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Influence of Chemithermomechanical Pulp on the Colour of Pulps Dyed with Direct Dyes

Abstract
The dyeability of chemical pulp and chemithermomechanical pulp (CTMP) and their mixtures with direct dyes were investigated. It was found that direct dyes were useful mainly for dyeing paper containing chemical pulps, but they can also be used for high-yield pulps (with high lignin content – for example BCTMP), reducing costs as a result of using cheaper fibrous semi-products.When increasing the amount of high-yield pulp in the paper product, we have to take into account that after dyeing the colour may change markedly in comparison to dyed chemical pulps.

Key words: *chemical pulp, CTMP, colour, dyeing, direct dyes.*

Introduction

Pulping and bleaching processes are connected with lignin removal; however, some amounts remain in the pulp. The higher the level of delignification, the brighter the pulp is. The use of only bleached chemical pulps increases production costs, and as a result the price of paper. As regards forest resources and environmental protection, manufacturers tend to use high-yield pulps (with high lignin content) in the production of printing paper. The manufacturing process for very bright pulps is characterised by poor yield: from 1 t of wood we can get from 400 to 500 kg of pulp. However, for pulp grades produced by mechanical methods, the lignin is removed in small amounts, and owing to this the pulp making process is highly efficient (93 - 95%). Unfortunately, these pulps are less bright as the lignin absorbs UV radiation and short-wave blue light [1, 2].

Colour is one of the most important parameters for paper products because it is often associated – although not always rightly – with high quality. The natural colour of paper and board is a product of the colour mixture of their components – pulp, fillers, adhesives, auxiliaries.

Observers do not always like the natural colours of paper products, which is one of the reasons why paper is coloured using various methods to obtain products of chromatic hue. Hue and intensity are adjusted to customer expectations. Paper is usually coloured with direct dyes [2 - 4]. High quality publications, such as books, picture albums, and diaries are usually printed on paper with a yellowish tint, but we can also find decorative grades (Text & Cover) with dark saturated colours, so-called earth colours or bright pastels.

Purpose

Specialist literature contains numerous articles on the results of dyeing bleached chemical pulps with direct dyes. It is, however, difficult to find studies on the influence of high-yield pulps on dyeing results with the use of these dyes; despite the fact that it has been claimed that direct dyes are useful in dyeing paper containing mechanical, semi-chemical and recycled pulp grades, thereby reducing costs owing to the application of cheaper semi-products.

Chemical pulp is obtained from the chemical cooking of wood. The wood yield of this pulp is about 50%. Chemothermomechanical pulp (CTMP) is mechanically produced by treating wood chips with chemicals and steam before mechanical defibration. This pulp is produced at a yield of > 85%.

The aim of this study focused on examining the impact of bleached CTMP on the intensity of pulp dyeing with direct dyes.

Experimental

Materials

- pulps - bleached sulphate and bleached chemithermomechanical (BCTMP)
- anionic direct dyes: Pergasol Blau 2R fl., Pergasol Rot 2B fl. and Pergasol

Table 1. *Fibrous composition and chromacity of model paper pulps; [a] CIE Whiteness below 40, e.g. lower limit for white paper pulps and paper.*

Paper pulp nr		1	2	3	4	5
bleached sulphate softpulp	% of pulp	25	18.75	12.5	6.25	-
bleached sulphate hardpulp	% of pulp	75	56.25	37.5	18.75	-
BCTMP	% of pulp	-	25	50	75	100
Properties:						
ISO Brightness, %		73.09	72.72	68.97	68.83	68.57
CIE Whiteness		66.96	41.12	(28.97)[a]	(27.65)[a]	(22.32)[a]
CIE Tint		-1.42	-3.24	-3.56	-5.17	-4.62
Chromacity coordinates:						
L*		95.19	92.94	92.63	92.29	91.70
a*		- 0.1	- 0.1	- 0.29	- 0.61	- 0.70
b*		+5.18	+9.93	+11.72	+12.54	+13.34
Colour difference ΔE* with reference to white standard		7.1	12.2	13.8	14.7	15.7

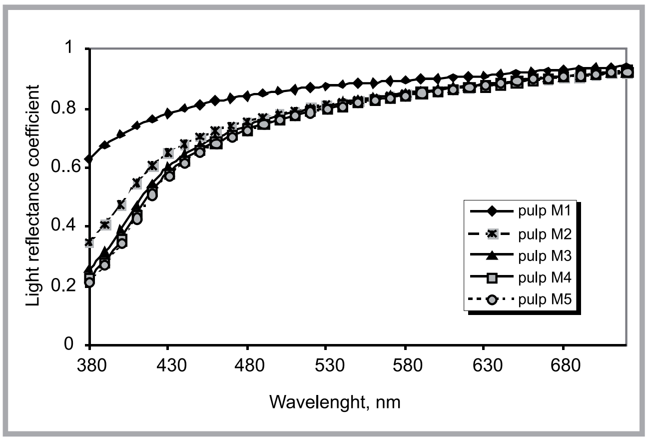

Figure 1. Light reflectance curves of paper pulps M1 – M5.

Gelb 6G fl. (CIBA Specialty Chemicals Inc.)

- cationic direct dyes: Pergasol Turquise F fl., Pergasol Rot F – 2B fl. and Pergasol Gelb F -6GZ fl. (CIBA Specialty Chemicals Inc.)

This study covers 5 model pulps whose colour parameters are presented in Table 1, and Figures 1 & 2.

Results

Chemical pulps had more or less the same light reflectance curves, and their colours were very similar. BCTMP pulp was characterised by high absorption in the range of blue and yellow colours and light reflectance factors, approaching those of slightly chemical pulps. The colour of CTMP became significantly more yellow

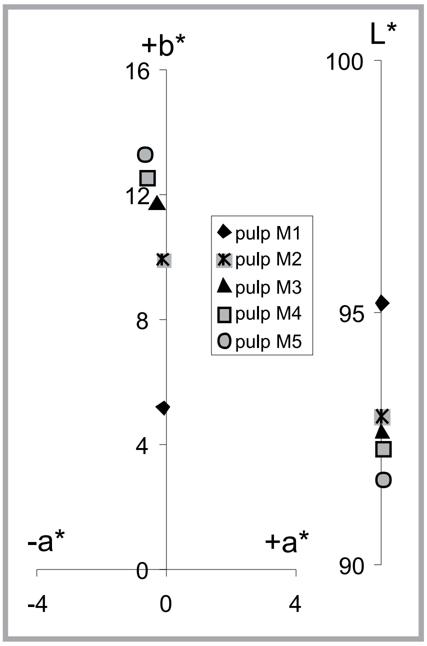

Figure 2. Chromacity coordinates of paper pulps M1 – M5.

As Figure 1 shows, the addition of BCTMP pulp increased the light absorption of the pulp in the violet and blue range. In this range the light reflectance factor decreased as the content of CTMP pulp was increased. With over 75% of CTMP pulp, the light reflectance curves practically coincided.

With the growth of CTMP content in the stock, the colour shifted towards the yellow range; however, the brightness decreased (Fig.3). ISO brightness also significantly dropped, and the 50% content of CTMP in the stock remained almost unchanged . Paper containing over 25% of CTMP could not be considered white as their CIE whiteness was below 40.

The dyeing of model pulps *M to M3* with direct dyes was equal. With a larger content of CTMP in the model pulp (*M4* and M5), it was observed that the fibre bundles were not properly dyed. When using anionic dyes, white water was slightly coloured (Figure 4). In the case of cationic dyes, the white water was not coloured.

Model pulp *M1* (from bleached sulphate pulp) had the highest colour saturation. After the addition of blue direct dyes, the colour of pulp with a larger content of lignin moved strongly towards being achromatic (green with slight saturation), and after an addition of red dyes it became slightly more yellow (Figures 5 and 6).

We can conclude that as the CTMP content was increased, the colours were less and less saturated. Although the brightness of blue and red colours increased, a higher lignin content reduced the brightness of pulps coloured with yellow dyes. Reduced colour saturation is connected with higher light absorption by lignin in mechanical pulp.

Based on subjective visual evaluations, the use of red and blue dyes for pulps with a large lignin content did not bring good effects. A 25% addition of CTMP made the colours look dull and muddy, whereas pulps with the yellow dye made a good impression. Using yellowish paper brings good effects, both environmental and economical, as it may contain more lignin. Customers do not expect different colours of such paper, therefore they will not pay much attention to the changing hue as a result of paper ageing. Owing to this fact, a larger amount of high-yield pulps may be used in such paper.

Summary

Direct dyes are useful mainly in colouring paper containing chemical pulps, but they may also be used in dyeing high-yield pulps (high lignin content) reducing costs as a result of using cheaper fibrous semi-products. When increasing the amount of high-yield pulp in the paper product to more than 25%, we have to take into account that after dyeing, the colour may change markedly in comparison to dyed chemical pulps.

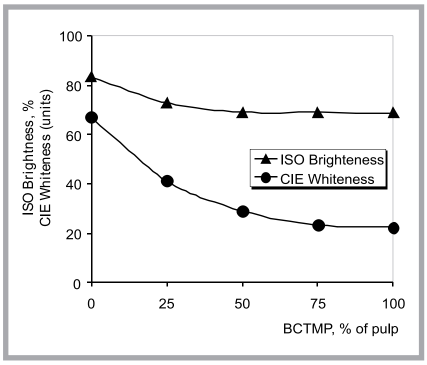

Figure 3. ISO brightness and CIE whiteness of paper pulps M1 – M5.

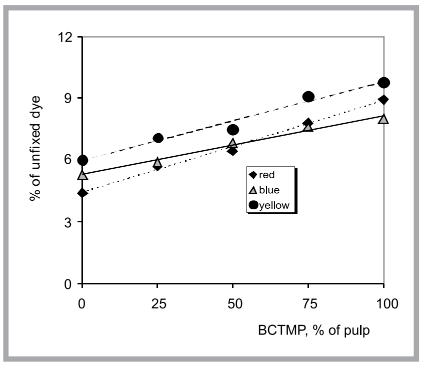

Figure 4. Influence of paper pulp on the anionic dyes in white water.

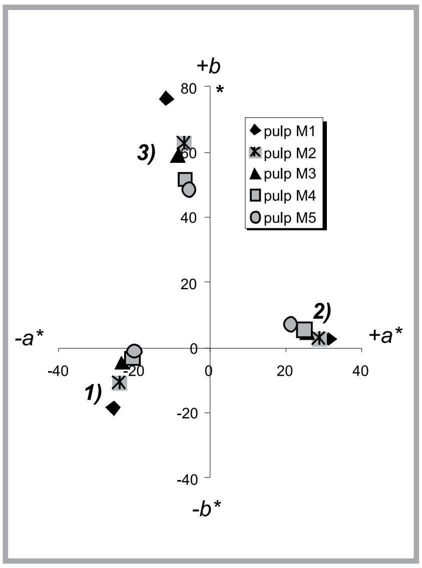

***Figure 5.** Chromacity coordinates of paper pulps M1-M5 ,dyed with the use of cationic direct dyes: 1 – blue, 2 – red, 3 - yellow; with a dye concentration of 0.5 % for? the weight of pulp.*

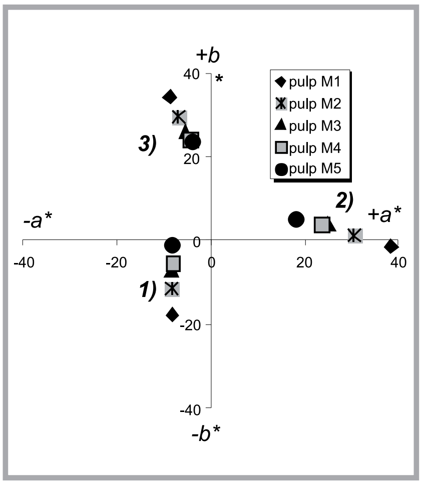

***Figure 6.** Chromacity coordinates of paper pulps M1-M5 dyed with the use of anionic direct dyes: 1 – blue, 2 – red, 3 - yellow; with a dye concentration of 0.5 % for the weight of pulp.*

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