

ZBORNIK RADOVA
PROCEEDINGS

MATRIB 2007

HOTEL POSEJDON, VELA LUKA
OTOK / ISLAND KORČULA, HRVATSKA
21-23. lipnja / June 2007.

ORGANIZATORI / ORGANIZED BY:

HRVATSKO DRUŠTVO ZA MATERIJALE I TRIBOLOGIJU
CROATIAN SOCIETY FOR MATERIALS AND TRIBOLOGY
INSTITUTE OF MATERIALS AND MACHINE MECHANICS
(SLOVAK ACADEMY OF SCIENCES)
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ZAKLADA HRVATSKE AKADEMIJE ZNANOSTI I UMJETNOSTI
INA INDUSTRIJA NAFTE – ZAGREB
PLINACRO d.o.o. - ZAGREB

IZDAVAČ / PUBLISHER:

Hrvatsko društvo za materijale i tribologiju
Croatian Society for Materials and Tribology
c/o FSB, Ivana Lučića 5, 10000 Zagreb
tel.: +385 1 61 68 389; fax: +385 1 61 57 126
e-mail: hdmt@fsb.hr, <http://www.fsb.hr/hdmt>

UREDNIK / EDITOR:

Krešimir Grilec

CIP zapis dostupan u računalnom katalogu Nacionalne i sveučilišne knjižnice u Zagrebu pod brojem 639182

ISBN 978-953-7040-12-3

NAKLADA / ISSUE:

150

TISAK / PRINT:

Vizual media d.o.o., Zagreb

ORGANIZATOR / HRVATSKO DRUŠTVO ZA MATERIJALE I TRIBOLOGIJU
ORGANIZED BY: CROATIAN SOCIETY FOR MATERIALS AND TRIBOLOGY
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FACTORS OF ENVIRONMENT AND THE STUDY OF PRINTING SUBSTRATE PROPERTIES

ČIMBENICI OKOLIŠA I STUDIJ SVOJSTAVA TISKOVNIH PODLOGA

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Stručni članak / Professional paper

Abstract: In the present technological moment the digital reproduction is accompanied by problems caused by insufficient knowledge of mechanism in printing processes depending on the characteristics of the printing substrates and ink which would ensure the exact reproduction of all graphic information. Except that, the scientific approach of the evaluation of ecological suitableness which is based on the definition, quantification and evaluation of the influences of the determined printing technique on environment, undoubtedly shows the recognizable unfavourable influence in the domain of raw materials, graphic material, printing processes and the disposal of the used products.

Only one part of the results of the above mentioned investigations, which concerns the different composition of the printing substrate and the digital prints exposed to the controlled influences of the accelerated ageing, is presented in this work. The investigations comprise non aged and accelerated aged papers of different compositions, prints on aged and non aged papers as well as the prints which were accelerated aged.

The investigation results are the contribution to theoretical explanation of the mechanism of the degradation processes in the ageing conditions which is particularly important for the printing output s of continuous value and for the preserving the cultural values.

Key words: printing substrate, digital printing, ageing, optical characteristics

Sažetak: U sadašnjem tehnološkom trenutku digitalnu reprodukciju prate problemi uzrokovani nedovoljnim poznavanjem mehanizama u procesima tiska zavisni od karakteristika tiskovnih podloga i bojila, koji bi osigurali točnu reprodukciju svih grafičkih informacija. Osim toga znanstveni pristup ocjene ekološke podobnosti koji se zasniva na definiranju, kvantificirajući i vrednovanju utjecaja određene tehnike tiska na okoliš nedvojbeno ukazuje prepoznatljiv nepovoljni utjecaj u domeni sirovina, grafičkih materijala, procesa tiska, te zbrinjavanju iskorištenih proizvoda.

U ovom radu prikazat će se samo jedan dio rezultata gore spomenutih istraživanja, koji se odnosi na različiti sastav tiskovne podloge i digitalnih otisaka izloženih kontroliranim utjecajima ubrzanog starenja. Istraživanjem su obuhvaćeni nestareni i ubrzano stareni papiri različitog sastava, otisci na starem i nestarem papirima, kao i otisci ubrzano stareni.

Rezultati istraživanja doprinos su teoretskom pojašnjenu mehanizma degradacijskih procesa u uvjetima starenja što je posebno značajno za ispis tiskovnih zapisa trajne vrijednosti, te očuvanju kulturnih vrijednosti.

Ključne riječi: tiskovna podloga, digitalni tisk, starenje, optičke karakteristike

1. INTRODUCTION

Deterioration in quality of an aged paper can manifest itself in chemical permanence and the decrease in mechanical durability [1]. The permanence of paper or prints depends on the chemical resistance of its components and of the influence of external factors [2]. It includes lightfastness and points at resistivity of the printing ink against fading and colour change after exposition to light [3].

The durability depends mainly on the physical and mechanical characteristics of the raw materials, impact of microclimatic factors such as heat, humidity or radiation and on contamination by ions and gas from the environment and action of microorganisms [4-6].

Exposure of paper to very short wavelength ultraviolet (254nm) radiation is induced post-irradiation effect, which are influenced internal and external factors [7]. Result of exposure to visible and ultraviolet radiation of paper is its discoloration effects during and after exposure. The aim of Bukovski report is to consider the share of the short-term action daylight with partly reduced UV radiation induced oxidation degradation of grounwood paper in the presence of various amounts of secondary chromophores, formed in the paper itself [8].

Natural ageing process of paper and prints causes the degradation of cellulose . The presence of moisture, oxidative agents and microorganisms are important in this process and especially the presence of acidic substances. The results in this case are the hydrolysis of cellulose that appears in shortening of its chain along with changes in content of crystalline form [9]. Shortterm irradiation of paper initiates light induced oxidation reactions, which continue even after paper is stored in the dark [10].

Discolouration of a paper may be caused by the formation of chromophores upon ageing as a result of exposure to among other light and volatile gases [11]. Many volatile compounds as well as alcohols, ketones, aldehydes, carboxylic acids aromatic and aliphatic hydrocarbons and eters can be released from paper during degradation processes depending upon paper chemical compositions.

Acid catalyzed hydrolysis of cellulose was recognized to be the primary reaction the accelerated deterioration of the paper. For study of accelerated ageing of paper new methods are being developed and recently a mathematical model was presented for temperatures from Rychlyet al.[12].

The investigation results of the exposition to the controlled influence of the accelerated ageing of the printing substrate and of digital prints are presented in this work. The investigation comprise the non aged and the accelerated aged papers of different composition, the prints on aged and non aged papers, as well as the accelerated aged prints.

The investigation results are the contribution to theoretical explanation of the mechanism of the degradation processes in the ageing conditions which is particularly important for the printing output s of continuous value and for the preserving the cultural values.

2. EXPERIMENTAL

Digital printing machine Xerox DC 50 was used for printing. The printing form contained different printing elements: multicoloured halftone photos, patches for determining

the colour density, halftone value and relative printing contrast, trapping fields, patches for determining dimensional stability and colour register control, surfaces for determining grey balance and standard FOGRA PMS wedge. Printing was done on fine art paper (Symbol Freelife Gloss, Fedrigoni), offset paper (Arcoprint, Fedrigoni) i recycled paper (PAN).

For accelerated ageing substrate and print the climatic chamber was used, under the following conditions: temperature 80°C, relative humidity 65% and ageing time of 24 days without the radiation influence. In the experimental part, three series of samples were processed: prints on non-aged paper, prints on aged paper and aged prints.

Optical parameters for the described samples series were performed by X-Rite spectrophotometer with the support of ColorShop program. The measuring results were processed by means of Data Analysis program and technical Graphic Origin Professional. Except that the spectrophotometer Datacolor Elrepho 450 was used for measurements. For shooting the spectrum of paper samples and prints in infra red areas FT-IR spektrofotometar Spectrrum One Perkin Elmer was used.

3. RESULTS AND DISCUSSION

In order to get more detailed insight into the changes of permanence of the printing substrates which were used for digital printing Xerox, the colorimetric values of different non aged and aged paper are presented.

Table 1. Colorimetric characteristics of the non aged and aged paper

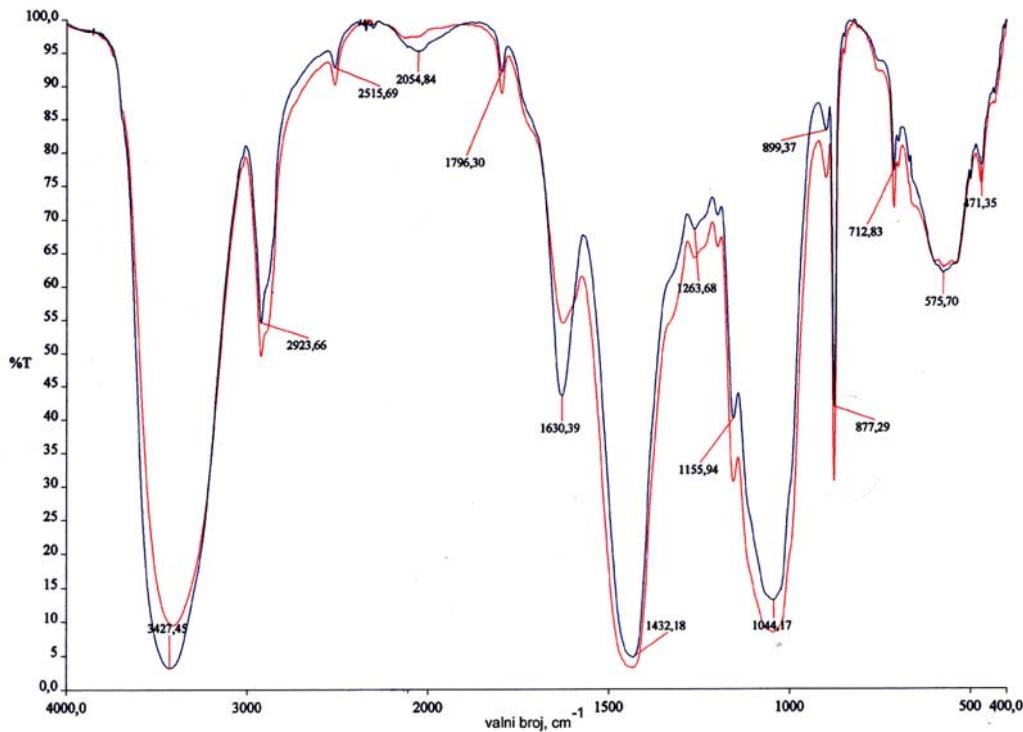
Sample	L*non aged	a*non aged	b* non aged	L* aged	a* aged	b* aged	ΔE
Offset paper	94,56	3,96	-8,83	93,88	2,89	-4,73	4,3
Fine art paper	95,97	1,51	-2,25	94,37	0,42	4,02	6,6
Recycled paper	86,73	-0,23	6,63	83,9	0,26	13,44	7,4

The investigation results show that the greatest colour differences ΔE are noticed between the non aged and the aged recycled paper. The fine art paper shows somewhat smaller difference in relation to the recycled paper. Offset paper shows the smallest change in colour difference of all ΔE = 4,3, but according to the evaluation criteria, the deviations of three stimulus information and this deviation are well visible.

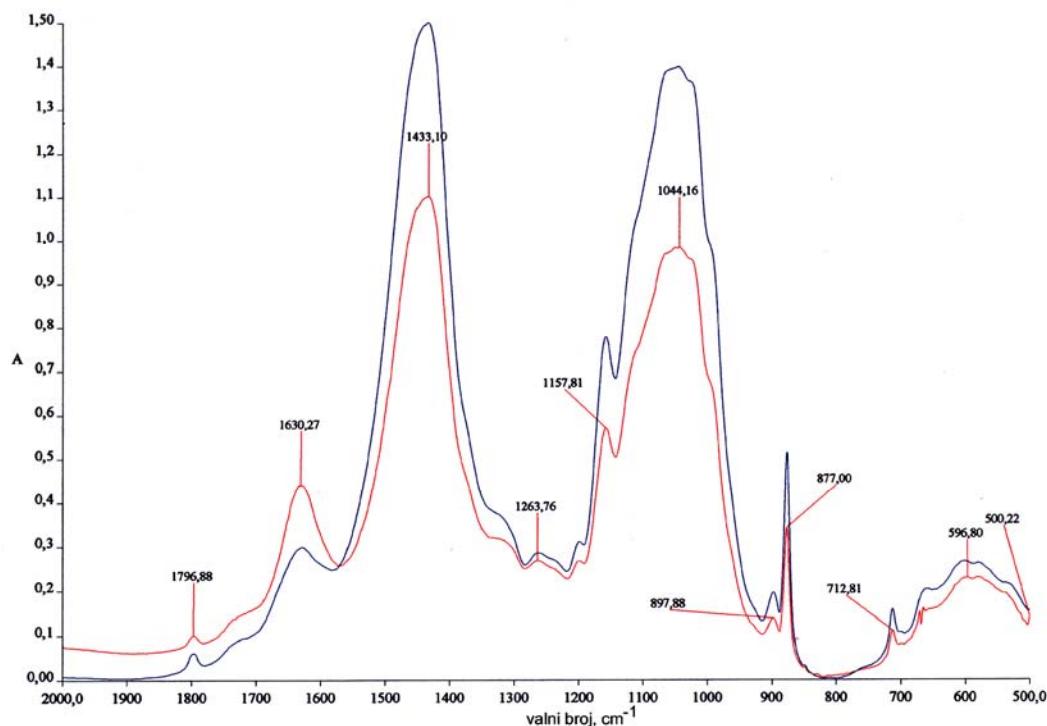
Observing the chromatic changes (a* and b*) between the non aged and the aged recycled paper, considerable shift within the yellow is visible, which causes the decrease of brightness L*. Fine art paper yellows too. The most stable optical properties are determined for offset paper which shows smaller changes within the blue area; it does not go into the yellow area and it does not have greater change in brightness.

Generally, the increase of b* value is attributed to the chromophores which are formed by degradation of paper components such as cellulose, chemicellulose and lignin.

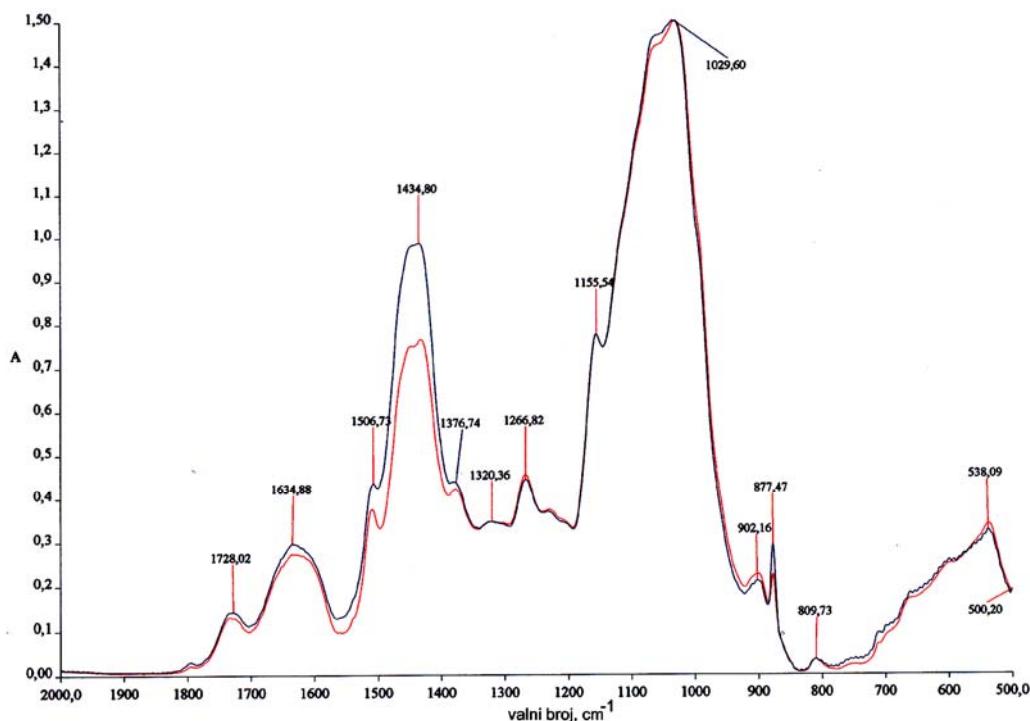
Figure 1 presents FT IR spectra in the area of wave numbers from 4000,0 to 400,0 cm^{-1} for non aged printing substrate and accelerated aged substrate with the aim for determination the quantity of influence in the change of the observed optical properties which can originate from degradation in the ageing conditions.



a) Comparative FT-IR spectrum for non aged and the aged fine art paper in the area of the wave number from 4000,00 to 400,0 cm^{-1}



b) Comparative FT-IR spectrum for non aged and the aged offset paper in the area of the wave number from 2000,00 to 500,0 cm^{-1} .



c) Comparative FT-IR spectrum for non aged and the aged recycled paper in the area of the wave number from 2000,00 to 500,0 cm^{-1} .

Figure 1: FT-IR spectra a) Comparative FT-IR spectrum for non aged and the aged fine art paper in the area of the wave number from 4000,00 to 400,0 cm^{-1} ; b) Comparative FT-IR spectrum for non aged and the aged offset paper in the area of the wave number from 2000,00 to 500,0 cm^{-1} ; c) Comparative FT-IR spectrum for non aged and the aged recycled paper in the area of the wave number from 2000,00 to 500,0 cm^{-1}

By observing the comparative FT – IR spectra obtained for the non aged and the aged papers, one can notice very little increase of absorbency in the area 1200 – 100 cm^{-1} representative for C – O stretching out, the stretching out of the ring and C-O-C vibration asymmetric stretching out. On the aged papers one can see the increase of absorbency in the area of 1600 – 1700 cm^{-1} . In the area near 1700 cm^{-1} and because of the free water in paper, the O – H stretching out is present.

Complex changes are noticed in the area of 1734 cm^{-1} , for which C=O vibrations are responsible, and which change with the time of paper ageing. The oxidation processes as the results of paper ageing, generate the carbonyl groups which have influence on the decrease of whiteness and the increase of yellowness of paper.

Except on the printing substrates, the ageing processes are noticed on the prints made on aged paper as well as on aged prints made on non aged paper. The results of these investigations are presented in figure 2 for cyan, magenta and yellow in full tone of colour.

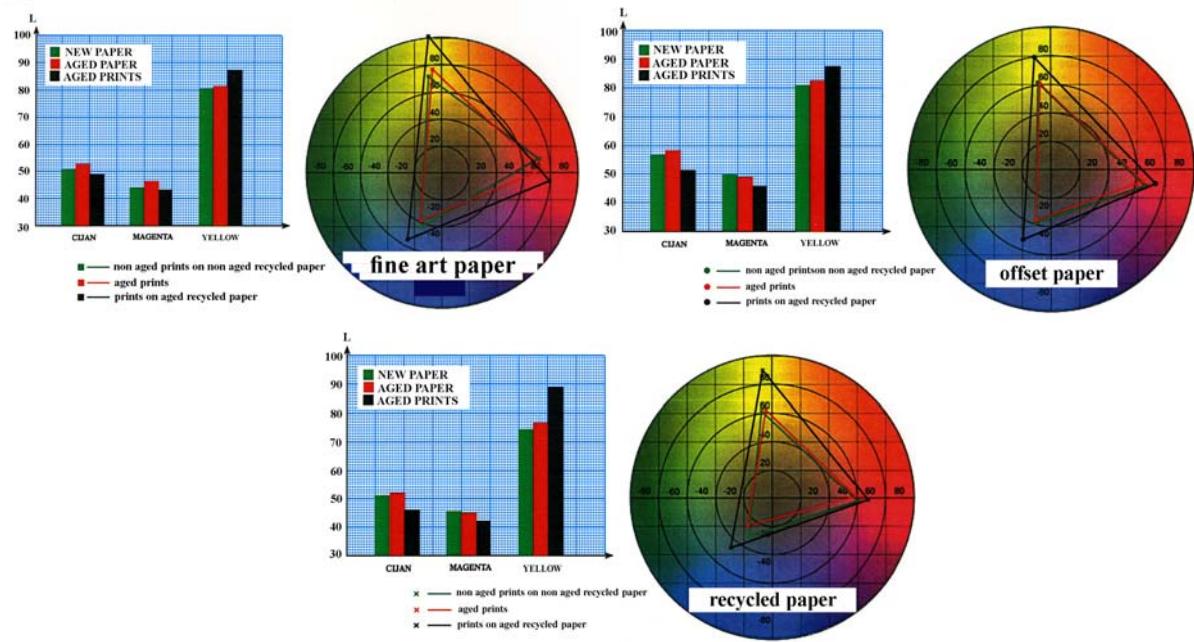


Figure 2. The influence of accelerated ageing on $L^*a^*b^*$ values

Based on the results presented in figure 2, the colour differences ΔE have been calculated as followed:

$$\Delta E_{1,2} = E_{\text{non aged prints}} - E_{\text{aged prints}}$$

$$\Delta E_{1,3} = E_{\text{non aged prints}} - E_{\text{prints on aged paper}}$$

$$\Delta E_{2,3} = E_{\text{aged prints}} - E_{\text{prints on aged paper}}$$

On Xerox prints on offset paper, there are not important changes in colour difference as the result of ageing. The colour difference appears on prints on the aged paper in relation to the prints on non aged paper $\Delta E_{1,3}$ C 16,9, M 9,9 Y 41,4. The greatest values for yellow print were obtained on aged paper in relation to the aged yellow prints $\Delta E_{2,3}$ 40,4.

By ageing the prints on non aged paper, the greatest changes in colour difference appear in cyan. The decrease of saturation in the blue area and somewhat less in the yellow and red area appear on such prints. By the ageing of prints made on aged paper the changes in color appear in the yellow area, but ΔE value is not as high as it is on the fine art paper.

On recycled paper, by ageing, the greatest colour differences are noticed between the non aged and the aged magenta prints.

4. CONCLUSION

The investigation results show that the greatest permanence in the described experimental conditions is achieved with offset paper. On Xerox prints, the medium value of colour difference is expressed in a series as follows: offset paper 15,6, fine art paper 14,6, recycled paper 13,8. In this printing technique, the print on aged paper has greater aberrations for some colours in relation to the print on non aged paper.

By FT – IR analysis it was proved that near the wave number 1600 cm^{-1} there is the increased intensity of the carboxyl peak with the increase of ageing period, which is the result of

oxidation processes. The changes were determined in the area of wave numbers from 1734 cm⁻¹, for which C = O vibrations are responsible, as the result of oxidation processes, which influence the decrease of whiteness and the increase of yellowness of paper.

In scientific sense, this work is the contribution to the explanation of the reproduction ageing in digital printing process including the relevant parameters of the reproduction process from the point of view of the formal characteristics of the printing substrate. The result application can contribute to the improvement of the reproduction objectivity.

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