The Role of Humidity Cycling in Accelerated Light Fastness Tests

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Abstract

The study investigates the fading of prints from 32 different ink/media combinations under three accelerated exposure conditions that are characterized by different sample humidity. All three tests predicted the same ranking of colorant stability. The most humid fading condition produced the strongest degradation in light, except for colorants with strong dye diffusion. The study confirms that for certain types of colorants, light fastness is very dependent on humidity. Fading tests and lifetime predictions should be made for the average humidity that the prints will be displayed at.

Introduction

Digital media have been greatly improved in light stability in recent years. Accelerated tests are used to test light stability. There is concern if very high intensity tests can predict much lower intensity real-life fading. Experience with accelerated test compared to real-life ageing in photography has indicated that very high intensity fading with the corresponding drying of the samples tends to overstate print stability. Re-moistening of the samples reduces print life predictions and aligns them with observed real-life display.[1]

The following paper extends this investigation to ink jet media.

Table 1

A high intensity light	B no light	C low intensity light
100 klux	Dark	50 klux
black panel 58°C / 13%rh	black panel 25°C / 80%rh	black panel 48°C / 21%rh
white panel 40°C / 32%rh	white panel 25°C / 80%rh	white panel 36°C / 38%rh
chamber 36°C / 40%rh	chamber 25°C / 80%rh	Chamber 36°C / 40%rh
I = cycled = 3.8h of A plus 1h of B II = no cycles = permanent A III = no cycles = permanent C		

Experimental Conditions

The effect of humidity cycling and exposure conditions were investigated in an Atlas weatherometer Ci-35 on the set of 8 media (4 polymer/4 porous) with 4 dye-based inks. The inks were all dye-based, a commercial thermal 4-colour ink, a commercial 6 colour piezo ink and two experimental 4 colour thermal inks with different dye sets. Three different accelerated fading conditions were compared to samples in real-life display in a library facing North/East placed at 2 m from a window over a period of 2 years. The real-life exposure corresponded to 7.7 Mluxh at 50% r.h. The actual accelerated exposure conditions, sample temperatures and corresponding humidities for I, II, and III are summarised in table 1.

Results

The test image consisted of wedges of 9 steps printed in y, m, c and k. The k channel was either a mixture of 3, 4 or only one colorant, dependent on the printer driver used. For every ink/media combination, the changes in density of y, m, c, k at 0.5 density (CL, ML, YL, KL) and 0.8 to 2.0 density (CD, MD, YD, KD) were plotted at exposure intervals of 2.5, 5, 7.5, 10 and 20 Mlux for the three accelerated conditions. The samples displayed in the library were measured after 6, 12 and 21 months. Typical plots of one ink/media combination of the relative changes in the lower density colours of CL, ML, YL, KL for the 4 methods are shown in figure 1.

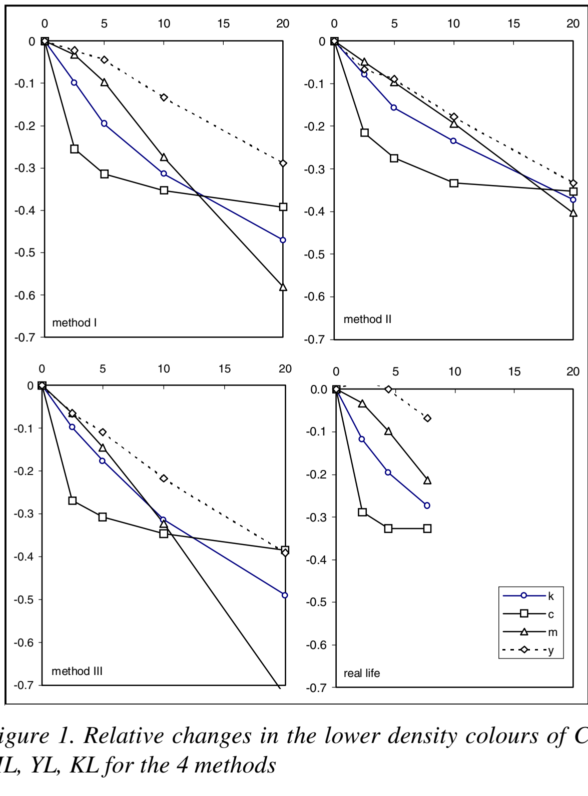

Figure 1. Relative changes in the lower density colours of CL, ML, YL, KL for the 4 methods

The relative density changes corresponding to 7.7 Mlux were interpolated from the accelerated test and averaged over all inks and the polymer or the porous media per colour channel and per method. The resulting averaged density changes for the case of light colour (CL, ML, YL) per method are shown for polymer media in figure 2a and for porous media in figure 2b. The plots for the dark colours looked very similar.

In another comparison, the density changes of the 4 inks at all Mlux intervals per colour channel for either polymer or porous media were correlated to the library samples. Two correlation plots for one colour channel, ML, are shown in figure 3.

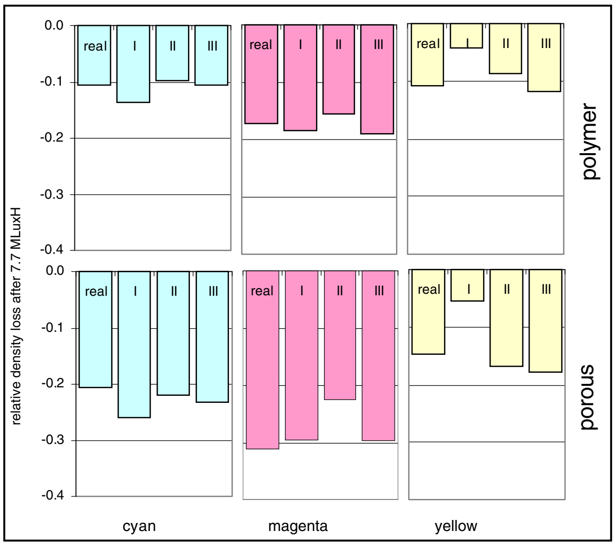

Figure 2a and 2b. Averaged relative density changes for the case of light colour per method are shown for polymer and porous media after 7.7 Mluxh

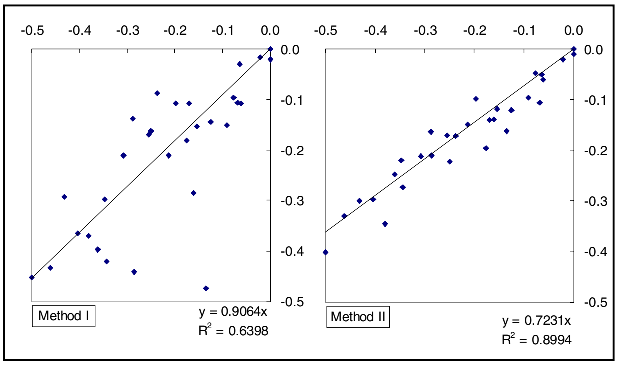

Figure 3. Plots of the correlation with real life for colour channel ML and the two methods I and II

Conclusion

From the light fading study of 32 ink-jet media/ink combinations, several conclusions could be drawn. For all colours except yellow, the three accelerated light exposure experiments predicted similar ranking of colour density changes and corresponded well with the real-life library samples. For magentas, the light/dark cycled test correlated better with the test at half intensity and with the real-life samples than the exposure at same intensity without cycles. Cyans showed fewer variations with the fading method. Yellows showed increased dye diffusion in the cycled test which masked dye degradation. The cycled test predicted the shortest life expectancies.

Some dyes diffuse strongly with humidity. Others have very different light stability in a de-aggregated form at high humidity[2] than at 50% r.h. High humidity may change the relative permanence of colours in a dye set (catalytic fading)[3] The actual print life of images containing such dyes will depend very strongly on humidity. In both cases light fastness tests at one single humidity condition cannot well predict life expectancy for different real environmental conditions. As is indicated in reference[4] accelerated tests should be done at conditions that simulate the later display conditions as closely as possible, in humidity as well as light exposure. Very low intensity accelerated exposures and cycled accelerated exposures take place under higher humidity which is more critical and more typical for actual print display.

References

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