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Evaluation of the influence of artificial UV ageing of printed images

Iskren Spiridonov [1], Rumyana Boeva [1]
[1] Department of Pulp, Paper and Printing Arts, University of Chemical Technology and Metallurgy, Sofia, Bulgaria

Introduction

Printing production has a great variety: books, newaspapers and magazines, advertising products, packaging and more.

Over time, sealed materials get older and can be caused by various factors: the natural ageing of paper and inks, the effects of temperature, the environment and human intervention.

The main problems that occur when storing various printed matter for a long time are related to the deterioration of color characteristics and loss of information from them, the change in color range and the color difference that result from the aging of the ink.

Artificial ageing can also be accomplished by light irradiation with UV rays. The test samples are irradiated on one side. Samples are then conditioned. UV irradiation has a significant impact on the elasticity and flexibility of the fibers and makes the paper more brittle and fragile. Improper storage is most often the cause of the mechanical destruction of works of art.

Problem Description

The main problems encountered in the long storage of printed or painted images are associated with deterioration of color characteristics and loss of information from them. Natural ageing is a rather slow process.

The main goals of this research are to investigate the influence of artificial UV ageing on the optical density, spectral and color characteristics of printed images.

The experiment have been performed in real printing conditions on state of art offset printing presses. The test images patches have been submitted to UV artificial ageing.

Methods

Two wide used and popular types of papers have been chosen for the experiment: Uncoated offset paper – with weight 80 g/m2 and Matte coated paper – 120 g/m2. On the paper samples the following analyses were made:

- Estimation of weight, [g/m2] (EN ISO 536:1998);
- The pH of the water extraction according to ISO 8947-83.

Artificial UV ageing was conducted in a Q-SUN Xenon Tests camera. The measurements were done on intervals: 0, 6, 12, 24, 36, 48, 72, 144 and 200 hours. Colour measurements were performed with spectro-photometer GretagMacbeth Spectrolino and X-Rite i1i0: GM Profile Maker, GM Measure Tool и GM Profile Editor and i1Profiler. Measurement conditions – standard light source D50, measuring geometry 45°/0° or 0°/45°, 2° standard observer (ISO 13655:2017; European Color Initiative; ICC.1:2004-10; ISO 2470:2002). Optimal inking quantity is predetermined (ISO 12647-2:2013).

Table 1 gives the test values for optimal inking. The optical density is determined by the thickness of the ink layer.

Results

Table1 *Optimal inking values expressed by $D_{100\%}$ for papers used in experiment*

Type of Paper	*Cyan*	*Magenta*	*Yellow*	*Black*
Uncoated offset paper	*1.10*	*1.10*	*0.90*	*1.20*
Coated matte paper	*1.55*	*1.60*	*1.45*	*1.85*

Graphic representation of the change in optical density (D) for Cyan, Magenta, Yellow, Black at 100%, 40% and 7% of the CMYK tone values for both papers, depending on the time of UV ageing

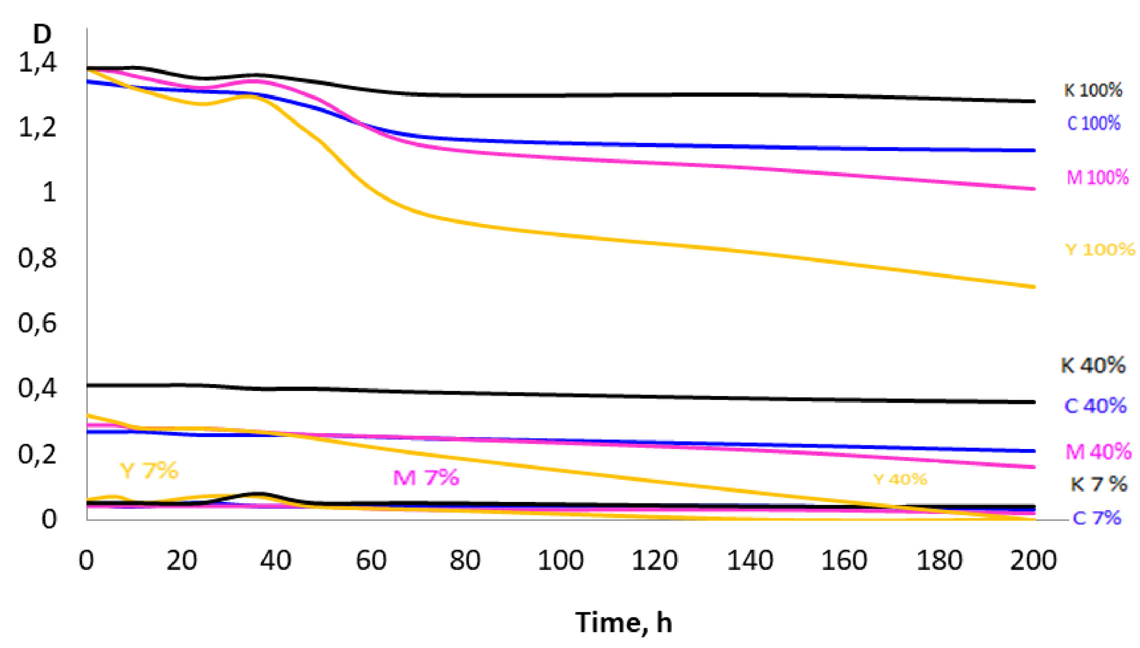

Figure 1 *Influence of artificial UV ageing on the optical density of coated matte paper*

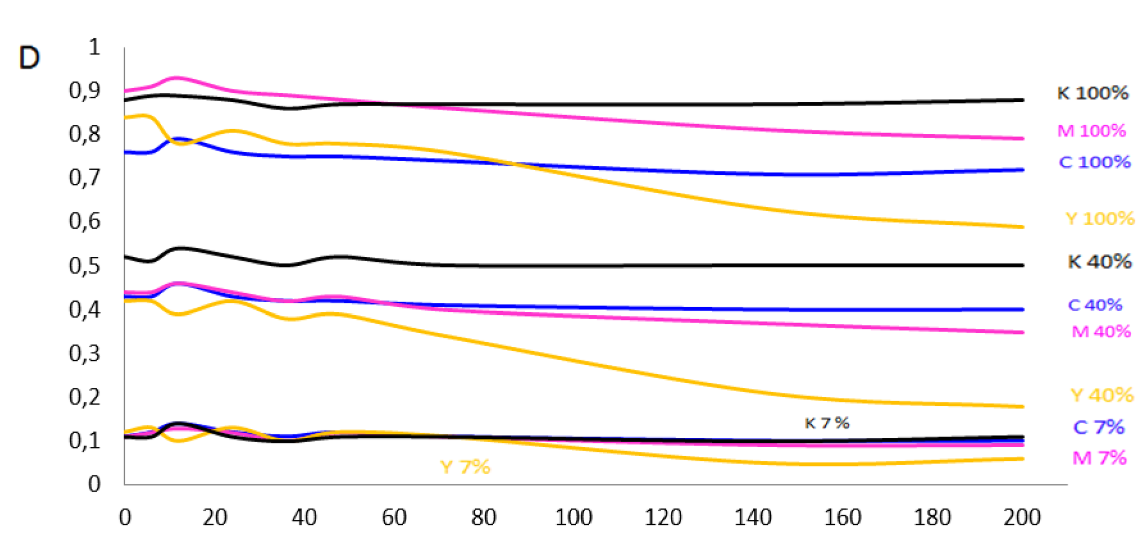

Figure 2 *Influence of artificial UV ageing on the optical density of uncoated offset paper*

Table 2 shows the differences in optical density of Cyan, Magenta, Yellow, Black between 0h - 200h of UV ageing for coated matte paper.

Table 2 *Difference in optical density for C, M, Y, K on matte paper*

$\Delta D_{0/200}$	*Cyan*	*Magenta*	*Yellow*	*Black*
7%	*0.02*	*0.02*	*0.06*	*0.01*
40%	0.06	0.13	0.32	0.05
100%	0.21	0.37	0.67	0.1

Table 3 *Difference in optical density for C, M, Y, K on offset paper*

$\Delta D_{0/200}$	*Cyan*	*Magenta*	*Yellow*	*Black*
7%	*0.01*	*0.02*	*0.06*	*0*
40%	*0.04*	*0.09*	*0.24*	*0.02*
100%	*0.04*	*0.11*	*0.25*	*0*

Investigation of the change in the color characteristics for both types of papers

Table 4 *The change in the color characteristics by CIE*Lch in the UV ageing for uncoated offset paper*

Time, [h]	**CIE L***	**CIE c***	**CIE h***
0	*94.21*	*6.80*	*280.07*
200	*93.97*	*5.14*	*100.14*

Discussion / Conclusion

Table 5 *The change in the color characteristics by CIE Lab in the UV ageing for uncoated offset paper*

Time, [h]	CIE L*	CIE a*	CIE b*
0	*93.77*	*1.40*	*-6.48*
200	*94.89*	*-0.94*	*4.04*

Table 6 *The change in the color characteristics by CIE*Lch in the UV ageing process for coated matte paper*

Time, [h]	CIE L*	CIE c*	CIE h*
0	*97.33*	*5.42*	*284.11*
200	*95.71*	*7.31*	*92.92*

Table 7 *The change in the color characteristics by CIE*Lab in the UV ageing process for coated matte paper*

Time, [h]	CIE L*	CIE a*	CIE b*
0	*97.32*	*1.33*	*-5.33*
200	*95.71*	*-0.29*	*7.51*

Conclusion

After performing of artificial UV ageing of 200 hours of irradiation, it was found that the greatest changes occurred for the saturation color coordinate, for the coated matt paper reaching values of ΔC *matte* 0/200 = 50.82 and 2 times larger than the uncoated offset paper ΔC *offset* 0/200 = 24.99 units. There is a significant change in the color tone (hue), for the coated matt paper reaching Δh= 16.53, and for the uncoated offset paper up to Δh= 1.52. In the process of UV irradiation, for both types of papers there was almost no change in the light (CIE*L) of the selected fields, except for magenta ink, for matt paper ΔL*matte* 0/200=10.72 and twice more for offset paper ΔL*offset* 0/200=4.36 units.

After 200 hours of UV irradiation, it was found, that the optical density become smaller with increasing of time of UV ageing. In some cases, in the light and medium tones of the 7% and 40% Yellow fields, the vanishing of the raster elements is observed. There is observed the same for both papers optical density changes in light tones (7%). At mid-tones (40%), the change in optical density is almost the same, but for matt coated paper the values being slightly higher. For dark tones (100%), it is evident that for matt coated paper occurs three times more changes in density (ΔD0/200= 0.1 ÷ 0.67 units), than for offset uncoated paper (ΔD0/200 = 0 ÷ 0.25 units).

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