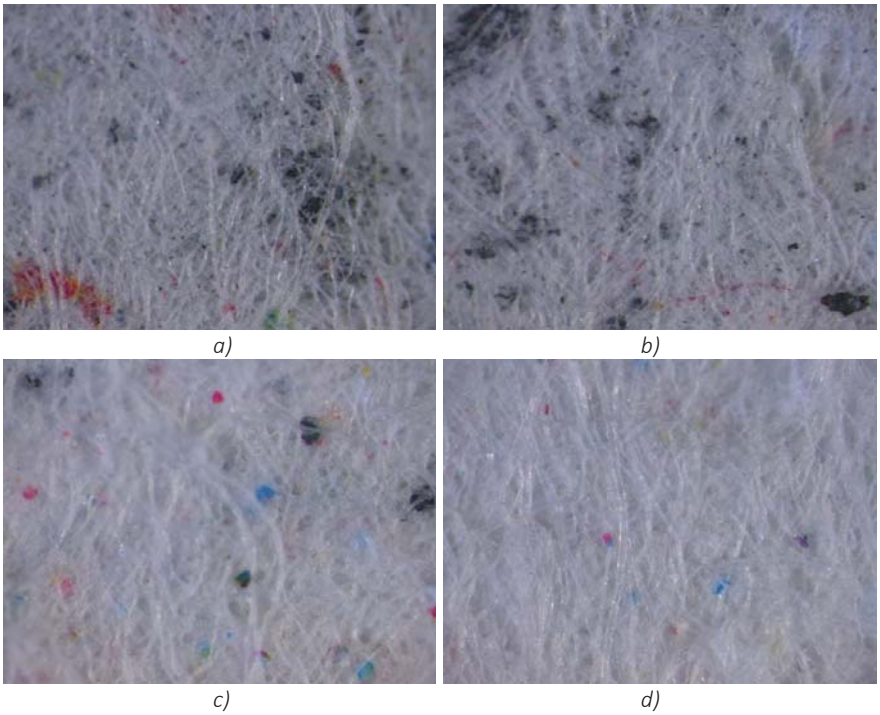

Figure 4: 3X microscope view of surface a) uncoated undeinked, b) uncoated deinked, c) coated undeinked, d) coated deinked

One of the main components of UV ink is acrylic resin. After curing with UV, this resin forms a hard coating layer on the surface of the substrate. It is very difficult to break up this layer, because of unacceptable speckle contamination of pulp formed after deinking. For this reason, printed products using UV ink have been seen as raw materials to be avoided in the recycling process. (Koizumi et al., 2022) In Figure 4, this situation is shown in the handsheets taken with the microscope.

4. CONCLUSIONS

Studies have shown that the printing system and the type of ink used are very important in the recycling processes of papers. Ultraviolet inks form a hard polymer layer on the substrate. This hard polymer layer formed is very difficult to break down while preparing the pulp. The dimensions of the fragmented ink particles are quite large and it is very difficult to remove them by flotation. (Bolanča & Bolanča, 2004) This situation has become more difficult in uncoated papers as the ink penetrates more into the paper. Inks that could not be removed during the flotation process caused the CIE L*, CIE a* and CIE b* values of the handsheets to be low.

5. ACKNOWLEDGMENTS

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