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BLAŽ BAROMIĆ 2015

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Senj, 16. - 19. rujan 2015. godine, Hrvatska
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I believe that you will find interesting papers with new data about scientific researches and knowledge, which will be incentive for further scientific work and development in the area of the papers published in the Proceedings.

I thank for the participation and cooperation in the creation of the Proceedings to all authors, Conference participants, Conference organizers, members of Organizing and Scientific and Review Committees, sponsors, donators and the team which designed and realized the Proceedings!

Editor

THE REFLECTANCE SPECTRUM OF RECYCLED PAPERS EXPOSED TO ACCELERATE AGEING ACCORDING TO USED FLOTATION DEINKING METHOD

REFLEKSIJSKI SPEKTRI RECIKLIRANIH PAPIRA IZLOŽENIH UBRZANOM STARENJU U OVISNOSTI O UVJETIMA DEINKING FLOTACIJE

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SAŽETAK

U radu je promatrana optička stabilnost laboratorijskih listova dobivenih reciklacijom iskorištenog novinskog papira nakon ubrzanog starenja. Metodom kemijskog flotacijskog deinkinga pri različitim eksperimentalnim uvjetima su reciklirane hrvatske dnevne novine. Ubrzano starenje pripremljenih laboratorijskih listova provedeno je u sušionuku pri temperaturi od 60°C u različitim vremenskim intervalima. Optička stabilnost svih laboratorijskih listova analizirana je kroz promjene refleksijskih spektara u odnosu na listove dobivene metodom reciklacije INGEDE 11. Rezultati ispitivanja pokazuju porast refleksije, svih laboratorijskih listova, u vidljivom dijelu spektra nakon starenja istihneovisno o procesnim uvjetima flotacijskog deinkinga. Najveći porast refleksije pokazuje laboratorijski list pripremljen iz suspenzije novinskog papira razvlaknjenog pri sobnoj temperaturi u procesu recikliranje.

Ključne riječi: ubrzano starenje, procesni uvjeti flotacijskog deinkinga, reciklirani papir, reflektancijske vrijednosti

ABSTRACT

This study observes optical stability of newspaper laboratory handsheets after exposing to accelerated ageing. By chemical deinking flotation method under different experimental conditions, Croatian daily newspaper was recycled. Accelerated ageing of prepared handsheets were done in an oven at 60°C, while exposure time was varied. Optical stability of all handsheets were analysed through changes in reflectance spectrum and compared to those made with frequently used deinking method INGEDE 11. Regardless the process conditions during the flotation deinking, it is a notable increase of the reflection values in the visible part of the spectrum after handsheets ageing. The highest increase of reflectance values is obtained on handsheet which was prepared from newspaper suspension disintegrated at room temperature during recycling process.

Key words: accelerated ageing, process conditions of flotation deinking, recycled paper, reflectance value

1 INTRODUCTION

Flotation deinking is the most common technique in paper recycling industry. Alkali made from hardwood (oak and beech tree) fly ash, named Eco-alkali [1], has high potential as an alternative to commercially sodium hydroxide used in INGEDE Method 11 (International Association of the Deinking Industry) [2, 3].

The most important criteria for flotation deinking efficiency are brightness and the number of visible ink specks per unit surface area of recycled paper. Gained results in previous researches have shown that flotation process with Eco-alkali provides lower particle removing efficiency than INGEDE Method 11. Since flotation process strongly depends on: the used surfactant type and its concentration, flotation duration and temperature, the results have shown that Eco-alkali could be successfully used in newspaper flotation process if these parameters could be adjusted [2]. Process parameters in paper recycling directly affect on deinking efficiency and consequently on the optical properties of recycled paper. For graphic industry, the paper optical characteristics are extremely important.

Plazonic et al have investigated the influence of surfactant on the optical characteristics of office papers. They conclude that chemical composition of paper and types of surfactant have important influence on paper optical stability during accelerated ageing. Adsorbed molecules of surfactants act like virgin fibres conservators on filter paper and protect virgin fibre network from accelerated ageing. Since the recycled fibres are chemically saturated by previously done recycled process and adsorption of surfactants is low, chemical treatment of those samples had no influence on their reflectance spectrum and accelerated ageing had no influence on their optical properties [4, 5, 6].

The natural process of deterioration starts as soon as paper is made. Temperature is one of the most important environmental influences on the optical stability of paper [7]. Since the fifties a great variety of accelerated ageing methods has been developed for paper, and the field of application of these methods in the practice of conservation of archival and library materials has broadened enormously [8]. Nevertheless, the fundamental and experimental research into the reliability of accelerated ageing analyses is only performed on a limited scale, i.e. the essential questions have not been resolved sufficiently and the findings have not resulted in the use of a generally accepted standard method [9]. Meaningful application of accelerated tests is on the role of the various reactions that contribute to the deterioration of paper [10, 11].

The aim of this research is to measure reflectance in visible part of electromagnetic spectrum of thermal accelerated aged newspaper handsheets made at different process parameters in chemical deinking flotation.

3 EXPERIMENTAL PART

Experimental samples for optical stability analysis were recycled papers which were kept in a room away from sunlight and high moisture for one year. By recycling daily Croatian newspaper in four chemical flotations deinking trials, where chemicals and process parameters were changed (Table 1.), four handsheet experimental samples were made.

Table 1 Flotation deinking trials

	Trial 1 (T1)	Trial 2 (T2)	Trial 3 (T3)	Trial 4 (T4)
Alkali	0.6% sodium hydroxide	33.5% Eco-alkali		
Sodium silicate	1.8%	1.8%	-	1.8%
Hydrogen peroxide	0.7%	0.7%	-	0.7%
Oleic acid	0.8%	0.8%	0.8%	0.8%
Temperature	45°C	45°C	45°C	24°C

In Trial 1 (T1) standard chemical deinking INGEDE Method 11 was done, where alkali media necessary for efficient ink particles removing from pulp, was achieved by sodium hydroxide. T1 was a control method for defining deinking efficiency of new alkali flotation deinking approach. Novel alkali, called Eco-alkali was applied in other three trials (T2, T3, T4). In Trial 2 (T2) alkali media was achieved by Eco-alkali, chemicals and surfactant processed at 45℃. The environmental impact of chemicals for conventional flotation deinking was minimized in Trial 3 (T3) which was done at 45℃ by applying only Eco-alkali without any additional chemical except surfactant, which is necessary for flotation. Cold flotation was done at 24℃ in Trial 4 (T4) with Eco-alkali, chemical and surfactant. Handsheets, after flotation, were prepared from pulp gained from these trials according to INGEDE Method 1.

One year after recycling each laboratory handsheet was submitted to accelerated ageing provided by Memmert's Universal oven Model UNB 400 at temperature of 60°C, while exposure time was variated (t = 24, 48 and 72 h).

Reflectance spectra values (R) were measured for all samples before ageing ($R_{non\ aged}$) and after accelerated ageing (R_{aged}) and gained results are presented as ΔR according to Equation (1):

$$\Delta R = R_{non\ aged} - R_{aged} \quad (1)$$

Handsheets reflectance measurements were processed using X-rite SpectroEye spectrophotometer in the interval of the wavelengths from 380 nm to 730 nm for every 10 nm, with standard illuminant D65 and 2 degree of observer. These measurements were analysed by Technical Graphic Origin 6.0 Professional.

4 RESULTS AND DISCUSSION

For better understanding the experimental results it is necessary to point out the process parameters used during the recycling process of newspaper. Process parameters provide better detachment of all impurities from fibres during disintegration stage and their separation from pulp suspension during flotation stage of newspaper recycling process. In all trials the alkali was used (sodium hydroxide in Trial 1 and Eco-alkali in other three trials). Except the alkali, hydrogen peroxide and sodium silicate was used in Trials 1, 2 and 4. And the third altered parameter in this study is disintegration temperature: 45°C (Trial 1, 2, 3) and 24°C (Trial 4).

Reflectance spectrum of non aged handsheet according to altered process parameters during the flotation deinking is presented at Figure 1.

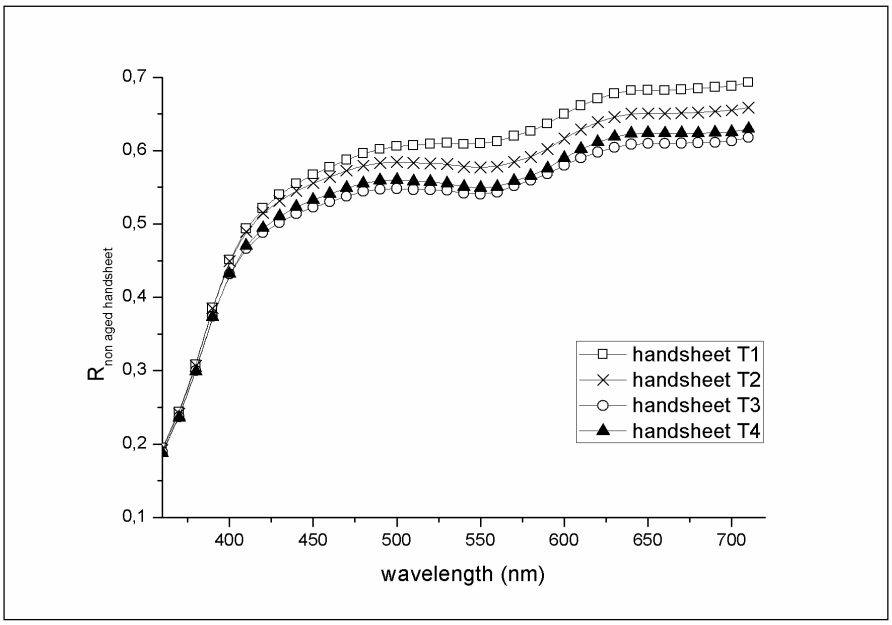

Figure 1 Reflectance spectrum of non aged handsheet

Handsheets prepared by INGEDE Method 11 (T1) before exposing to accelerated ageing have the highest reflection values in the whole spectrum. Slightly lower reflectance is measured on handsheets made in Trial 2. Those results indicate how sodium hydroxide gives better optical properties to handsheets than Eco-alkali. By decreasing the disintegration temperature from 45°C to 24°C, the reflectance values are even more decreased. The lowest reflection values of handsheets are achieved in Trial 3 where during recycling process hydrogen peroxide and sodium silicate were not used.

The spectrum differences (ΔR) results of accelerated aged handsheets, prepared by different process conditions during flotation deinking method, are presented at Figure 2.

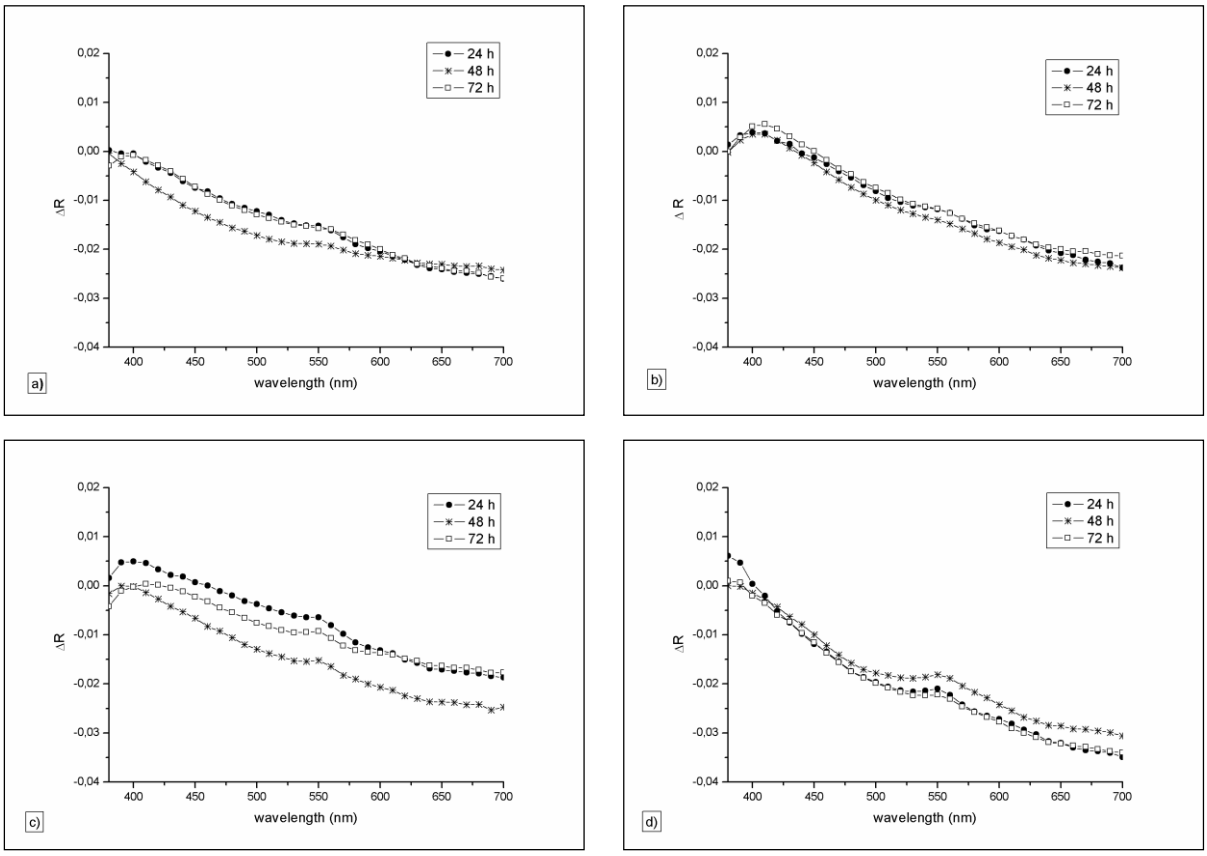

Figure 2 The influence of ageing time on handsheet spectrum differences reflectance according to process conditions: a) Trial 1, b) Trial 2, c) Trial 3 and d) Trial 4

Negative values of ΔR in the visible part of spectrum indicate the increase of reflectance values after ageing all handsheets. Observing all ageing times, the ageing in duration of 48 h gives the biggest changes of reflectance values on handsheets made in all experimental trials.

Influence of alkali on ΔR values

Spectrum differences reflectance results are similar for handsheets made in Trial 1 and 2. Those results show how Eco-alkali provides the same optical stability of handsheets in relation to sodium hydroxide, the most used alkali in chemical deinking flotation process.

Influence of hydrogen peroxide and sodium silicate on ΔR values

Handsheets made in trials 1, 2 and 4 gives similar or equal ΔR values after exposing to accelerated ageing from 24 to 72 hours, while handsheets made in trial 3 (Figure 2c) give different ΔR values. Those handsheets made in trial 3 are made from pulp suspension without presence of hydrogen peroxide and sodium silicate.

Influence of disintegration temperature on ΔR values

Regarding to all observed spectrum differences reflectance, the highest decrease of ΔR value is noticed for handsheets prepared in trial 4 (Figure 2d) where the newspaper desintegration was done at temperature of 24°C.

5 CONCLUSION

This research has brought about several conclusions:

- according to used flotation deinking method, newspaper handsheets reflectance is the highest for handsheets prepared by INGEDE Method 11
- using the Eco-alkali in chemical deinking flotation process, newspaper handsheets reflectance is lower when hydrogen peroxide and sodium silicate are not used or if disintegration temperature is decreased.
- according to used flotation deinking method, newspaper handsheets reflectance is increasing after accelerated ageing
- accelerated ageing of handsheets in duration of 48 h gives the highest reflectance values regardless to process parameters of chemical deinking flotation
- Eco-alkali provides the same optical stability of aged newspaper handsheet as sodium hydroxide which is the most used alkali in paper recycling process
- absence of hydrogen peroxide and sodium silicate in disintegration stage during newspaper recycling process cause optical instability of recycled paper
- pulp suspension temperature in disintegration stage of newspaper recycling process has the greatest impact on optical stability of handsheets

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