Test Methods for the Long-Term Permanence Behavior of Photographs and Fine Art Prints Made with Large-Format Flatbed Printers Using UV-Curable Pigment Inks

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Abstract

Recent advances the last several years in the image quality of wide-format inkjet printers using high-stability UV-curable pigment inks made possible by smaller drop sizes; higher addressable DPI, use of dilute cyan, magenta, and gray (light black) inks in addition to standard full concentration CMYK ink; and the availability of white inks together with glossy and matte surface "clear inks" (some UV-curable printers now have up to nine separate ink channels), have now made it practical to utilize these printers for visually high-quality photography and fine art applications where images are frequently viewed at very close range. Improvements in the printers have coincided with a trend toward ever-larger prints in the high-end of the photography art market during the past ten years, and UV-curable technology is now poised to play a major role in this expanding market segment.

With silver-halide-dye color prints by a number of photographers including Andreas Gursky, Cindy Sherman, Jeff Wall, Richard Prince, Thomas Struth, Jeff Koons, Thomas Ruff, and others commanding very high prices – with a number of individual color prints sold at auction during the past several years selling for more than three million dollars each – there is significant concern about long-term permanence characteristics of these color prints with their dye-based images when exposed to light during display, and when stored in the dark.

With UV-curable prints, there are special concerns due to limited field experience with the new technology; complicating the situation is the fact that there are a wide variety of pigment ink systems available from the large number of worldwide printer manufacturers and ink suppliers. In addition, UV-curable prints are being made on a wide range of substrates, many of which have not previously been used as supports for photographic prints. UV-curable white inks and "clear inks" are new to the field. Experience over the past 50 years has shown that new photographic printing technologies may have modes of deterioration, including gradual formation of yellowish stain over time resulting from a variety of mechanisms, that have never been observed to occur with previous imaging systems. Large-format UV-curable printers are quite expensive and, if it should turn out that a particular printer/ink system purchased by a print provider has permanence shortcomings, it can be very costly indeed to replace the printer with a completely new system.

This study describes test methods and reports results from the comprehensive suite of eight predictive print permanence tests developed by Wilhelm Imaging Research during the past 25 years. These tests include: 1) Indoor light stability with fluorescent illumination (glass-filtered); 2) Indoor light stability (UV-filtered); 3) Indoor light stability (non-filtered with high UV-content); 4) Arrhenius dark storage tests; 5) Resistance to atmospheric ozone; 6) Resistance to degradation in high-humidity environments; 7) Water-resistance; and 8) Tests for the presence or absence of optical brightening agents (OBAs). In addition, prints made on various support materials have been subjected to a cycling wide-range humidity and temperature stress test that has recently been developed by Wilhelm Imaging Research. Based on these tests, WIR print permanence ratings obtained with representative UV-curable prints are compared with pigment inkjet, dye-based inkjet, color silver-halide, and other types of color prints.

Among the advantages of UV-curable printers for the high-quality photography and fine art market are:

1) UV-curable printers can be used with a very wide range of substrates: acrylic, aluminum, glass, wood, plywood, uncoated artists papers, canvas, flexible and rigid vinyl, and more. In most cases, with the exception of glass and certain other materials, no pre-treatment or "primer" is necessary prior to printing. The UV-induced curing process is essentially instantaneous, eliminating the drying time required with water-base, latex, and solvent inks.

2) Very large format UV-curable flatbed printers are available – up to 10x20 feet (3.2 x 6.4 meters) or even larger. Roll-fed UV-curable printers are available up to 16 feet (4.9 meters) wide and can make prints of essentially any length. With traditional inkjet printers using aqueous pigment and dye inks, latex inks, solvent inks, and dye-sublimation inks, 64 inches (5.3 feet or 1.62 meters) generally is the maximum width available for high-quality RC-base photo papers, and fine-art papers suitable for printing high-quality photographs. Kodak Professional Endura silver-halide-dye color photographic papers are not available in widths exceeding 72 inches (6 feet or 1.83 meters) and Fujicolor Crystal Archive Professional silver-halide-dye papers are generally available in widths only up to 50 inches (4.17 feet or 1.27 meters). Thus, UV-curable printers offer the only available method for producing high-quality photographic and fine art prints in widths larger than 72 inches (6 feet or 1.83 meters).

3) Flatbed UV-curable printers provide the only available method of making high-quality prints on rigid panels such as aluminum, acrylic sheet, glass, plywood, etc. With many systems, white ink is available which can provide a white background on these types of materials as an integral part of the printing process.

4) With reverse printing on the backside of acrylic sheet with UV-curable printers employing white ink, it is possible to

produce photographic prints on large acrylic sheets in a single step that have the same or greater color gamut, brilliance, density range, and freedom of differential gloss as do traditional face-mounted silver-halide or inkjet prints that have been adhered to the backside of acrylic sheet with pressure-sensitive adhesive films or silicone adhesives (e.g., the "Diasec" face-mounting process available in Europe), which is a complex, multi-step process that requires special materials and equipment. Because of their brilliance, "depth" and stunning visual impact, large-format face-mounted silver-halide color prints have become very popular in the high end of the fine art photography market in recent years. The largest of these prints consist of two or more pieces of silver-halide photo paper that have been trimmed to the image and placed with the edges in contact during a complex face-mounting process. Unfortunately, however, the seams where the pieces of paper meet remain visible upon close examination, which is a significant shortcoming that both photographers and collectors have objected to. Backprinting with UV-curable inks on large sheets of acrylic completely eliminates this problem and greatly simplifies and speeds up the print production process. In addition, the pigment-based UV-curable inks have the potential for far greater stability than the dye images of the silver-halide color papers that have traditionally been used for face-mounted color prints.

5) The recent introduction into the market of large, thin, and lightweight LED illuminated backlit frames ("light boxes") allow for the backlit display of large-format UV-curable images reverse printed on the backside of clear acrylic sheet. Backlit images can have a brightness range that greatly exceeds that possible with reflection prints, and can equal the brilliance of LCD or Plasma digital displays. Backlit frames also eliminate the need for the installation of the specialized gallery lighting fixtures required for brightly and evenly illuminating reflection prints (which, depending on the ceiling height and architectural features of a display area, can be very challenging and costly with large-format photographs.) Backlit displays are becoming increasingly popular with fine art photography and high-end commercial displays in retail stores.

6) With many UV-curable printers, "clear ink" can be applied as a clear surface coating over the entire image ("flood coating") to eliminate differential gloss, increase color brilliance and d-max (greatly reducing surface light scatter, especially in this higher image densities). The "clear ink" can also be applied image-wise as a spot varnish for special effects. The physically durable surface of UV-curable inks and non-absorbent aluminum or acrylic substrates may allow display without the need for framing under protective glass or acrylic sheets; because of cost and weight considerations, this is a particular advantage with very large prints. In many situations, backing materials are also not required for framing, thus further reducing the weight of finished pieces.

Principal Author's Biography

Henry Wilhelm is the founder and director of research at Wilhelm Imaging Research, Inc. Through its website, the company publishes print permanence data for desktop and large-format inkjet printers, silver-halide color papers, and digital presses. WIR test methods have become the worldwide de facto standard for print permanence evaluation and are currently being used by HP, Canon, Epson, and other OEMs. Wilhelm Imaging Research also provides consulting services to museums, archives, and commercial collections on sub-zero cold storage for the very long-term preservation of still photographs and motion pictures.

Wilhelm has authored or co-authored more than 25 technical papers that were presented at conferences sponsored by the Society for Imaging Science and Technology (IS&T) and the Imaging Society of Japan (ISJ) in the United States, Europe, and Japan. With contributing author Carol Brower Wilhelm, he wrote "The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures," published in 1993. The complete 758-page book is available in PDF/A format at no cost from <www.wilhelm-research.com>. Since the book was posted on the WIR website in 2003, more than one-half million copies have been downloaded worldwide.

Wilhelm is the recipient of the Photoimaging Manufacturers and Distributors Association (PMDA) "2007 Lifetime Achievement Award" for his work on the evaluation of the permanence of traditional and digital color photographs. In 2011 he received an honorary Doctor of Science Degree from Grinnell College.

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