Influence of Enclosure and Mounting Materials on the Stability of Inkjet Images

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Abstract

Enclosures and mounting materials greatly affect the stability of inkjet images both when stored in the dark and when exposed to light. Samples were printed on Creative Memories® inkjet paper with an Epson® Stylus Photo 780, 1270, or 2000P printer, allowed to dry for 24 h at room temperature, and then mounted on acid-free, lignin-free, buffered album pages with Photo Mounting Corners or Photo Mounting Sleeves. In some cases, a Page Protector was placed over the sample. We evaluated inkjet images for color change in both image and non-image areas.

Introduction

Currently, inkjet printers dominate the home market. Exceptional photographic quality papers and low-priced inkjet printers deliver outstanding color and sharpness. Consumers want confidence that the stability and permanence of inkjet images will equal traditional silver halide images when stored in an album.

Two enclosures are commonly used today in scrapbooks to protect photographs and other memorabilia from humidity, environmental pollution, and physical damage:

1. A Creative Memories Page Protector is a 0.055 mm polypropylene sheet that fits over the entire album page. Reinforcing tape extends past the mounting surface by 1.5 mm in order to secure the Page Protector to the album page.
2. A Creative Memories Photo Mounting Sleeve is a 0.075 mm polyester sheet that encloses a photographic print or other memorabilia. The sleeve is usually mounted to the album page with double-sided adhesive tape. Both ends of the sleeve are left open for easy removal of the item.

Creative Memories Photo Mounting Corners allow the image to be mounted to the album page without the need to place adhesive directly on the material. These polypropylene corners are backed with a self-adhesive strip that is applied directly to the album page. Both polyester and polypropylene are suitable for enclosures in contact with photographic images.[1]

Experimental

We generated inkjet test samples on two types of cast-coated Creative Memories Inkjet Photo Paper and on Creative Memories Inkjet Matte Paper (M). Type I of the cast-coated papers (CC-I) was incompatible with pigmented inks, while Type II (CC-II) had a surface coating compatible with pigmented inks. We printed test samples with the Epson Stylus Photo 780, 1270, and 2000P printers. The 780 and 1270 use identical dye-based inks, while the 2000P uses pigment-based inks. All samples were allowed to dry for 24 h at room temperature before testing occurred.

The test print is comprised of step wedges consisting of 20, 40, 60, 80 and 100 % solid blocks of black and each of the primary and secondary colors. Four 1 mm wide color bars show lateral ink diffusion, and text from 1 to 10 points illustrates visible sharpness. A non-printed area shows changes to the paper base.

We conducted accelerated aging with four Tenney™ T6RS environmental chambers maintained at 40.0, 50.0, 60.0, and 70.0 ± 0.3°C. Each chamber was also controlled at 50 ± 2 % RH. Samples were stored in a Creative Memories album and mounted on acid-free, lignin-free, buffered album pages with Photo Mounting Corners or Photo Mounting Sleeves. Two test samples were used for each paper/enclosure combination.

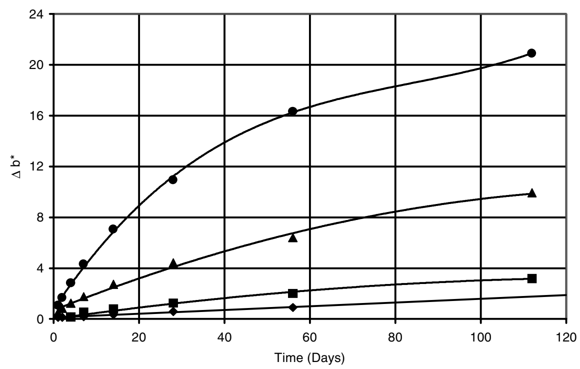
An Atlas™ Ci3000+ Weather-Ometer® was used for all light exposures. Lamp irradiance power was set to 0.35 W/m^2 @340nm, which corresponds to approximately 94 Klux.[2] The chamber was maintained at 25 ± 1°C and 50 ± 2 % RH.

We measured Status A densitometry and colorimetry with a 2-degree observer and D65 illuminant with a GretagMacbeth™ SpectroEye™ spectrophotometer. CIELAB colorimetry was used to characterize the unprinted area of each sample.

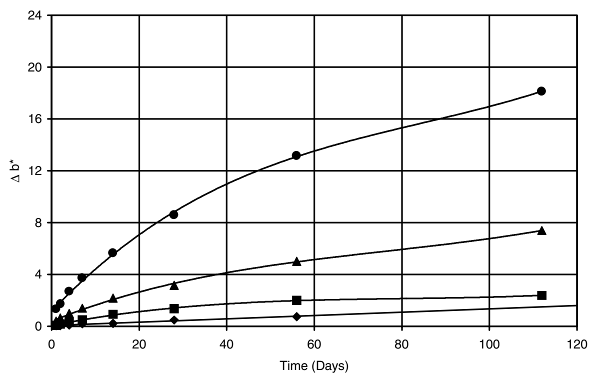
Dark Stability Tests

Samples of CC-II and M papers were placed in accelerated aging chambers at 40.0, 50.0, 60.0, and 70.0 ± 0.3°C for 112 days. During this time period, we did not observe sufficient change in color densities to allow accurate prediction of dye lifetimes at room temperature. For M paper, we did observe some yellowing which was apparent as an increase in Δb*. For this analysis, a change of 2.0 in Δb* was used as the endpoint criteria. This endpoint is the approximate point where yellow color formation becomes objectionable. The data for the yellowing of CC-II was insufficient for accurate curve fitting. Further tests are being conducted with this paper.

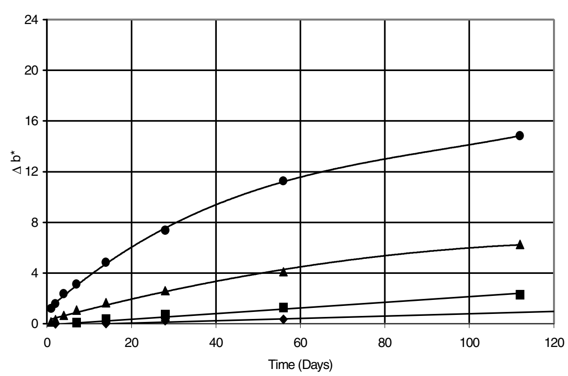
We obtained the time for Δb* to change 2.0 from plots of b* vs. time for each temperature, Figure 1A, B, and C.



(A) Unprotected



(B) Page Protector



(C) Photo Mounting Sleeve

Figure 1. •b vs. time for M inkjet paper under dark storage conditions at 40 (♦), 50 (■), 60 (▲), and 70°C (●).*

Arrhenius calculations were then made to determine the approximate length of time to reach the endpoint criteria at a temperature of 23°C, Figure 2.

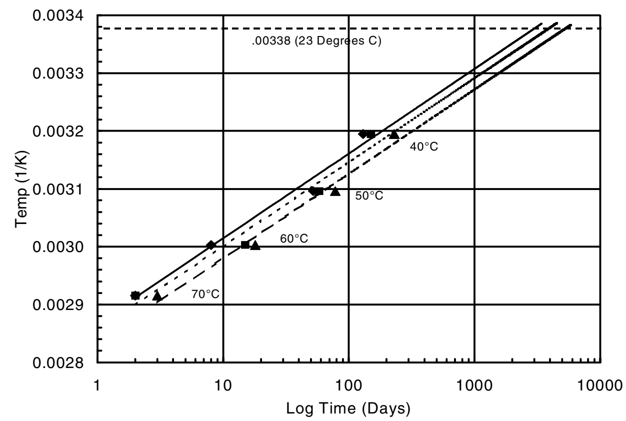


Figure 2. Arrhenius plots for the time to reach a Δb of 2.0 for M inkjet paper stored in albums unprotected (—♦—), with Page Protectors (--- ■ ---), and with Photo Mounting Sleeves (— ▲ — —).*

Extrapolations of the Arrhenius plots in Figure 1 to 23°C are summarized in Table 1.

Table 1. Predicted times for a 2.0 change in Δb* for M inkjet prints at 23°C.

Enclosure	Time for 2.0 Δb*	R^2 Value
Album Page	6.0 years	0.980
Page Protector	11.2 years	0.963
Photo Mounting Sleeve	15.4 years	0.982

In these tests, the time required to reach a Δb* of 2.0 is significantly longer when the inkjet image is protected with either a Page Protector or Photo Mounting Sleeve. In fact, the addition of a Photo Mounting Sleeve to the test samples more than doubles the time before objectionable yellowing occurs. In this case, intimate contact between the Photo Mounting Sleeve and the inkjet paper significantly retards the influence of environmental contaminants.

Causes of Yellowing

CC-I and CC-II papers were stored in contact with eight materials for 12 weeks to determine possible external causes of yellowing. These materials included manila folders, buffered album page paper, corrugated cardboard, non-corrugated cardboard, newsprint, polypropylene, polyvinyl chloride, and leather. The samples were kept in an office environment where the average temperature was 22°C and the average relative humidity was 51%.

Out of the eight materials tested, only two showed an increase in Δb*. Figure 3 shows the effect that corrugated cardboard has on the yellowing of the inkjet papers.

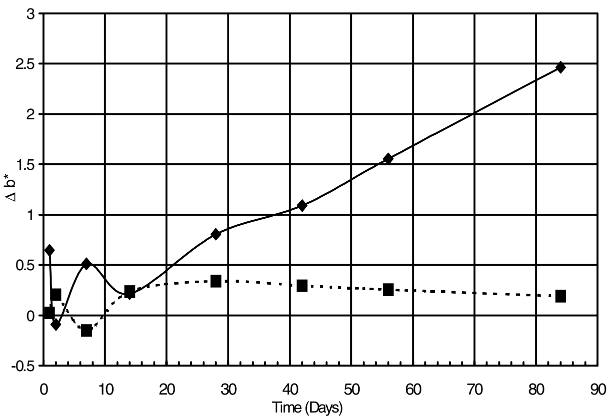


Figure 3. Measurements of Δb for CC-I (—♦—) and CC-II (- -■ - -) corrugated cardboard for 84 days.*

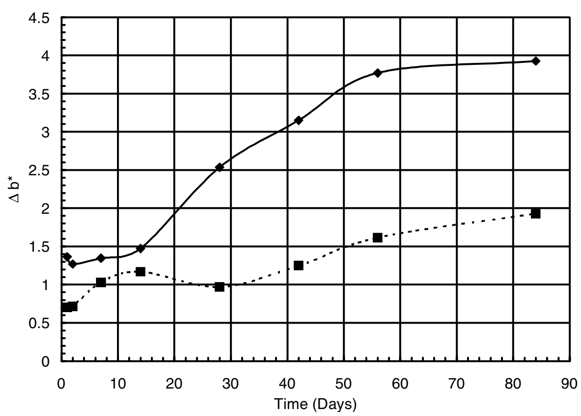


Figure 4. Measurements of Δb for CC-I (—♦—) and CC-II (- -■ - -) in contact with a manila folder for 84 days.*

CC-I starts to yellow in contact with corrugated cardboard at approximately 14 days and reaches a Δb* of 2.0 at 22 days. CC-II did not yellow in contact with corrugated cardboard. The substrate that produced the greatest increase in yellowing of inkjet papers was the manila folder. CC-I paper shows a Δb* of 1.4 within the first 24 hours and a 2.0 change occurs at 22 days of contact, Figure 4.

In this test, CC-II showed less yellowing than CC-I in contact with manila folders. Based on these results, manila folders are not recommended for the storage of inkjet images.

Inkjet papers may also adsorb antioxidants such as BHT 4,4'-methylene-bis-2,6-di-*t*–butylphenol (BHT) from the environment. BHT, which is frequently present in polyethylene and polypropylene, reacts with NO_2 and other oxidants to produce a yellow color.[3,4] Reaction of an inkjet paper with BHT in solution provides a simple test for the yellowing that may result during the natural aging of inkjet papers, Table 2.

Table 2. Δb* after 72 h exposure to two drops of a 1 % solution of 4,4'-methylene-bis-2,6-di-*t*–butylphenol (BHT) in 2-propanol.

Substrate	Δb* after 72 h
M	7.7
CC-I	30.1
CC-II	40.0

The pigment compatible CC-II yellowed more than the pigment incompatible CC-I in the BHT solution test. In contrast, CC-II showed less yellowing than CC-I when exposed to materials such as corrugated cardboard and manila folders. Consequently, we conclude that solution reactivity tests for yellowing may do a poor job of predicting actual performance during natural aging.

Light Stability Tests

Light stability tests were performed on CC-I, CC-II, and M papers. All 3 papers were tested first without a protective enclosure and then with Page Protectors and finally with Photo Mounting Sleeves. All samples were printed in duplicate on the Epson Stylus Photo 780 printer, except for M samples, which were printed on the 1270. CC-II was printed with both the 780 and the 2000P so that a comparison could be made between the stability of dye-based inks and pigmented inks.

Magenta was the least stable dye for all three unprotected test papers. The magenta density was measured for the 80 % coverage areas and scaled to a 1.0 initial density.[5] A 30 % dye loss was used as the endpoint because this amount of dye loss corresponds to objectionable image deterioration. When images were unprotected, all samples except CC-II printed with pigmented inks showed significant deterioration during the 192 h 94 Klux test, Figure 5 and Table 3.

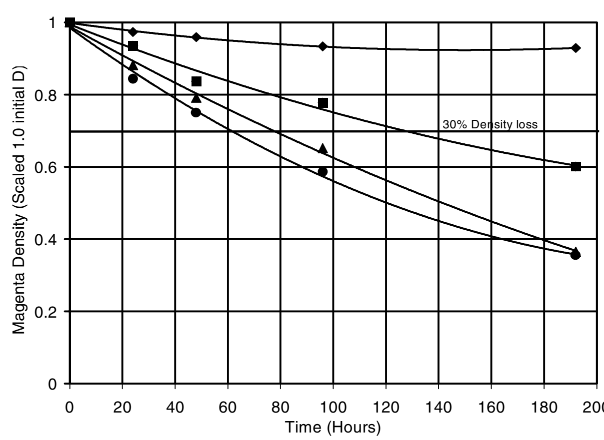


Figure 5. Magenta density loss for unprotected inkjet test samples: CC-II/2000P (♦), M/1270 (■), CC-I/780 (▲), and CC-II/780 (●).

Table 3. Time for a 30% Magenta density loss for inkjet paper samples.

Inkjet Paper	Unprotected	Page Protector	Photo Mounting Sleeve
CCI (780)	77 hours	>200 hours	>200 hours
CC-II (780)	61 hours	72 hours	66 hours
CC-II (2000P)	>200 hours	>200 hours	>200 hours
M (1270)	127 hours	>200 hours	>200 hours

CC-II printed with pigmented ink showed less than 10 % loss of magenta density. In contrast, the CC-II printed with dye-based ink shows the greatest fading of magenta dye, with a 30% loss at 61.3 hours of testing. This paper and ink also displayed the greatest amount of fading when covered with a Page Protector or Photo Mounting Sleeve.

The data for the samples covered with the Page Protector and Photo Mounting Sleeve enclosures was also calculated and interpolated to a 1.0 initial density. Very little fading occurred with the CC-I and M samples covered with either enclosure. Magenta density loss during the 192 h test ranged from 4 % to 64 %, Table 4.

Table 4. Magenta density loss after 192 h light exposure.

Inkjet Paper (Printer)	Album Page	Page Protector	Photo Mounting Sleeve
CC-I (780)	63.5 %	28.2 %	27.5 %
CC-II (780)	64.5 %	51.0 %	54.2 %
CC-II (2000P)	7.1 %	4.3 %	5.0 %
M (1270)	39.7 %	17.4 %	21.2 %

CC-II printed with pigmented inks had the most stable image, while the CC-II printed with dye-based inks showed the most fading with both the Page Protector and Photo Mounting Sleeves. In general, Page Protectors and Photo Mounting Sleeves proved equally effective at preventing image fade during light exposure.

Summary

Both Page Protectors and Photo Mounting Sleeves help preserve inkjet images and help preserve inkjet images stored in the dark. These enclosures also reduce yellowing. Mounting Sleeves are preferred because the Photo Mounting Sleeve completely surround the image allowing minimal exposure to adverse atmospheric conditions during storage. Light fading can greatly be reduced by the addition of a Photo Mounting Sleeve or Page Protector. This improvement is present even with the CC-II and pigmented ink combination, which displayed excellent light stability.

Acknowledgements

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Biography

Since 1998, Mark Mizen has served as Director of Technology for Creative Memories. In his position, he is responsible for materials specifications, product testing, and new product development for Creative Memories photographic storage system. He is a member of ANSI and ISO committees on image permanence and physical properties. From 1989 to 1998, Mark Mizen worked for 3M and then Imation on photothermographic imaging systems. He received his Ph.D in Physical Organic Chemistry in 1990 at the Massachusetts Institute of Technology.