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ABSTRACT:

A Long-Term Study of Light-Induced Yellowish Stain Formation That May Develop Over Time in Chromogenic Color Prints and Contemporary Inkjet Prints Exposed to Light on Display Followed by Storage in the Dark

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Light-induced yellowish stain formation in photographic papers that developed in dark storage was first documented in the 1993 book, *"The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures"* by H. Wilhelm and C. Brower. At the time, the phenomenon was described by the authors as *"RC Base-Associated Image Fading and Yellowish Staining"* and, a closely related problem, as *"'Framing Effects' in Light Fading with Prints Framed Under Glass or Plastic Sheets"* (pp. 72-77). With Kodak Ektacolor 74 RC prints (1977-1982) for example, levels of light-induced yellowish stain continued to steadily increase after 10 years in dark storage at ambient room temperature and relative humidity. Significant reciprocity failures in accelerated light-fading tests, depending on the specific type of print media and colorant set, frequently exacerbate the manifestation of these problems in long-term display and dark storage of photographs.

Further investigations of light-induced and thermally-induced yellowish stain formation in chromogenic and inkjet prints were reported by H. Wilhelm in Japan in June 2003: (*Proceedings of Japan Hardcopy 2003*) and in the United States in October 2003: *(Proceedings of IS&T's NIP19: International Conference on Digital Printing Technologies*). These studies showed that the yellowish stain species produced by light-induced stain formation is typically in itself very unstable to exposure to light. That is, the yellowish stain "fades" on exposure to light. Unfortunately, the yellowish stain can return to near its original level when the print is again stored in the dark.

While light-induced yellowish stain is most easily observed in the white borders of prints, high levels of yellowish stain can have visually devastating effects in, for example, pale blue skies, and in near neutral areas of a print. In museum collections, many examples of prints made in the 1970s and 1980s by Stephen Shore, Joel Meyerowitz, and Richard Misrach, among many others, exhibit high levels of light-induced and thermally caused yellowish stain, generally accompanied by severe dark fading of the cyan image dye.

For this study, more than 10,000 light-exposed and subsequently dark-stored samples from the 50-year period covered by *"The Wilhelm Analog and Digital Color Print Materials Reference Collection"* (1971-2021) were examined. The study is focused on identifying the specific types of print media that are highly susceptible to the gradual development of light-induced yellowish stain after light exposure, those that are moderately susceptible, and those that are not noticeably affected by this problem. The prints were subjected to light with three different spectral power distributions – including UV filtration with Acrylite Gallery UV Filter OP3, which has a UV cut-off at 390-400nm. In addition, prints were exposed to light both with and without air flow between the prints and the glass and the acrylic OP3 filters.

Fluorescing optical brightening agents (OBAs) may be directly involved in light-induced yellowish stain formation (beyond the simple loss of UV-activated fluorescing brightening activity), especially in RC-base papers, which are polyethylene coated papers in which the top polyethylene layer contains titanium dioxide (TiO_2) as a white, reflective pigment. In this study, the presence and subsequent decay of OBAs is measured and reported using a MegaVision Multispectral Imaging System which has the capability of quantifying the levels of OBA activity in photographs in terms of human visual perception (H. Wilhelm, K. Boydston, K. Armah, and B. Stahl: *Proceedings of "Imaging Conference JAPAN 2011"*).

These degradation processes will be mathematically modeled for selected media and colorant sets with the eventual goal of providing a method for the long-term prediction of light-induced yellowish stain behavior for both chromogenic and inkjet prints.