The Light Induced Deterioration Of Inkjet Media in Frames

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Abstract

Previous research has indicated that airborne pollutants can cause physical damage to inkjet print media. This study was initiated to determine if inkjet media enclosed in sealed window-glass-covered frames could generate volatile reducing or oxidizing agents (redox agents) when exposed to light which could potentially cause such damage. An additional objective was to determine if the attenuation of UV energy by window glass in frames could mitigate previously observed damage of ink-receiver layers (IRL) and whether glass-covered sealed and unsealed frames would produce different results. Because of the dual objectives, this was a study in two parts. Results of the first part of this investigation indicated that a resin-coated (RC) black-and-white silver-gelatin photographic print, included as a control, produced the largest change in a redox detector. One of the two inkjet photo papers included in this study also produced a noticeable change, but to a lesser degree. The detectors with the other inkjet photo paper and the polyester film control showed no noticeable change. In the second study, the same two unprinted inkjet papers were exposed to 50 kilolux xenon light for twelve weeks, each in three separate framing configurations. One frame was sealed with its glass cover identical to the frames in the first experiment but without the redox detector film. Another had a glass cover like the first configuration, but the glass was spaced slightly above the papers and was open on all four sides to allow for ingress of ambient air. The third configuration did not have a glass cover. Results of the second investigation indicated that glass reduced physical damage caused by light for both inkjet photo papers. However, the open frame produced the greatest reduction in cracking in the inkjet paper that showed a noticeable change in the redox detector in the first investigation; much more than the closed frame. This might have been because the volatile redox agents generated during exposure to light escaped from the open frame. The other paper buckled in the tightest wedge setting of the brittleness apparatus (near complete fold). This failure occurred in the paper support and was not the result of exposure to light because unexposed paper showed the same result. However, the IRL in this paper completely disintegrated after exposure to light in the frame that did not include a glass cover. A larger study should be done to include a wider variety of inkjet papers to determine if the generation of redox agents in closed frames is a widespread phenomenon or whether it is limited to only a few. This additional investigation should include the frame variations used in this study.

Introduction

The purpose of this project was to evaluate whether light induces pollutant formation in certain inkjet photo papers, and then determine if specific framing practices can mitigate or exacerbate this effect. Titanium dioxide (TiO_2) is frequently included as a whitening agent in the image-side polyethylene layer of resin coated photo papers. T.F. Parson et al reported in 1979, that when TiO_2 is exposed to light it can lead to the formation of Ti_2O_3 and singlet oxygen which is an aggressive oxidant [1]. In early color photo papers, the formed singlet oxygen attacked the prints polyethylene layer causing both yellowing and embrittlement. Cracking of the oxidized polyethylene layer propagated through the gelatin layer showing crazing at the print's surface. This problem was addressed in manufacture by the addition of anti-oxidants to the polyethylene layer.

Previous experiments on resin-coated inkjet papers showed some ink-receiver layers (IRL) to be prone to embrittlement on exposure to light or ozone [2]. It was therefore theorized that light may have induced the formation of singlet oxygen in the modern papers and caused the embrittlement.

Two experiments were performed in this current project to test the theory. The first used a redox detector to determine if examples of resin-coated inkjet papers would, in fact, form oxidizing agents on exposure to light, and the second evaluated whether UV blocking framing glazing would mitigate the effect or sealed framing packages would exacerbate it. Besides this paper, there appears to be no other published research on physical damage to inkjet prints in frames caused by light exposure.

The audience for this paper is primarily those charged with the task of displaying digital print collection materials in cultural heritage institutions such as museums, libraries, and archives. The goal is to provide them with good information on potential light-induced damage to inkjet media in sealed frames. Other users may find benefit from this work, especially consumers, art galleries, picture framers, professional photographers and manufacturers of imaging materials.

Sample Preparation, Test Procedure and Measurements

For the first investigation, unprinted samples of two glossy porous photo RC inkjet papers from different manufacturers, a black-and-white silver-gelatin photographic RC print included as a control and another known inert control (polyester film) were held in separate 5 x 8 inch sealed frames along with a colloidal silver redox detector film. Conservation mat board was used to construct the frames [3]. The edges of the frames were sealed with aluminum foil tape [4]. The detectors were shielded from light and were not in direct contact with the test samples. A diagram of the frame is shown in Figure 1. The detector film is comprised of a thin colloidal silver/gelatin layer on a polyester base. The International Organization for Standardization (ISO) recognizes this film for use in a photographic activity test for enclosure materials (ISO 18916) [5].

The framed papers and control were exposed to 50 kilolux xenon light for twelve weeks at 25°C/50%RH. (Twelve weeks exposure to 50 kilolux of xenon light is equivalent to 52 years of 450 lux at eight hours per day of simulated daylight.) The densities of the redox detectors were measured before and after the test to de-

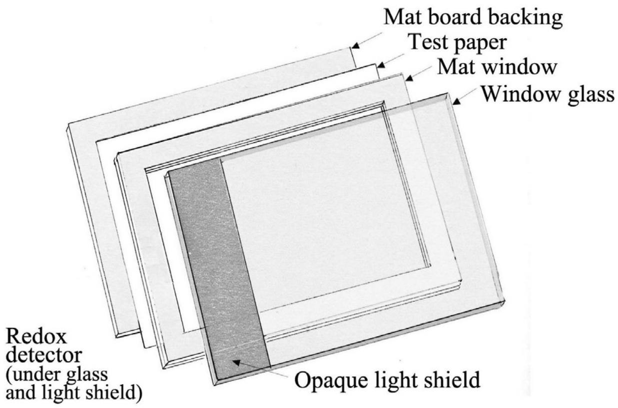

Figure 1. *Diagram of frame used to detect redox emissions from test print media exposed to light.*

termine if, and to what extent, the detectors changed. The data generated were compared to those obtained with replicate frames containing samples kept in the dark for twelve weeks.

In the second study, the same two unprinted inkjet papers were exposed to 50 kilolux xenon light for twelve weeks also at 25°C/50%RH, each in three separate framing configurations. One frame was sealed with its glass cover identical to the frames in the first experiment but without the redox detector film and light shield. Another had a glass cover like the first configuration, but the glass was spaced slightly above the papers and was open on all four sides. The third configuration did not have a glass cover. The exposed samples were tested in triplicate for cracking according to the procedure described in ISO 18907 [6]. The samples were evaluated visually both with and without magnification to determine the wedge diameter where cracking or other damage was first seen.

Experimental Results and Discussion

The changes in the colloidal silver detector blue densities for all three papers and the polyester control after exposure to 50 kilolux xenon light exposure for twelve weeks are provided in Figure 2. Blue density was used because the detector is yellow in color. The black-and-white silver-gelatin photographic print produced the largest change in the redox detector. One of the two inkjet photo papers also produced noticeable change, but to a lesser degree. The detectors with the other inkjet photo paper and the polyester film control showed no noticeable change.

Results of the second study, where the two unprinted inkjet papers were exposed to 50 kilolux xenon light for twelve weeks each in the three separate framing configurations described previously are provided in Table 1. In this table, the larger the diameter (provided in inches) where cracking is first observed, the more easily the IRL is cracked with flexing.

Results of this second investigation indicated that glass reduced the effect of light on producing physical damage to the IRLs for both inkjet photo papers. The open frame produced the greatest reduction in cracking in inkjet Paper B; much more than the closed frame. This may have been because the volatile redox agents generated during exposure to light escaped from the open frame. Inkjet Paper A buckled in the tightest wedge setting of the brittleness apparatus (near complete fold) as seen in previous

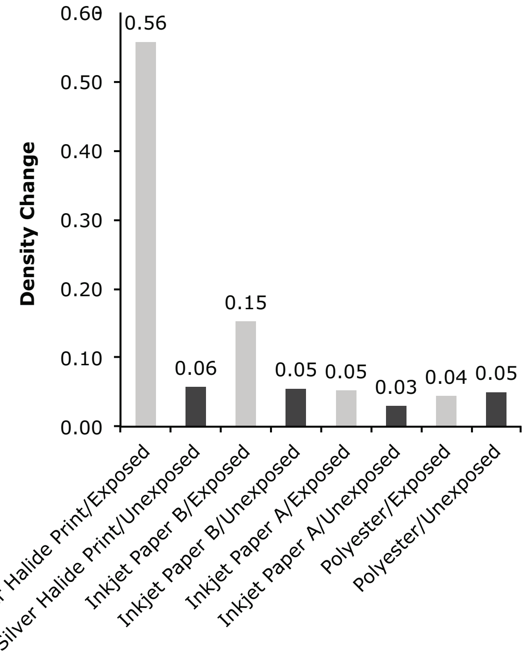

Figure 2. *Results of changes in the colloidal silver detector blue densities after 50 kilolux xenon light exposure for twelve weeks for all three test print media and the polyester control.*

Table 1. Results of cracking tests for inkjet Papers A and B after exposure to 50 kilolux xenon light for twelve weeks, each in three separate framing configurations.

Paper ID	Condition	Averages	Observations
Paper A	No Glass Open Frame	0.14	Buckling/fold - IRL Disintegrated
Paper A	Glass Covered Open Frame	0.15	Buckling/fold - IRL Intact
Paper A	Glass Covered Closed Frame	0.15	Buckling/fold - IRL Intact
Paper A	Unexposed/Open Frame	0.15	Buckling/fold - IRL Intact
Paper B	No Glass Open Frame	1.57	Cracking
Paper B	Glass Covered Open Frame	1.25	Cracking
Paper B	Glass Covered Closed Frame	1.44	Cracking
Paper B	Unexposed/Open Frame	0.76	Cracking

experiments [2]. This failure occurred in the paper support and was not the result of exposure to light because unexposed paper showed the same result. However, the IRL in Paper A completely disintegrated when pulled through the brittleness apparatus after exposure to light in the frame that did not include a glass cover. Collection care personnel are unlikely to fold collection assets but the clear increase in brittleness is still a concern.

Conclusions and Recommendations

This investigation should be considered to be preliminary; only two unprinted photo inkjet papers were included. However, the results indicate that some photo inkjet papers can generate redox agents that might result in physical damage to these papers in sealed frames. It is also clear that window glass can significantly mitigate physical damage to prints caused by exposure to light. A larger study should be done to include a larger variety of inkjet papers to determine if the generation of redox agents in closed frames is a widespread phenomenon or whether is limited to only a few. It would also be important to know if certain inkjet paper technologies, such as porous and polymer photo-coated papers as well as fine art papers, are more prone to produce this problem. Additional work could be done to determine if the generation of redox agents in closed frames would produce image fade, ink bleed, or discoloration of the print papers. Until a more comprehensive study is done, no recommendation can be made on the question of whether there would be significant risk of displaying inkjet prints in sealed frames.

References

[1] Journal of Applied Photographic Engineering, Volume 5. Number 2, Spring 1979 (T.F. Parsons, G.G. Gray and I.H. Crawford "To RC or Not to RC")

[2] Technologies for Digital Photo Fulfillment (TDPF) conference in Las Vegas in January 2012 (Salesin, E. and D. Burge "The Cracking of Inkjet Colorant Receiver Layers on Exposure to Light and Ozone" Technical Program and Proceedings)

[3] Pearl White Conservation Board, Item No. 97-409-1 from Archival Methods LLC, 235 Middle Rd., Henrietta NY 14467, (866)-877-7050, archivalmethods.com

[4] 3MTM Aluminum Foil Tape 425 Silver 4.6 mil, 3M.com

[5] ISO 18916:2007-06-15 Imaging Materials - Processed Imaging Materials - Photographic Activity Test for Enclosure Materials (International Organization for Standardization, Geneva, Switzerland, 2007)

[6] ISO 18907:2000(E) Imaging Materials - Photographic Films and Papers - Wedge Test for Brittleness (International Organization for Standardization, Geneva, Switzerland, 2000)

Author Biography

Gene Salesin, Research Assistant, received a B.S. in chemical engineering from the University of Michigan and an M.S. and Ph.D. in chemistry from Case Western Reserve University in 1960 and 1962, respectively. He retired in 1997 after 36 years of employment in the research laboratories and several manufacturing divisions at Kodak. He held a management position during his last few years there, leading the staff involved with providing the technical instructions and specifications for the manufacture of black-and-white films. Dr. Salesin joined IPI in 2004 and has been involved in the permanence properties of magnetic tape and digital prints.