Artificial aging of outdoor prints

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Abstract

Outdoor advertising remained an effective and informative way of broadcasting a message to the receptive public. Poster advertising is still an important element of media campaigns. Large format inkjet printing technology has become one of the major technologies to produce posters in the last decade. Inkjet technology allows the use of wide range of substrates with solvent based, water based and UV curable inks. Outdoor printed products have to resist the degrading components of weather: solar radiation, moisture, rain, wind, etc. The estimation of the useful lifetime of the printed product for outdoor application is provides important information for the costumer. Expected lifetime of the printed products can be estimated by on site outdoor or laboratory testing. Laboratory test equipment is capable of providing the environmental effects and a controlled aging process. Our current research focuses on the apparent changes of visual quality of outdoor inkjet prints during the aging process. Two plastic and two laminated paper substrates were chosen, all of them recommended for outdoor use. We investigated how the optical parameters of our test prints change after equal subsequent doses of radiant exposure.

Keywords: accelerated aging, outdoor and laboratory weathering, fading

1. Introduction, research objectives

Outdoor advertising continues to be an important marketing tool since the second part of the 19th century, with the advance of large format and quantity printing. Today it is considered a favorite campaign medium, capable of influencing the decision of the buyer and providing aesthetic experience in the same time. Decades ago outdoor printed products were made by screen printing technology, nowadays, with the advance of digital technologies inkjet, electrophotographic and thermographic technologies are also applied. Billboards, together with large format printing opened new business opportunities in print industry. A wide range of substrates can be used for outdoor printing: paperboard, vinyl, canvas, etc. Plastic substrates are very popular because of their better resistance against weather than paper based substrates. Outdoor products are printed with water or organic based and UV curable inks, which resist weathering (solar radiation, moisture, rain, wind, etc.) to a certain extent. The general experience with outdoor printed products exposed to weather effects is that these products will fade, loose or change color. Deteriorated visual appearance is a crucial problem for high quality printed products. Outdoor advertisement needs to last until the validity of the message communicated holds (*Image Permanence Institute, 2007*).

Solar irradiation, temperature and moisture are the main weather factors that cause damage to outdoor products, but gases, contaminants, dust, etc. may also have a significant effect. The combined effect of the individual factors can be even more damaging. In outdoor or laboratory experiments the combined effect needs to be investigated (*Atlas Weathering Testing Guidebook, 2001*).

The durability of prints is determined by the substrate, the ink, and the other compounds alltogether. Aging is an irreversible physical and chemical process taking place over time. Durability depends mainly on the physical and mechanical properties of materials, affected by the factors of the micro-climate like heat, moisture and radiation, environmental ionic and gaseous pollutants, microorganisms (*Bolanča I. and Bolanča Z. 2004*). The process of aging starts immediately after printing, whether with digital or traditional technology. During aging the components of the substrate and the ink change simultaneously. Heat and moisture are the main factors affecting color prints, fading may also caused by the formation of chromophores upon ageing as a result of exposure to light and volatile gases (*Majnarić et al. 2010*). A common method of testing the resistance to aging of prints is artificial aging. During accelerated aging it is possible to control or measure variables, like the radiant exposure in a specific wavelength range, relative humidity, temperature. The aging of the printed product is testified by the changes of its physical, chemical and optical properties (*Debeljak-Karlović, Gregor-Svetec, 2011*).

Our research work focused on the objective evaluation of the gradual degradation of visual quality of test specimen. Two plastic and two laminated paper substrates were chosen, with two types of large format inkjet printers. We investigated how the colorimetric properties of our test prints change after equal subsequent doses of radiant exposure.

2. Experimental

In our discontinuous accelerated aging experiment inkjet prints of the test chart were irradiated in a laboratory artificial aging device. We used Atlas Suntest XLS+ material tester with ISO 4892-2 Method B6 without wetting. Irradiance was 45 W/m^2 in the 300 nm - 400 nm range. The temperature of the test chamber was 24°C - 65°C during the tests. Each individual test run lasted 48 hours, during which the specimen recieved approximately 7776 KJ/m^2 radiant exposure (Table 1).

Table 1: Operating time (t) and corresponding radiant exposure (H) values on the sample plane of the test chamber

t (hours)	0	48	96	144	192	240	288	366
H (kJ/m^2)	0	7776	15 552	23 328	31 104	38 880	46 656	54 432

We aged 4 specimens in our experiment. Two of our specimens were plastic: Multifix Vynil HQ 500g/m^2 and Endotex Ex 500g/m^2, printed by Roland Soljet Pro III XC-540 large format inkjet printer. The other two, High Color Contrast paper 180g/m^2 and Zenith Photo Matt paper 180g/m^2 were printed with Canon imagePROGRAF iPF8000 large format inkjet printer, and laminated with heat activated glossy laminating pouch (80 microns) from manufacturer Eurosupplies.

After each 48 hour period of artificial aging optical density, tone value increase, color tri-stimulus values were measured and color gamut of the specimen were determined. A X-Rite SpectroEye spectrophotometer and an Eye-One IO automated scanning table has been used to obtain optical density and colorimetric data. In this paper we present the results of 6 and 8 steps of 48 hour aging of the laminated paper and of the plastic substrates.

3. Results

The measured optical properties are quantitative indicators of fading. In a previous research work we concluded, that the minor changes in optical density values may not be a sensitive indicator of the visual appearance of fading (*Á. Borbély, Cs. Horváth, R. Szentgyörgyvölgyi, 2012*). We found 0.0-0.04 units decrease in optical density of the full tone process colors as a result of the aging process. The magenta process color was the most sensitive to irradiation in all cases.

The magnitude of the changes on a perceptual scale can be best represented by the color shifts of the full tone process and secondary colors in CIELAB uniform color space and calculated color differences between the original and the aged specimen in CIE 1976 ΔE^*_{ab} units. Figure 2 and 3 demonstrate the color shift magnitudes in case of the paper and plastic substrates.

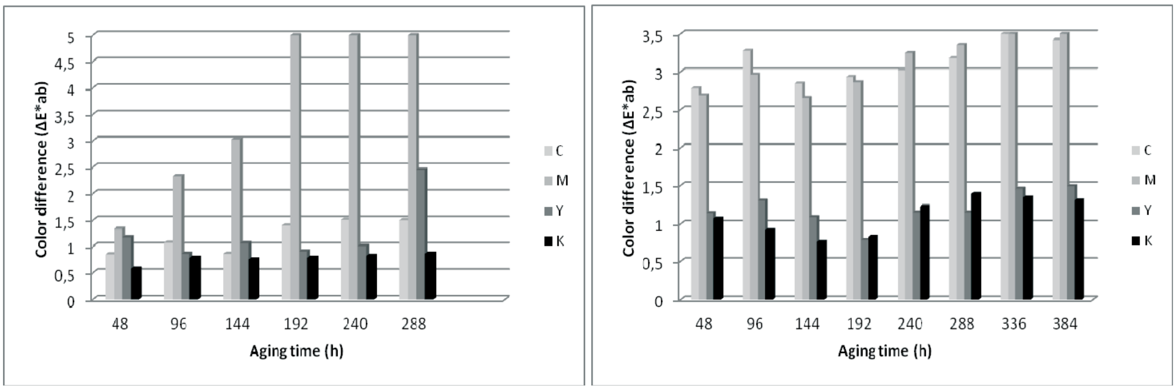

Figure 1: Color differences of solid patches of process colors (C, M, Y, K) at 48 hour steps of aging. Inkjet prints on Zenith Photo Matt paper (left) and Multifix Vynil HQ plastic (right) substrates

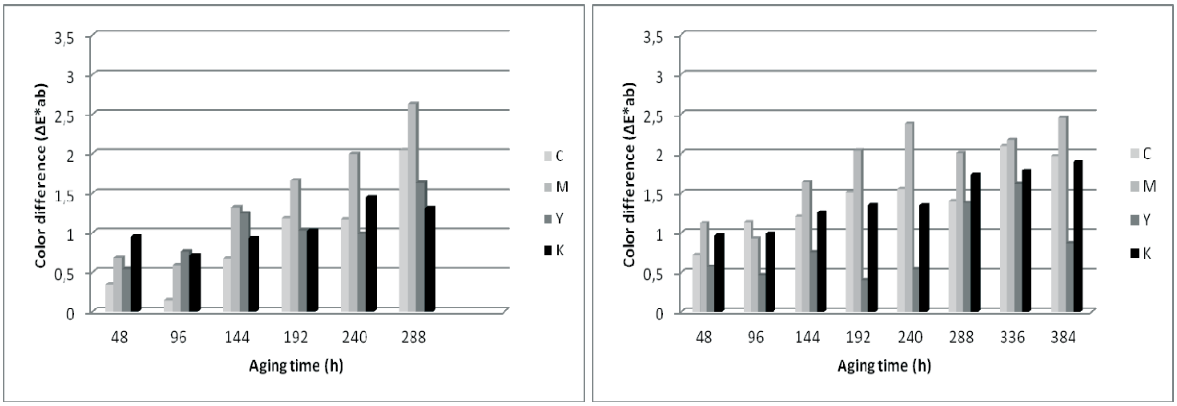

Figure 2:
Color differences of solid patches of process colors (C, M, Y, K) at 48 hour steps of aging.
Inkjet prints on High Color Contrast paper (left) and Endotex Ex plastic (right) substrates

Colorimetric shifts of the process colors are combined in case of secondary colors and CMY halftones. The magnitude of the shifts of chromatic grays at different tone levels (figures 3 and 4) remained in the range of that of the process colors for paper and plastic substrates as well.

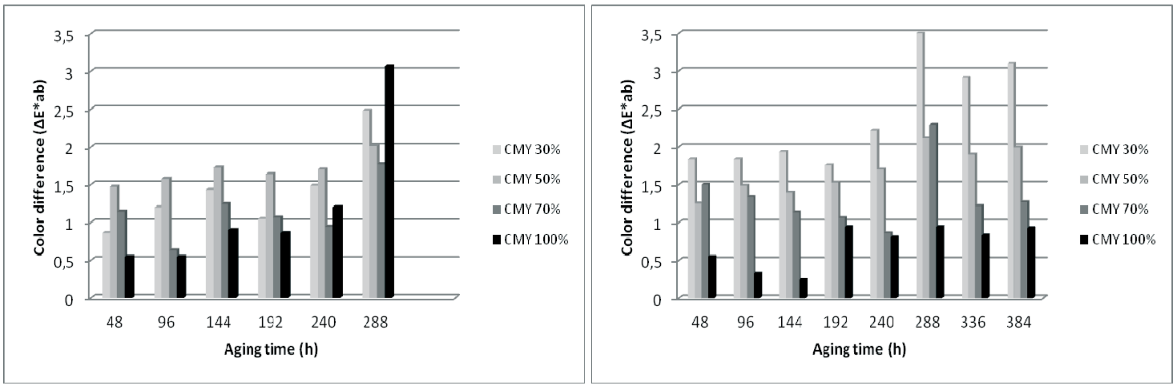

Figure 3:
Color differences of full tone and halftone patches chromatic grey (CMY) at 48 hour steps of aging.
Inkjet prints on Zenith Photo Matt paper (left) and Multifix Vynil HQ plastic (right) substrates

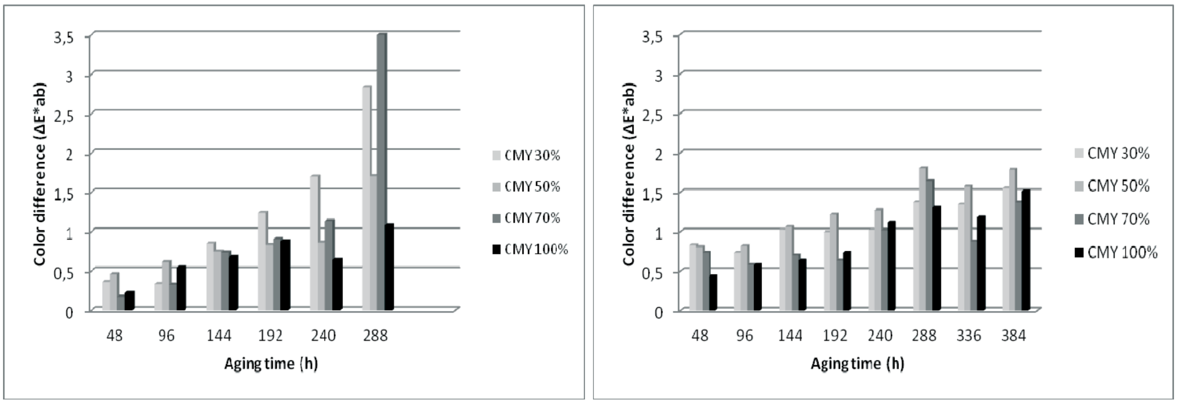

Figure 4:
Color differences of full tone and halftone patches chromatic grey (CMY) at 48 hour steps of aging.
Inkjet prints on High Color Contrast paper (left) and Endotex Ex plastic (right) substrates

The range of reproducible colors (color gamut) was determined using a 400 patch test chart, the standard profiling method, and profile analysis software. The measurement and computation process was completed after every 48 hours of aging, in order to obtain information on fading of the most saturated colors. The shrinking of the color solid volume with irradiation is shown on Figure 5.

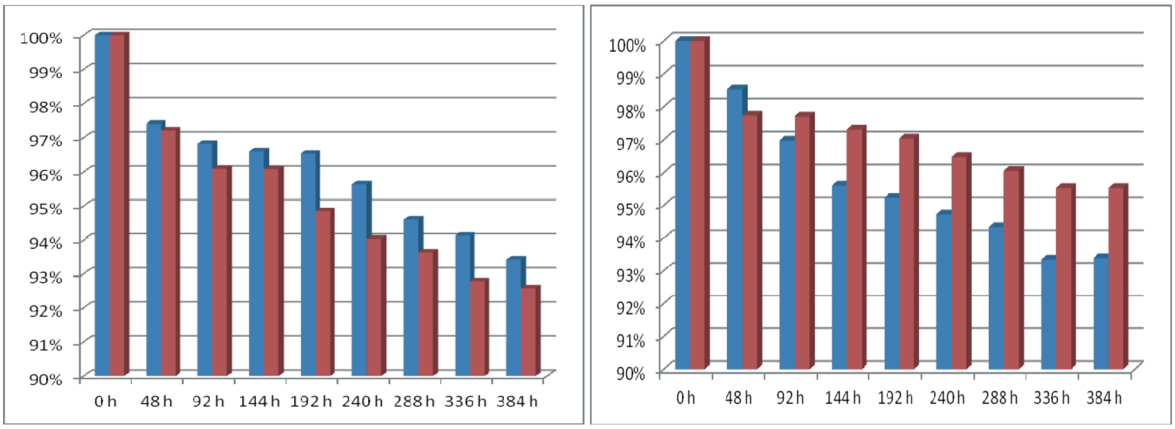

Figure 5: Color gamut changes of test prints after 48 hour steps of aging. Inkjet prints on Zenith Photo Matt paper (left, blue) and Multifix Vynil HQ plastic (left, red) substrates, High Color Contrast paper (right, blue) and Endotex Ex plastic (right, red)

4. Conclusions

We investigated the changes of optical properties of inkjet prints on laminated paper and plastic substrates during an accelerated aging experiment. Specimens were irradiated in a weathering testing instrument for 48 hour terms (equal doses of 7700KJ radiant exposure) under controlled conditions, optical properties were measured after each term.

Optical density was found to be a weak indicator of the magnitude of changes in appearance due to fading. We experienced color differences that were well above the threshold level on laminated paper and inkjet substrates. The magenta process color appeared to be the most sensitive to irradiation induced fading in all cases. The color gamut of the test prints decreased by up to 10% in case of all substrates during the whole experiment.

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