A Survey of the Light Fading Stability of Digital Pictorial Reflection Prints

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Digital prints can be made from scanned and digitized photographic originals, digital camera images, and computer-generated images. The ability to have full control over image contrast and color saturation – long a practical impossibility with traditional color photography – has made computer image processing programs such as Adobe Photoshop, Micrografx Picture Publisher, and HSC's Live Picture extremely appealing to photographers and picture editors alike.

Computer-based image processing makes it possible to do digital dust spotting and retouching, as well as dodging and burning at the microscopic level, with a level of sophistication and subtlety that was not previously possible in photography. These and other image-enhancement procedures need be done only once with a digital image file – not each time a print is made as was the case in the past.

Words in type, graphic elements, and multiple images can be easily and seamlessly combined. Once photographers get a taste of these and the many other advantages of digital image processing, most will never go back to the old way of doing things. For these people, the traditional darkroom is dead. Indeed, the darkroom has never even been a part of the personal experience for many of those now entering the imaging field for the first time.

Once an image has entered the digital realm, there are now a wide variety of options available for making prints from the digital file. As digital color prints increasingly supplant photographs made with traditional processes in the marketplace, the light-fading stability of digital prints – and how their stability compares with that of traditional color prints – has become a topic of major interest in the photographic field.

Included in this light-fading stability study are digital output from thermal dye transfer printers (often referred to as "dye sublimation" printers); medium- and high-resolution ink jet printers; silver halide-based dye-release-transfer; thermal wax transfer; prints made with dry-toner electrophotographic copier/printers; prints made with liquid-toner electrostatic printers; high-stability pigment-gelatin processes; and other types of digital output, including prints made with traditional chromogenic photographic papers. These processes form color images with either CMY (cyan, magenta, and yellow), or with CMYK (cyan, magenta, yellow, and black) dyes or pigments. Among those print materials included in this study are:

Kodak XtraLife Prints from XLS 8600 Thermal-Dye Printer (with 4th pass protective coating)

Kodak Ektatherm Prints from XLS 8300 Thermal-Dye Printer

Kodak Ektatherm Prints from XLT 7720 Thermal-Dye Printer

Sony UP-D8800 Thermal-Dye Printer

3M Rainbow Thermal-Dye Printer

Tektronix Phaser 480 Thermal-Dye Printer

Nikon Cool Print Thermal-Dye Printer

Fargo PrimeraPro Thermal-Dye Printer

Radius (SuperMac) Proof Positive Thermal-Dye Printer

Shinko (Mitsubishi) ColorStream/DS Thermal-Dye Printer

Fuji Pictrography 3000 Printer (silver halide-based dye-release-transfer process)

Fuji Thermal-Autochrome Printer

Epson Stylus Color Ink Jet Printer (with 1995 ink set)

Hewlett-Packard 540 Ink Jet Printer

Tektronix Phaser 300i Ink Jet Printer

LaserMaster DisplayMaker Ink Jet Printer

Iris Graphics Ink Jet Printer (with "standard" Iris ID ink set)

Iris Graphics Ink Jet Printer (with improved-stability Iris "Fine Arts" ink set)

Xerox Majestik Color Laser Copier/Printer

Canon CLC 550 Color Laser Copier/Printer

Cactus Electrostatic Prints (liquid-toner process with pigmented toners)

3M Scotchprint Electrostatic Prints (liquid-toner process with pigmented toners)

Indigo E-Print 1000 Digital Printing Press

Fujicolor SFA3 Color Prints (traditional RA-4 chromogenic process)

Kodak Ektacolor Supra Color Prints (traditional RA-4 chromogenic process)

EverColor Prints (high-stability pigment-gelatin process)

UltraStable Prints (high-stability pigment-gelatin process)

The light-fading characteristics of these prints were evaluated with temperature- and humidity-controlled (24°C [75°F] and 60% RH) accelerated light-fading tests employing Cool White fluorescent lamps with an illumination level of 21.5 klux at the sample plane. To determine the effects of spectral distribution on fading, specimens of each type of print were exposed to bare-bulb, glass-filtered, and UV-filtered illumination. The light-fading characteristics of the prints were evaluated using procedures developed by the author and are reported in terms of "predicted years of display to reach image-life fading limits."[1]

Of particular interest is the sensitivity of the various types of prints to the fading effects of the 313nm UV emission of bare-bulb fluorescent lamps. Fujicolor, Ektacolor, and other types of current Process RA-4 chromogenic color prints have a UV-absorbing print overcoat that effectively absorbs harmful UV radiation; the fading observed with such prints on display is caused primarily by visible light. Most types of digital prints presently do not have UV-absorbing coatings, and in most cases this leaves the prints very susceptible to the influence of UV radiation.

Prints made by the various processes were found to exhibit an extremely wide range of light-fading stabilities, with some having color images that are among the longest lasting known in photography while others are among the least stable.

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1) Wilhelm, Henry and Brower, Carol (contributing author), *The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures,* Preservation Publishing Company, Grinnell, Iowa, 1993, pp. 61–100.

Thermal-Dye Transfer [Dye-Sub] Prints

Predicted Display Life in Years

	Bare-Bulb	Glass Filter	UV Filter
Kodak XLS 8600 (Kodak XtraLife Ribbons) (with 4th-pass protective coating)	7	24	35 (est.)
Kodak XLS 8300	4	22	29
Kodak XLT 7720	4	13	23
Sony UP-D8800	2.5	6	7
Nikon Cool Print	2.5	5	6
3M Rainbow	1.5	1.8	1.8
Tektronix Phaser 480	2.0	2.5	2.8
Fargo PrimeraPro	1.7	2.2	2.3
Radius (SuperMac) Proof Positive	2.0	2.2	2.3
Shinko (Mitsubishi) ColorStream/DS	1.5	2.0	2.0

Traditional Color Prints

Predicted Display Life in Years

For Printing Color Negatives	Bare-Bulb	Glass Filter	UV Filter
Fujicolor SFA3 Color Paper	38	54	57
Konica Color QA Paper Type A3	17	18	18
Agfacolor Paper Type 9	15	15	16
Kodak Ektacolor Portra II Paper	12	12	13
For Printing Color Transparencies			
Ilford Ilfochrome Classic (Cibachrome)	21	29	33
Fujichrome Paper Type 35	14	19	19
Kodak Ektachrome Radiance Paper	13	14	14
Agfachrome Paper CRN	10	10	11

Inkjet Prints

Predicted Display Life in Years

	Bare-Bulb	Glass Filter	UV Filter
Hewlett-Packard 540 Printer	$<$6 months	$<$6 months	$<$6 months
Epson Stylus Color Printer	$<$6 months	$<$6 months	$<$6 months
Iris Graphics Printer (ID inks on smooth paper)	1	1.4	1.8
Iris Graphics Printer (ID inks on watercolor paper)	3	4	4
Iris Graphics Printer (Fine Arts inks on smooth paper)	3	4	5
Iris Graphics Printer (Fine Arts inks on watercolor paper)	7	14	17
Iris Graphics Printer (Ilford Ilfojet inks – 1995)	?	?	?
Canon A1 Bubble Jet Printer	2	3	3
LaserMaster DisplayMaker (Encad printer)	2	6	16
LaserMaster DisplayMaker Express (1995)	?	?	?

Silver Halide-Based Dye-Release-Transfer

Predicted Display Life in Years

	Bare-Bulb	Glass Filter	UV Filter
Fuji Pictrography 3000 Prints	3	7	8
Fuji Pictrography 3000 Prints (improved)	4.5 (est.)	10 (est.)	12 (est.)

Other Digital Print Processes

Predicted Display Life in Years

	Bare-Bulb	Glass Filter	UV Filter
Cactus Electrostatic Prints (Specialty Toners)	>60	>60	>60
3M Scotchprint Electrostatic Prints	>100	>100	>100
Digital Airbrush Prints (e.g., Vutek)	>100 est.	>100 est.	>100 est.
Xerox MajestiK Color Laser Copier/Printer	12	16	17
Canon CLC 550 Color Laser Copier/Printer	19	22	25
Indigo E-Print 1000 Digital Printing Press	11	12	13
Fuji Thermo-Autochrome Prints	<2.0	<2.0	<2.0
	(with significant yellowish stain)		
EverColor Pigment-Gelatin Prints	>200	>200	>200
UltraStable Pigment-Gelatin Prints	>200	>200	>200
Ataraxia Studio Pigment-Gelatin Prints	>200	>200	>200

Challenges in Evaluating the Image Stability of Digital Print Materials

- CMY vs. CMYK (with various black printer implementations)
- Wet-intermixing fading effects with dye-based inkjet inks [catalytic fading]
- Influence of different substrates on inkjet fading rates
- Differences in fading rates as a function of image density and halftone method
- Influence of spectral distribution of illumination on fading
- Effects of laminates and coatings on fading and staining
- Densitometry vs. colorimetric methods — selection of fading end-points
- Fading behavior of colorants composed of multiple dyes or pigments
- Effects of relative humidity and temperature on fading
- Potential reciprocity failures in accelerated light fading/staining tests
- Water solubility tests with inkjet inks
- With thermal-dye prints, evaluating the potential for dyes to transfer to plasticized PVC, susceptibility to fingerprints, and the tendency of image dyes to transfer to other prints (dark stability)