The Importance of Dark Keeping Factors in Determining Overall Image Permanence of Photographs

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Abstract

Traditional reporting of the image permanence of photographs has tended to primarily focus on light stability. The reality of how consumers use and store prints is that the vast majority of the print's life is spent stored in the dark. The dark stability of traditional silver halide photographic paper is primarily driven by thermal affects. However, many of the newer digital materials used for photographic prints are susceptible to additional dark factor impacts including humidity and atmospheric pollutants. These can result in predicted life times being significantly shorter than reported by light stability data alone. This paper will discuss these additional dark factors and provide comparisons to traditional silver halide photographic paper.

Introduction

Image permanence is driven by four environmental factors, light, heat, humidity, and atmospheric pollutants. Of these four factors heat, humidity, and atmospheric pollutants are considered "dark" factors. Unlike the light environmental factor, image degradation caused by the dark factors take place all the time, in both dark as well as light conditions. Image permanence claims are often driven by the light stability of the product; however, the dark factors are the most critical because typically consumer prints spend most of their lifetime in the dark. Even prints on display, if they are sensitive to any of the dark factors, can degrade much more quickly than their light stability claim implies. This paper will discuss the atmospheric pollutants factor, its impact on image stability of various digital print technologies, and the importance of good dark factor stability for long term image preservation [1, 2].

Experimental Design

The experimental design consisted of testing three digital printing technologies. This included a dye-on-porous inkjet system, a liquid toner electrophotographic (EP) system, and a silver halide system, in this case KODAK PROFESSIONAL ENDURA Premier paper. Printing systems were selected based on their common use in portrait social professional labs. All samples were placed in an ozone chamber with an ozone concentration of 1.0 ppm and 50% relative humidity and tested in accordance with ISO 18941 [3]. The test was run to a cumulative exposure of 744 ppm-hr (31 days). Analytical test targets and professional commercial images were included in this test. Analytical data was obtained from the targets and the images were used to show the visual impact of the image degradation due to ozone. The test targets were measured periodically throughout the length of the test. The test was measured at D-min, 1.0 density and near D-max. Data was stored in Microsoft Excel and plotted and analyzed using JMP®.

Results

D-Min

Comparison of D-min stability of the three printing technologies showed three different results. Figure 1 shows the D-min stability of the EP technology. Overall there was a slight D-min density loss and a slight color balance change. This degree of change would not cause a concern in a professional market application.

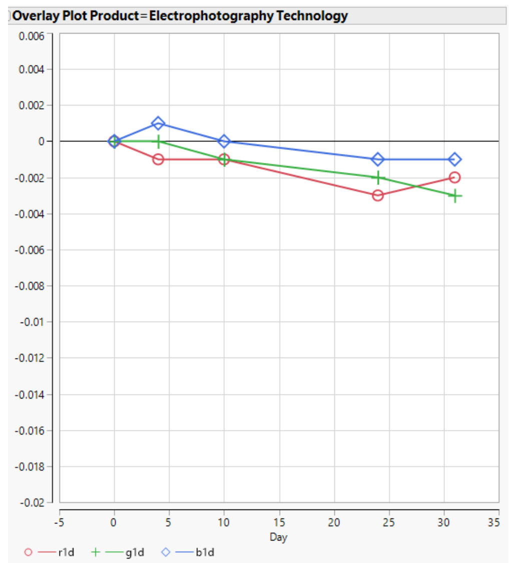

Figure 1. *D-min stability performance of the EP technology*

Figure 2 shows the D-min stability of the inkjet technology. Overall there was a large loss of D-min density with a color balance change. While this density change is large it moves to a preferred lighter position. The color balance position however could be objectionable because of the more noticeably lighter D-min.

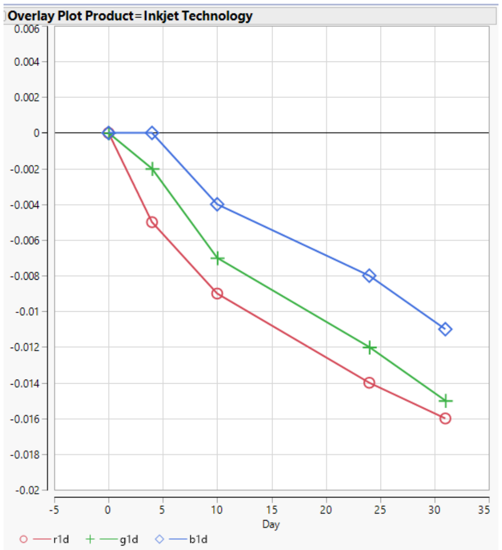

Figure 2. *D-min stability performance of the inkjet technology*

Figure 3 shows the D-min stability of the silver halide technology. Overall there was little change over the course of the test.

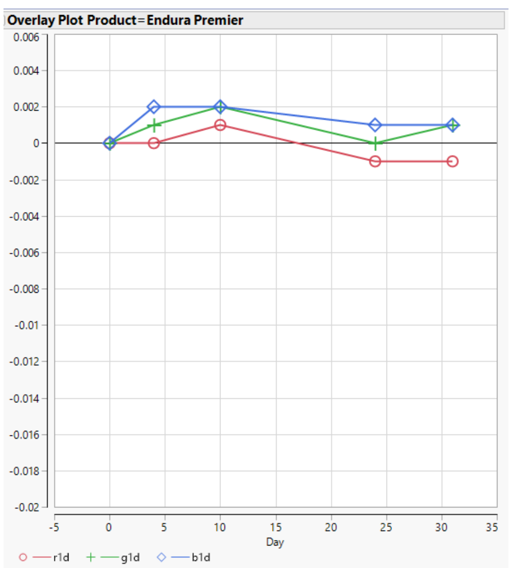

Figure 3. *D-min stability performance of the silver halide technology*

Neutral Density 1.0

At a neutral density of 1.0 the three technologies perform differently. Figure 4, EP technology, has a loss of cyan and magenta colorants causing a color balance shift in the neutral density moving it in the yellow color direction. This change is not very large, it is noticeable especially given the human eye sensitivity to neutrals, and color shifts from neutral, at 1.0 density.

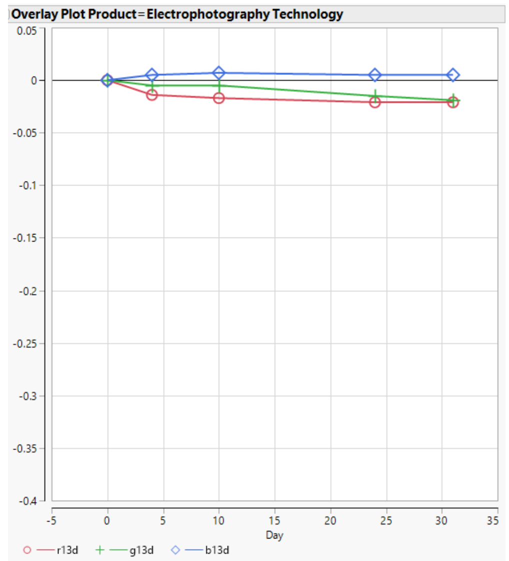

Figure 4. *1.0 Neutral density stability performance of the EP technology*

Inkjet technology showed a high sensitivity to ozone with a very large density loss in all three colors. See Figures 5. The color balance shift is relatively small early in the test but gets quite large later in the test. The large overall density loss and color balance shift would be easily seen and is very objectionable. At the end of the 31-day test, almost 40 percent of the inkjet colorant was lost at 1.0 density.

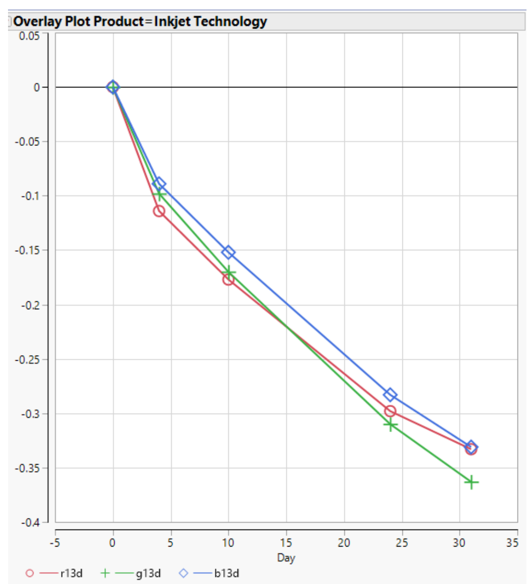

Figure 5. *1.0 Neutral density stability performance of the inkjet technology*

The silver halide technology has no sensitivity to ozone and consistently shows no change throughout the course of the test. See Figure 6.

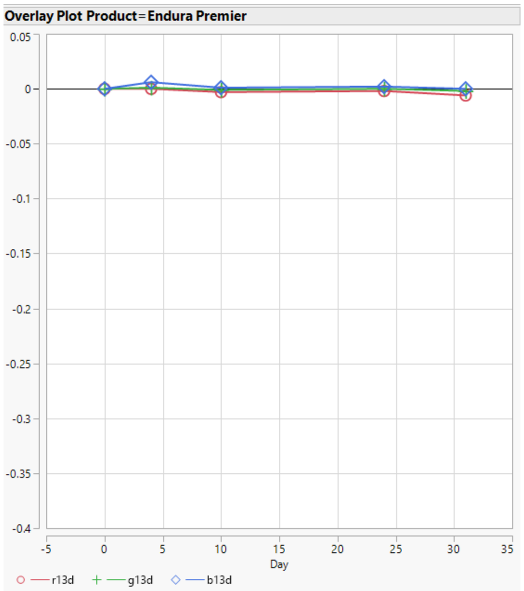

Figure 6. *1.0 Neutral density stability performance of the silver halide technology*

Upper Scale

At a neutral density near D-max the three technologies perform differently and similarly to 1.0 density data. Figure 7, EP technology, has a loss of cyan and magenta colorants causing a slight color balance shift in the high-density portion of the image moving it in the yellow color direction. This change is not noticeable especially in near D-max densities.

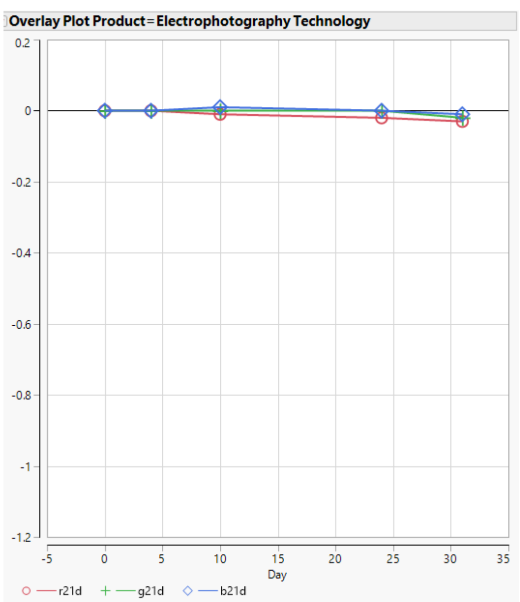

Figure 7. *Near D-max stability performance of the EP technology*

Inkjet technology, shown in Figure 8, has a high sensitivity to ozone with a very large density loss in all three colors near D-max. The color balance shift is large and is easily seen and is very objectionable in high density areas of the print. At the end of the 31-day test, nearly half of the inkjet colorant was lost in the upper scale.

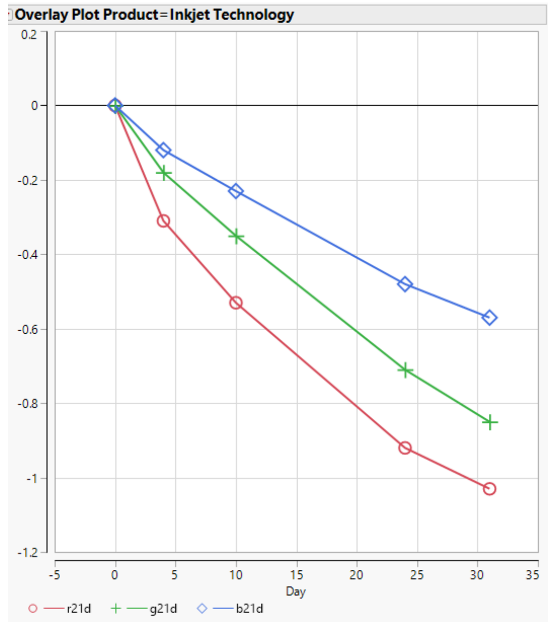

Figure 8. *Near D-max stability performance of the Inkjet technology*

The silver halide technology has no sensitivity to ozone in a near D-max portion of the print. See Figure 9.

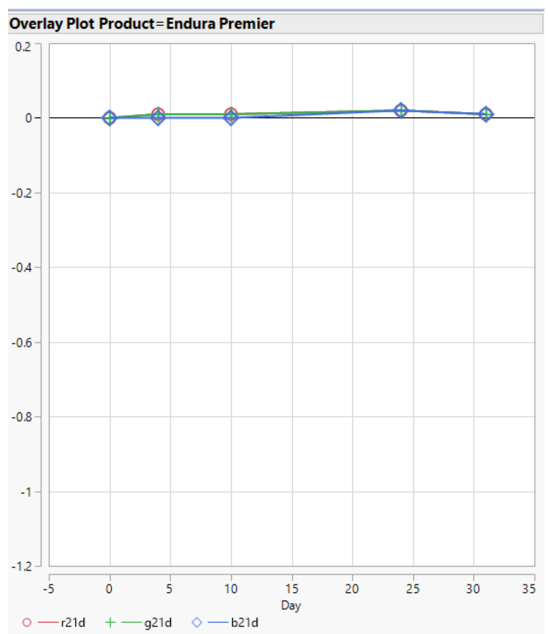

Figure 9. *Near D-max stability performance of the silver halide technology*

Discussion

The impact of poor image permanence to atmospheric pollutants can be severe. Consider a level of ambient ozone in typical consumer homes of five parts per billion, and a conservative endpoint of 30 percent fade from 1.0 density. The indoor ozone concentration is based on various studies done in consumer homes around the world [4, 5, 6]. The 30 percent fade is a conservative level that has been used in the industry for many years, and represents the point at which a consumer may find the image to be objectionable [7, 8, 9]. With the five parts per billion in-home concentration, an ozone test conducted at 1 part per million represents a 200X acceleration of time. Therefore the 31-day test described here would represent 17 years in a typical home. Looking at the data from the inkjet technology, about half of the colorant was lost in the midscale and nearly 75 percent lost in the upper scale at the 31-day test point. This is just 17 years in a typical home. The point of 30 percent fade occurs at 23 days. Using the acceleration factor, this level of fade would occur in as few as 12.6 years. When consumers are expecting print lifetimes of 100 years or more, based on product claims using just the light stability performance, 10-15 years would be very disappointing.

Conclusion

Image permanence is driven by four environmental factors, light, heat, humidity, and atmospheric pollutants. Of these four factors heat, humidity, and atmospheric pollutants are considered “dark” factors because they can impact print permanence both in the light and in the dark. In this paper we discussed how ozone, a common atmospheric pollutant, can have a large effect on image permanence. Three printing technologies reacted very differently from the impact of ozone. The electrophotographic technology had a small effect on overall image quality with the print going slightly light and yellow enough to be noticeable. The dye-on-porous inkjet technology showed a large overall density loss and color balance shift leaving the image quality objectionable. Finally, the silver halide technology was unaffected by ozone. With virtually no loss of colorant due to ozone, the silver halide technology shown in the KODAK PROFESSIONAL Endura Premier Paper is the superior choice for stability against atmospheric pollutants.

Even with long light stability claims for these technologies, as little as 17 years was enough to noticeably degrade the electrophotographic and inkjet technologies with ozone levels found in typical homes. In the case of dye inks on porous media the degradation was severe and would be noticeable in as little as eight years. In conclusion, when choosing a print technology for long print life, it is critical to consider all four environmental factors. Light stability is important for long term display but the dark factors, heat, humidity, and atmospheric pollutants, are critical in all display and dark storage environments.

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Author Biography

Patrick Webber is a principal scientist at Kodak Alaris. He has worked in the industry for over 35 years and has held a variety of positions in silver halide paper including manufacturing, research, and development of color products at Eastman Kodak and now Kodak Alaris. His primary focus for the last 25 years has been the development and commercialization of professional silver halide media products for digital use. He is certified as a six-sigma black belt. He has been awarded two U.S. patents and is the author of many technical papers. Pat currently is the world-wide color paper product manager. He also leads the systems team for the design and development of new color output media.