The Effect of Ozone on the Quality and Stability of Inkjet, Chromogenic and Silver Digital Images

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Abstract

We have characterized the effect of 1 ppm of ozone at 50 % RH and 23°C on dye-based and pigmented inkjet images, on chromogenic, and on silver black-and white images on resin coated paper in dark storage. Prints in albums were evaluated unprotected and in polyethylene page protectors (PP) and sleeves (S). In this work, we evaluated the effect of ozone on density, colorimetry, and physical appearance.

The primary effect of ozone was density loss. Mounting prints in an album minimizes the effect of ozone on inkjet prints. Sleeves or page protectors provide additional, protection against the effect of ozone. We recommend this additional protection for long-term storage of inkjet prints in albums.

Introduction

A number of publications describe the effect of ozone gas and/or general atmospheric pollutants on the fading of inkjet prints (1-3). Similar information led the Image Permanence Institute to seek a grant for measuring the efficiency of enclosures on retarding the fading of imaging materials in the presence of ozone (4). This evaluation was a visual one and led us to undertake a project to quantitatively assess the effect of ozone on current materials.

Experimental

The test target included yellow, cyan, magenta, neutral, red, green and blue step scales and was printed chromogenic paper and on silver black and white resin-coated paper with a Durst Lambda Laser Printer. Creative Memories Glossy Inkjet Photo Paper was printed with an Epson 1270, and Creative Memories Matte Paper was printed with an Epson 2200.

These specimens were measured for density and CIE L*a*b* parameters on the GretagMacBeth Spectrolino™. Samples were then submitted to an independent testing laboratory for treatment with 1 ppm ozone at 23°C and 50% RH. The specimens were mounted in 7 inch albums and tested unprotected, mounted under page protectors and mounted with photo mounting sleeves. Controls samples were placed free hanging in the ozone chamber.

The albums were filled with the test prints as well as mounting paper cutouts, stickers and miscellaneous adhesives all made by Creative Memories and found in a "typical" album.

Albums were submitted to the ozone treatment as complete albums. The albums and the free-hanging samples were returned after 4, 7 and 14 days for analysis of color change and for visual inspection of physical changes.

Results

The returned samples were analyzed with the Spectrolino but the primary results were quite apparent visually. Table 1 shows the numerical changes in ΔE, while Table 2 shows the numerical changes in density of cyan, magenta, and yellow Dmax patches. Little change was apparent in the chromogenic and silver black and white images.

The glossy inkjet paper had dye-based ink and its primary fadings were in the magenta and cyan dyes. Dye fade was apparent in both neutral and single color patches. For this sample, the magenta density decreased approximately twice as fast as the cyan density.

The matte inkjet paper had pigment-based ink and its primary fading was in the yellow pigment. Fade of the yellow pigment was only readily apparent in the single color patches.

Conclusions

Mounting and storing inkjet prints in an album is the single most effective way to reduce the damage due to environmental pollutants such as ozone. Page protectors and mounting sleeves provide additional protection. Albums are meant to be enjoyed, not remain closed on shelf. Greater deterioration is clearly apparent after longer exposure times. In our work, we found that magenta and cyan dyes in dye based inkjet materials are particularly vulnerable. Ozone also destroys the yellow pigment currently used in pigment based inkjet systems.

Table 1. ΔE for Dmax neutral patch.

Paper	Storage	ΔE 4 days	ΔE 7 days	ΔE 14 d
Silver BW	Free Hung	0.1	0.1	0.1
Silver BW	Album	0.1	0.2	0.2
Silver BW	Album PP	0.1	0.3	0.3
Silver BW	Album S	0.2	0.1	0.1
Chromogenic	Free Hung			0.9
Chromogenic	Album	0.1	0.3	0.1
Chromogenic	Album PP	0.1	0.2	0.2
Chromogenic	Album S	0.1	0.4	0.1
Photo Inkjet	Free Hung	34	41	51
Photo Inkjet	Album	1.1	2.2	2
Photo Inkjet	Album PP	1.4	2.6	2.1
Photo Inkjet	Album S	1.2	2.5	1.9
Matte Inkjet	Free Hung	0.6	1	1.6
Matte Inkjet	Album	0.1	0.2	0.2
Matte Inkjet	Album PP	0	0.2	0.1
Matte Inkjet	Album S	0.1	0.2	0.1

Table 2. Density change for cyan, magenta, and yellow Dmax color patches after 14 days exposure to 1 ppm ozone.

Paper	Storage	Δ Dmax Cyan	Δ Dmax Mag	Δ Dmax Yel
Silver BW	Free Hung	0.01	0.00	0.00
Silver BW	Album	0.00	0.00	0.00
Silver BW	Album PP	0.01	0.01	0.00
Silver BW	Album S	0.00	0.00	0.00
Chromogenic	Free Hung	-0.02	0.02	-0.01
Chromogenic	Album	-0.02	-0.02	-0.02
Chromogenic	Album PP	0.00	0.01	.00
Chromogenic	Album S	-0.02	-0.02	-0.01
Photo Inkjet	Free Hung	-0.60	-1.06	-0.15
Photo Inkjet	Album	-0.01	0.00	0.04
Photo Inkjet	Album PP	0.00	0.00	0.04
Photo Inkjet	Album S	0.01	0.01	0.04
Matte Inkjet	Free Hung	-0.07	-0.01	-0.58
Matte Inkjet	Album	0.00	0.00	0.00
Matte Inkjet	Album PP	0.00	0.00	-0.01
Matte Inkjet	Album S	0.00	0.00	-0.01

This test represents a significantly more severe ozone exposure than encountered in indoor environments. In St. Cloud, MN, we have observed ambient indoor ozone levels between 0.002 and 0.036 ppm, with 0.01 ppm as a representative value. In this study we did not investigate multiple ozone concentrations; however, if the effect of ozone is proportional to concentration, 14 days at 1 ppm would correspond to approximately four years at a nominal indoor ozone concentration of 0.01 ppm. Of course, highly polluted environments may have greater levels of ozone and proportionately more rapid dye decomposition.

References

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Biographies

David Kopperl has been working as a Senior Materials Scientist at Creative Memories, the first company to offer consumers photo storage information, products and hands-on assistance, since early 2003. Prior to that he worked in the Image Stability Technical Center of Eastman Kodak Company for over thirty years. He holds a B.S. in Chemistry from Case Institute of Technology and an M.S. in Chemistry from Rochester Institute of Technology.

Since 1998, **Mark Mizen** has served as Director of Technology for Creative Memories. Mark Mizen received his Ph.D. in Physical Organic Chemistry at the Massachusetts Institute of Technology.