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Comparison of Colorimetric Values of Prints Made with Cyan Ink on Different Polymer Materials

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Abstract

Flexographic printing process has been established as a very competitive printing method and a broadly used printing technique. Consequently, as a more demanding packaging printing has to be performed, flexographic printing process became a strong competition to the gravure printing process. It is a quality and cost-effective printing technique used in respect to various types of substrates. This research analysis was focused on testing flexographic prints on six different polymer materials. Namely, it is mandatory for good quality prints to have good coverage even at low film thicknesses when printed on the printing substrate and the previously printed ink film, respectively. Therefore, the acceptance of cyan ink to the different polymer printing substrates and acceptance to the previously applied white ink were analysed. A number of samples of cyan ink acceptance with various viscosities were compared with each other by using spectrophotometric values converted into colorimetric values L*, C*, h°.

Keywords: polymer material, uneven coverage of the ink, surface tension

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1. Introduction

The quality of printing is an extremely important element in the packaging industry simultaneously depending on the properties and quality of printing substrate and printing ink, and the printing method. Flexible packaging, one of the fastest growing segments in the packaging industry, primarily consists of polymer materials. Polymer materials belong to the most important packaging materials today due to their excellent barrier properties and good mechanical, chemical and optical properties (transparency, lightfastness) [1]. Polymer materials are also the second most important packaging materials in Europe and the most dynamic one, with a growing trend of some 4-5% per year [2]. Flexographic print is a printing technique, which uses printing plate made of rubber and photopolymer when printing with fast-drying inks. Its flexible plate and low viscosity ink enable printing on a wide range of absorbent and non-absorbent printing substrates [3]. Interaction between inks and polymer materials is a very complex process dependant on physical and chemical properties of both, inks and substrates. Polar inks have good adhesive properties when used with polymer materials containing strong polar properties. Without any treatment, the surface of most polymer materials contains non-polar or deficient polar properties. Hence the industry usually uses different methods of processing polymer material surface before printing anything on it, in order to ensure acceptable surface properties. In this paper we presented the results of examining the cyan inks acceptance with different viscosities to the non-processed polymer materials and previously applied white ink. Flexographic inks are usually fast-drying inks and have low viscosity. Kinematic viscosity is a very relevant property of flexographic inks. It is dependent on printing ink structure and temperature [4]. Generally speaking, adhesive properties depend on the surface energy of a polymer printing substrate. The surface energy of a solid is measured by using indirect methods. In our example, it is calculated by way of measuring the contact angle and surface tension of liquids (water, ethanol and glycerol).

2. Experimental Methodology

The quality of printed samples was observed and compared based on the ink acceptance to the printing substrate. Lab samples were made by using flexographic solvent-based cyan ink (Huber Decko Bond Top) on polymer materials. After they were produced, polymer materials were stored for the same time period under the same conditions (t=20°C, RH=60%). Transparent polymer materials: polyethylene (PELD), polypropylene (PP), polyvinyl chloride (PVC), polyester (PET), white coloured polymer materials: polyethylene (PELDb) and polypropylene (PPb) were chosen as printing substrates. The characteristics of the used printing substrates are listed in the following Table 1. The surface energy of polymer substrates and samples covered with dried white ink was calculated with a goniometer using Young equation [5,6].

Table 1. Values of polymer materials' surface energy measured before and after the white ink had been used for printing.

Material	Surface energy (mN/m)	Material + white ink	Surface energy (mN/m)
PELD	24,57	PELD W_1	23,21
PELDb	25,68	PELDb W_1	28,31
PET	45,49	PET W_1	23,83
PP	31,42	PP W_1	22,12
PPb	30,36	PPb W_1	26,97
PVC	32,98	PVC W_1	18,44

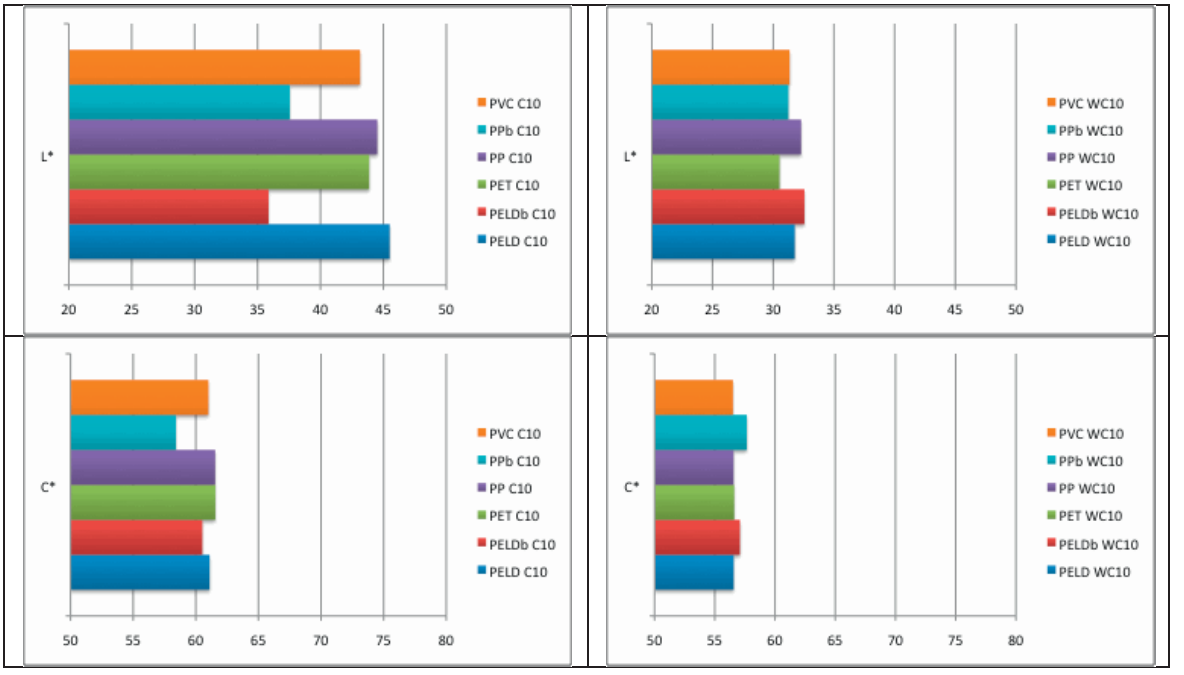
Samples were printed with K Hand Coater device. Wired K Hand Coaters are produced by winding precision drawn stainless steel wire onto a stainless steel rod, resulting in a pattern of identically shaped grooves. These grooves control the wet film thickness. The use of K Hand Coater device (marked with 1) created ink film thickness of 6 µm. After the printing process, samples were dried for 24 hours under laboratory conditions.

The coverage of polymer materials with ink and the cyan ink acceptance were observed by using spectrophotometric measurements and image analysis of non-uniform reproduction of the solid area. Both examinations defined a region of interest sized 30 x 15 mm^2 in all samples that were contrasted.

Spectrophotometric measurements were performed using a device SpectroEye produced by manufacturer X-Rite, under measurement conditions of status E, without a polarizing filter on a substrate (10 papers) made of cellulose fibres. Spectrophotometric measurements provided data on the optic properties of samples which were observed by way of using L*, c*, h° values. The measurement conditions were: standard illumination D65 and 10 observers.

3. Results and Discussion

Below is a list of measurement results for all polymer materials marked with C, if the cyan ink was printed on a substrate directly, and with WC, if the cyan ink was printed on a dried white ink. With regard to their viscosity, the samples were marked with % depending whether the solvent used for cyan ink was 10%, 15% or 20% technical ethanol which matches the viscosity of 57 s, 45 s and 34 s respectively, based on Ford. The viscosity of a non-solvent cyan under the same laboratory conditions was 90 s, and of white ink 57 s, based on Ford. Label 1 describes the ink film.



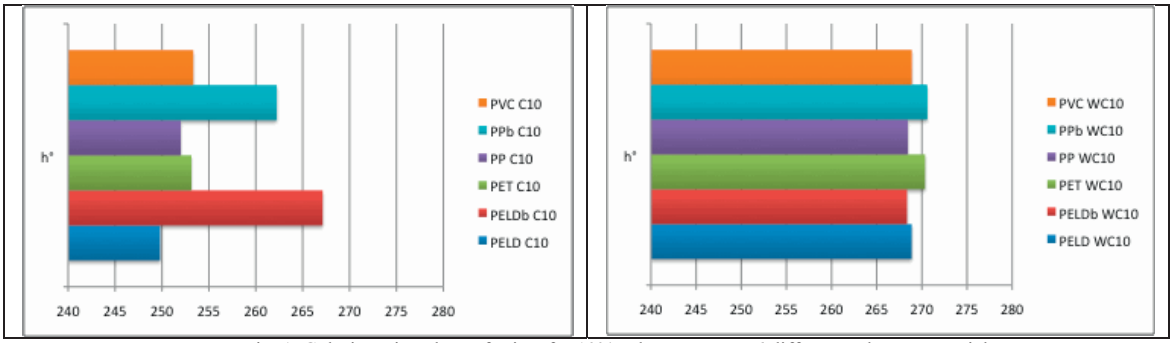
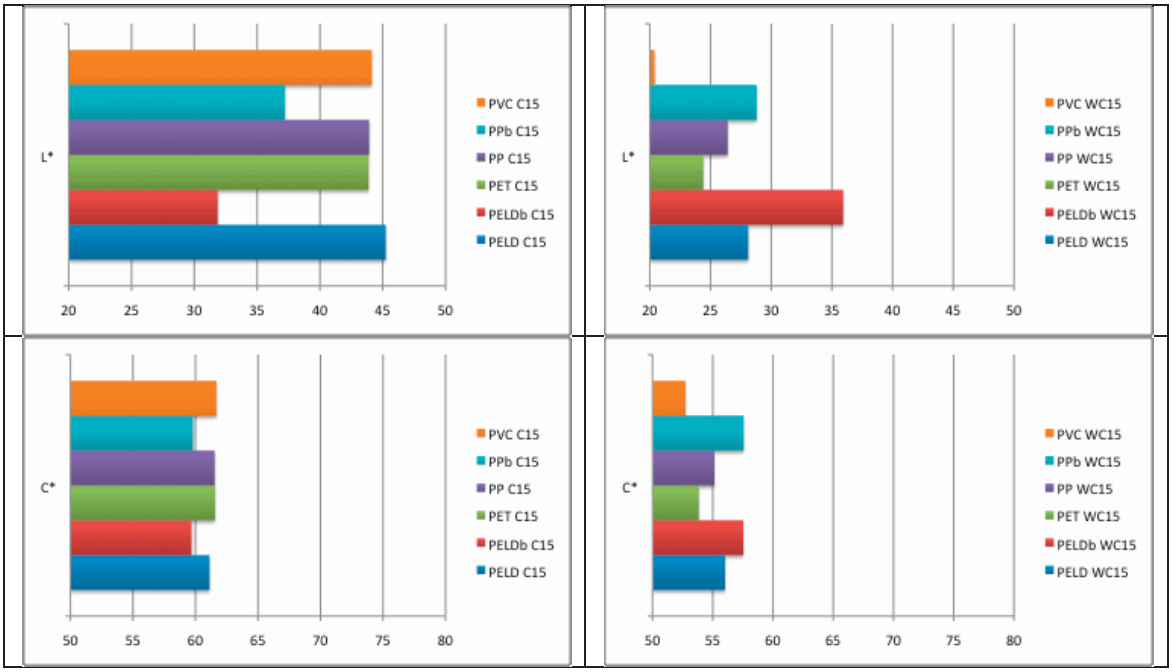


Fig. 1. Colorimetric values of prints for 10% solvent cyan on 6 different polymer materials.

It is observable from figure 1 that values of lightness, chrome and hue are very similar in samples printed with cyan ink on top of a white dried ink. By way of observing the values of lightness and chrome, it can be detected that samples printed with cyan ink directly on polymer materials have higher values of these features in comparison to samples printed with white ink and cyan ink. In samples that were printed with cyan ink only, the highest value of lightness was measured in relation to substrate PELD (L*=45,50), while the lowest value of lightness was registered in relation to substrate PELDb (L*=35,87). The values of chrome in samples printed with cyan ink directly on various substrates are very similar (C*=60,52-61,55), with an exception of substrate PPb in relation to which the value was lower (C*=58,41). Samples printed with cyan ink on top of a white dried ink have higher or very similar hue values (h˚=268,35-270,58), while in samples printed with cyan ink only, these hue values differ, with their lowest value being (h˚=249,80).



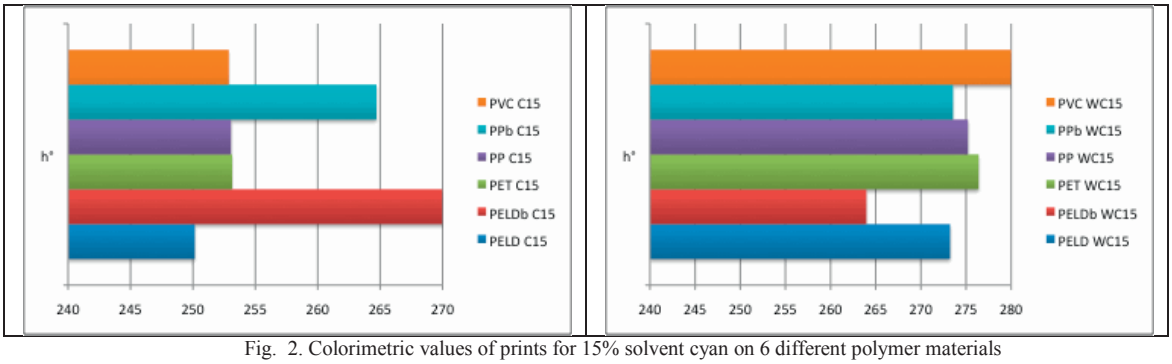


Fig. 2. Colorimetric values of prints for 15% solvent cyan on 6 different polymer materials

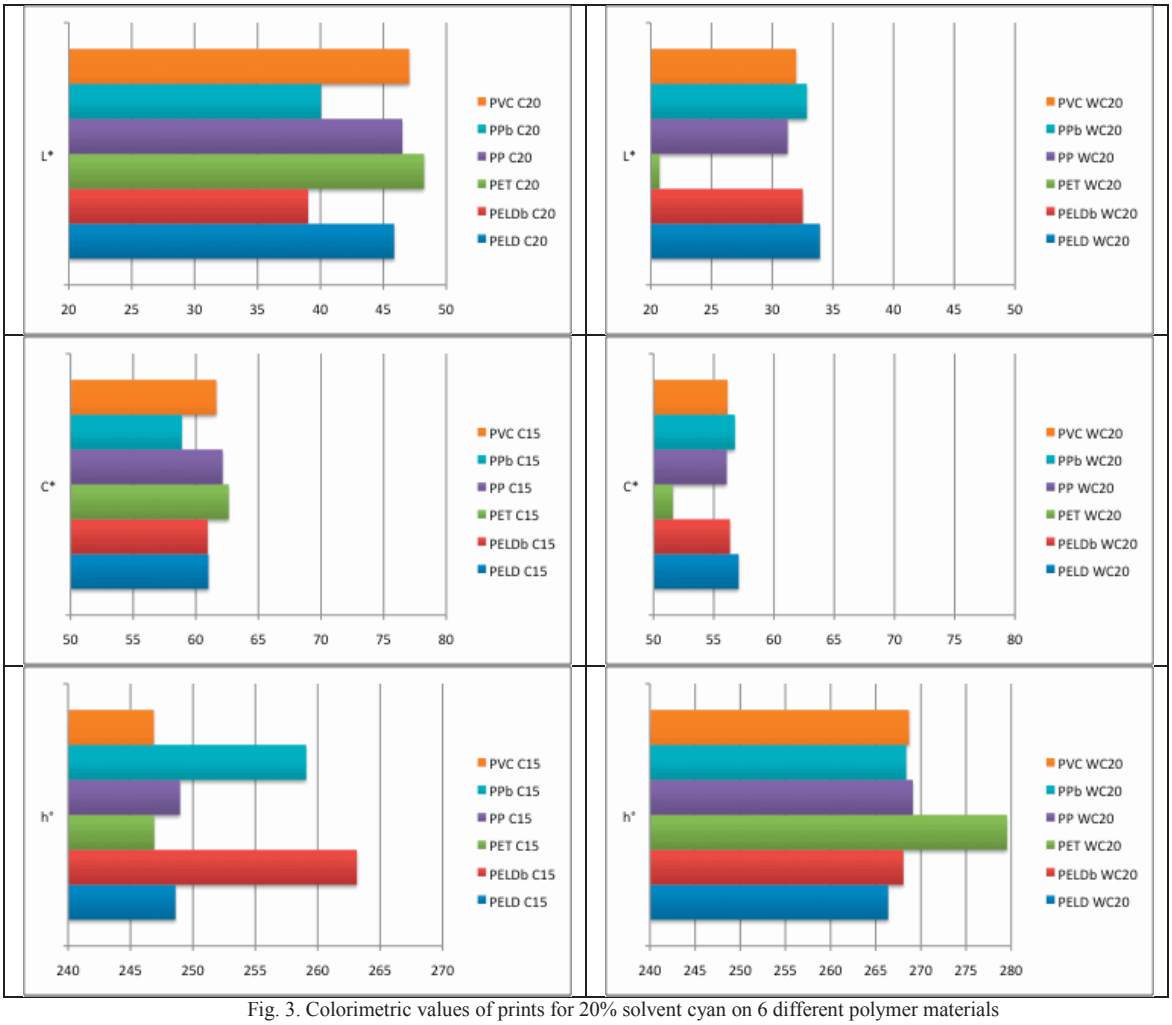


Fig. 3. Colorimetric values of prints for 20% solvent cyan on 6 different polymer materials

The same trend as present in samples printed with cyan ink with the highest viscosity value can be observed from figures 2 and 3.

3. Conclusion

Samples printed with cyan ink directly on polymer materials have higher lightness in comparison to samples printed with cyan ink on top of a white dried ink which was previously printed on polymer materials. The same trend can be observed by thinning cyan ink.

Chrome values are higher in samples printed with cyan ink only than in samples printed with cyan ink on top of a white dried ink, that is, the saturation is higher. Hue values of samples printed with cyan ink on top of a white dried ink have blue colouration, while hue values of samples printed with cyan ink on top of a white dried ink display green-blue colouration, with an exception of values in relation to substrate PELD, which display blue colouration.

It can be concluded that prints made with cyan ink of the highest viscosity value on top of a white dried ink are equal in relation to all colorimetric values and observed polymer materials. In case of lower viscosity values of the cyan ink, the equality of colorimetric values in relation to different substrates is disappearing.

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