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

By Henry Wilhelm, Effiba Armah, Ken Boydston,
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"Colour Photography and Film: Sharing knowledge of analysis, preservation, conservation, and migration of analogue and digital materials."

Florence, Italy

Online Virtual Conference – March 29, 2021

Photographic Prints

19th Century Prints = Analog/Chemical Processes

20th Century Prints = Analog/Chemical Processes

21st Century Prints = Digital Pigment & Dye Processes

It is believed that at the present time, more than 99% of the world's photographic prints are being produced with digital color and monochrome processes.

Included are modern prints made from scans or digital camera captures of original film and glass plate negatives and transparencies.

Digital Photographic Print Processes

1) **Silver-Halide – Dye** (chromogenic) (Kodak and Fuji with Durst Lambda in 1994)

2) **Dye Diffusion Thermal Transfer – Dye** (Kodak "dye-sub" printers in 1991)

3) **Aqueous Inkjet – Dye** (especially with Iris Graphics printers in 1989)

4) **Aqueous Inkjet – Dye** (especially with Epson printers from 1994)

5) **Aqueous Inkjet – Pigment** (especially with Epson printers from 2000)

6) **Aqueous Inkjet – Pigment** (with HP and Canon printers from 2006)

7) **Solvent Inkjet – Pigment** (many manufacturers, from the mid-1990's)

8) **Latex Inkjet – Pigment** (especially with HP Latex printers from ~2008)

9) **Electrophotographic – Pigment** (especially with Indigo from ~1993)

10) **UV-Curable Inkjet – Pigment** (many manufacturers, especially from ~2010)

11) **Sublimation Inkjet Thermal Transfer – Dye** (on fabrics, from ~2008)

12) **Sublimation Inkjet Thermal Transfer – Dye** (ChromaLuxe aluminum print panels (white and clear "metal prints"), plywood, and other materials, from ~2010)


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Photography

C-prints fade into the light

Experimental process of the early 1990s is proving unstable

LONDON. All colour photographs fade, but some are fading more quickly than others. At a recent seminar for new photography collectors at the Photographers' Gallery in London, audience members were warned of the risks of purchasing c-prints dating from the early 1990s by artists such as Andreas Gursky because of the works' inherent instability.

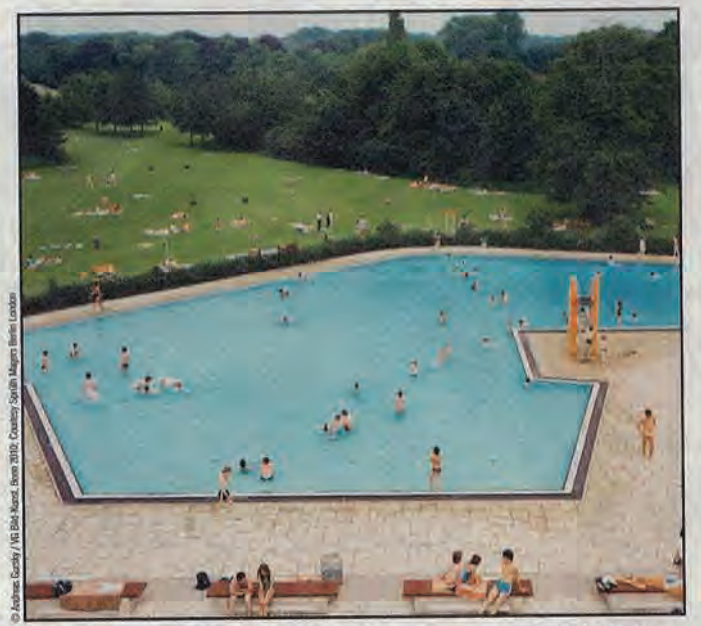
Michael Wilson, the co-producer of the James Bond films and a major collector of photography, told the audience that some c-prints from this period have faded so dramatically that they have been reprinted and replaced.

"C-prints are unstable, especially [those dating] from the early 1990s. I recommend anyone [interested in collecting these] go to the big auctions to see the photographs from the early 90s that are being sold for a million pounds: the cyan [blue] is gone or is going fast."

Wilson said that photographers such as Gursky and other contemporaries of his "experimented with [processes] that were not established". He also questioned whether a new print of a photograph could be as authentic as the original edition.

"How do you replace something that's supposed to have a history? Does it help to have a [new] print? It's not the same as the earlier one. These are problems that come with experiments," he said.

A student of Bernd and Hilla Becher in Düsseldorf, Gursky, 55, is known for his large-scale, digitally manipulated colour works that include panoramas of stock exchanges, hotels, raves and shop displays. He achieved critical and commercial success in the mid 1990s. In 1999 the annual growth rate for a Gursky image topped 3,000%.



© Andreas Gursky / VG Bild-Kunst, Bonn 2010. Courtesy Sprüth Magers Berlin London

This unfaded Gursky of 1987 has been kept out of bright light

Ben Burdett, the director of the Atlas Gallery in London, says the market hype was part of the problem. "Photography requires a lot of connoisseurship and understanding of the medium. With all those dollars being spent on Gursky four or five years ago, some of that went out of the window. People were buying it because it was a Gursky and it was the thing to have. Gursky took on a cult status, like Hirst," said Burdett.

The materials of c-print—or chromogenic—colour photography are complex organic compounds, which are unstable. Unlike the constituents of black and white photographs, the ingredients of c-prints continue to undergo chemical reactions rather than stabilise. Light, heat, and water in the atmosphere all accelerate the process.

Gursky was one of the first artists to make oversized c-prints. "If you were going to make big colour prints in the early 1990s, you had to do it chromogenically," says Wilson. "Inkjet printing was just not good enough then." Because c-prints on this scale are relatively recent it is only now that collectors and conservators are starting to understand fully the challenges of maintaining such works.

Another issue with Gursky's work is that each image is face-mounted; a layer of plexiglass is placed on top of the image and, in effect, the picture is fused to it. Conservators say they do not yet know if this process, which gives photographs a slick, wet look, accelerates degradation. Plexiglass is also sensitive and scratches easily. Because the image is fused to it, it cannot be replaced the way a layer of glass would be.

The Museum of Modern Art in New York has a large collection of Gursky c-print photographs, several of them dating from the early 1990s. In an emailed statement Jim Coddington, its chief conservator, said: "MoMA is conducting long-term experiments and studies to better understand the fading of these works and appropriate display conditions for improved longevity. We are also doing research on care of the plexi-face mount, to prevent scratches and other disfigurements that might also necessitate replacement of the work."

Another major Gursky collector is Eli Broad in Los Angeles. Joanne Heyler, chief curator at the Broad Art Foundation, said: "We have not noted any fading problems with the Gurskys in [our] collection. I've certainly seen some c-prints by various artists at auction over the years that appear to have spent too much time in bright light, and look very faded, so buyers of these works have to be careful."

Gursky's art dealer Monika Sprüth of Sprüth Magers said in an email: "A c-print stays in perfect condition if it is handled properly and if the conservation instructions are followed. In this regard I would like to refer to the forthcoming group show at K21 in Düsseldorf 'Auswertung der Flugdaten' [11 September to 30 January 2011]." As the concept of the exhibition is to show only vintage prints, Gursky reviewed all the works from this time in his possession for a final selection. "All works are in excellent condition and can be displayed," said Sprüth.

> *"Go to the big auctions to see photographs from the early 90s. The cyan blue is gone or going fast"*

Gursky started to work exclusively with the Diasec technique in the middle of the 1990s. Diasec is a special process to create a durable bond between a c-print and acrylic glass to provide protection against UV light, atmospheric conditions and chemical impurities in the air. "A Diasec sealed and handled properly guarantees an even longer duration because of the high protection standards. Nevertheless, manufacturing errors may occur, as with many other techniques. In this case, after excluding the possibility of the owner having disregarded the conservation instructions—often works are asked to be replaced after a long period of solar irradiation for example— works are reproduced by the artist," said Sprüth. **Cristina Ruiz**

World Trade Center architect's archive saved

The State of Michigan has stepped in to preserve the architectural records of Minoru Yamasaki (1912-86)—the American modernist responsible for designing the World Trade Center in New York. The records were to be destroyed following the recent closure of the late architect's Michigan office, but quick action by state preservation bodies saved a sizable collection of drawings, photographs, slides, renderings, handwritten notes as well as Yamasaki's personal library. **E.S.**

India restores Zoffany's *Last Supper*

A team of conservators from the Indian National Trust for Art and Cultural Heritage have begun restoration work on Johann Zoffany's, *The Last Supper*. The work by the German neoclassicist has hung in St John's Church in Kolkata since the church's consecration in 1787. It is suffering from the effects of the country's humid climate as well as from earlier restorations that have included using putty to fill tears. Conservators expect to complete the $33,000 project sometime this summer. **E.S.**

England's religious buildings get £17.5m

England's churches, chapels, synagogues and other places of worship have received a £17.5m injection thanks to a grant from English Heritage and the Heritage Lottery Fund. The money will be used to repair 154 Grade I and II listed buildings across the country. Since 2002, £123m has been awarded to 1,300 listed places of worship. Sites to benefit from the grant include the Princes Road Synagogue in Liverpool and the Church of St John, Bethnal Green, London. **E.S.**

Kodak Alaris, the part of the company that supplies Kodak Endura Ultra and other chromogenic papers (silver-halide color papers) and processing chemicals, as well as still-camera films, was wholly acquired by the Sino Promise Group Limited of China on November 1, 2020.

http://www.sinopromise.com/index/index/l/en-us.html

William Eggleston

LOS ALAMOS


GAGOSIAN GALLERY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The Permanence and Care of Color Photographs:

Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures

Cecil W. Stoughton – August 14, 1963 (Courtesy of the John Fitzgerald Kennedy Library)

Henry Wilhelm

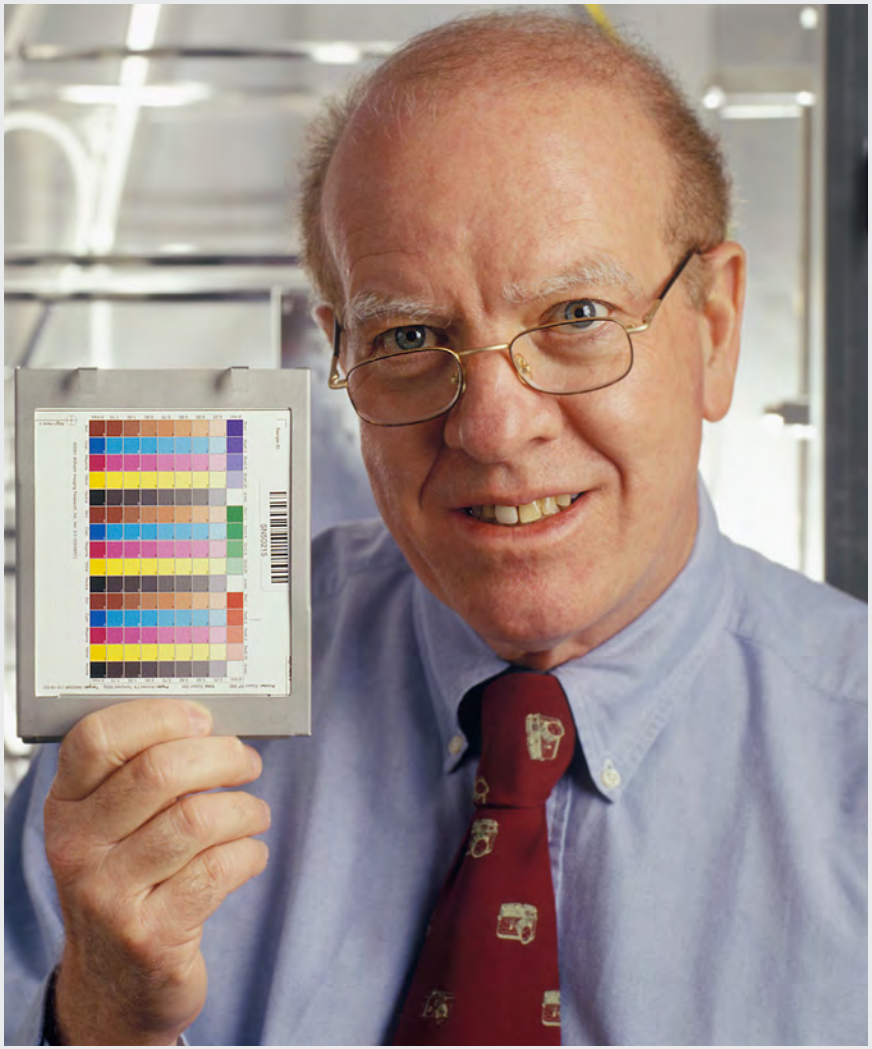
with contributing author

Carol Brower

The Wilhelm Analog and Digital Color Print Materials Reference Collection

All Materials Printed With Color and Monochrome Test Targets Using the Printers, Processing Chemicals, and Inks of Their Time

- Traditional Analog and Modern Digital Color Print Materials
- Modern Digital Black and White Print Materials
- Definitive Product and Process Identification and Dating
- Extensive 380–730nm Spectral Data from 800-Patch Color and Neutral Gray Scales
- Comprehensive WIR Eight-Factor Print Permanence Ratings Data
- Sortable/Searchable Databases



50 Years: From 1971 to 2021
The Only Collection of
Its Kind in the World

Itemized Description of the Wilhelm Color Print Materials Reference Collection

(Updated March 10, 2021)

The Wilhelm Analog and Digital Color Print Materials Reference Collection consists of printed analog color, digital color, and digital black and white photographic print materials, with associated accelerated test data and print permanence reports organized in sortable/searchable databases

1) Analog color film and print materials from 1971 to 1993 (includes permanence test data): **~475 products**
2) Analog and digital color print materials from 1993 to 2000 (includes permanence test data): **~1,220 products**
3) Digital color and B&W print materials from 2000 to 2021 (with spectral data from 380 to 730 nm in 10 nm increments for 800-patch neutral, cyan, magenta, yellow, red, green, and blue color scales): **1930 products**
4) Total identified film, print paper, and printer/ink/paper products from 1971 to 2021 (50 years): **3,655 products**
5) Multiple targets for each printer/ink/media combination subjected to eight separate WIR permanence tests: (1) display permanence (light stability) tests with five different light exposure conditions: glass filter with 5mm air-gap and glass in direct contact with sample surface; (2) acrylic UV filter with 5mm air-gap and acrylic UV filter in direct contact with the sample surface; and (3) unfiltered "bare-bulb" light exposure; (4) multi-temperature Arrhenius dark storage tests; (5) unprotected ozone resistance; (6) resistance to high humidity; (7) water resistance; and (8) determination of the presence or absence of optical brightening agents (OBAs)
6) "Natural Aging" test targets are stored in the dark at ambient room temperature (24°C/60% RH) and "Long-Term Subzero Freezer Preservation" test targets for instrument calibration and visual reference are preserved in a freezer at –20°C (–4°F)
7) Individual, documented test targets included in the digital portion of the collection: **22,480 test targets**
8) TOTAL number of calibration pages and digital and analog test targets in the collection: **27,800 individual items**
9) Individual test target measurements in the digital portion of the collection: **~146,484 target measurements** (an average of 35 test targets are measured daily, most with 135 individual color, neutral scale, and d-min paper white patches)
10) Individual spectral measurements made of the color and neutral (including full-image monochrome) patches in the test targets for all materials in the digital portion of the collection: **~570 million spectral measurements**
11) Data storage, backed-up off-site daily, for spectral measurements and permanence reports: **~158 gigabytes**
12) Boxes and rolls of unprinted inkjet paper and canvas which are in addition to the printed samples database: **~1,900 packages**
13) Large-format inkjet printers (17 to 64-inch; up to 12 inks) and desktop inkjet, dye-sub, and other digital printers: **~370 printers**
14) Microsoft Access databases with WIR developed and programmed Borland Delphi interfaces, providing search/sort capabilities

“Freezer Control” Test Samples and Other Printed Materials Preserved in Moisture-Protected Freezer Storage at –20°C (–4°F)

One of the unique features of the Wilhelm Reference Collection is the quantity of test prints with associated spectral data and those that have not been measured have been safeguarded in freezer storage since they were first made. Pristine (unused and unmeasured) prints include both analog and digital color print samples.

The upright freezer (photo, upper left) houses the control samples for all Arrhenius and Reciprocity Tests. Targets printed and measured for specific tests but, for a variety of reasons, were never put into test are also stored here.

The other three photos show the walk-in Wilhelm-Smithsonian Freezer Preservation Vault, which is maintained at -20°C (-4°F). Targets that have been tested and reached one or more criteria failure endpoints, as well as those that have not been subjected to test conditions, are preserved here.

“Freezer Control” Test Samples and Other Printed Materials Preserved in Moisture-Protected Freezer Storage at –20°C (–4°F)

The photos on this page show a variety of items that are preserved in the Wilhelm-Smithsonian walk-in freezer, inkjet-printed product literature, test targets printed with Iris Graphics prints from the beginning of the fine art inkjet era in the early 1990’s, photographs identified as to the paper, printer, and inks, etc. (Note: the large white storages boxes contain many hundreds of historically important newspapers, including complete issues of *The New York Times* for both September 11 and 12, 2001, which document the terrorist attacks on the World Trade Center in New York City. These are believed to be the only pristine copies of these two newspapers in existence.)

The Wilhelm Imaging Research Archive of Desktop and Large-Format Inkjet Printers, Dye-Sub Printers, and Other Digital Printers

The Wilhelm Digital Printer Archive houses hundreds of large-format, medium-format, and desktop printers made by Epson, Hewlett-Packard, Canon, Kodak, Lexmark, Brother, Olympus, Sony, Alps, and others for producing calibration pages, test targets, and pictorial samples in the Wilhelm Print Materials Reference Collection.

A 15-Year History of Digital Printing Technology and Print Permanence in the Evolution of Digital Fine Art Photography – From 1991 to 2006

Henry Wilhelm
Wilhelm Imaging Research, Inc.
Grinnell, Iowa U.S.A.

Abstract

Since digital fine art photography printing began in 1991 with the difficult to operate and costly to maintain $126,000 Iris Graphics Model 3047 inkjet printer using water-soluble cyan, magenta, yellow and black dye-based inks with poor light stability – but which could nevertheless print beautiful large-format photographs from digital files on a wide variety of artists papers, both thick and thin – the industry has seen rapid progress in the development of far lower cost, faster and easier to operate printers. Central to this evolution have been the dual concerns of image permanence and image quality. An increasingly competitive inkjet industry has driven the development of, at first, more stable dye-based inks and ink-specific optimized inkjet media. More recently, piezo and thermal head printers using high-stability, multi-colorant pigmented ink systems from Epson, Hewlett-Packard, and Canon have come to dominate the field. At the same time, in a massive reshaping of the industry, the reduced costs of both printers and computer systems coupled with Adobe Photoshop and other advanced image editing software has made it possible for digital fine art printmaking to move from a small group of specialized providers into the hands of individual photographers and artists – worldwide.[1]

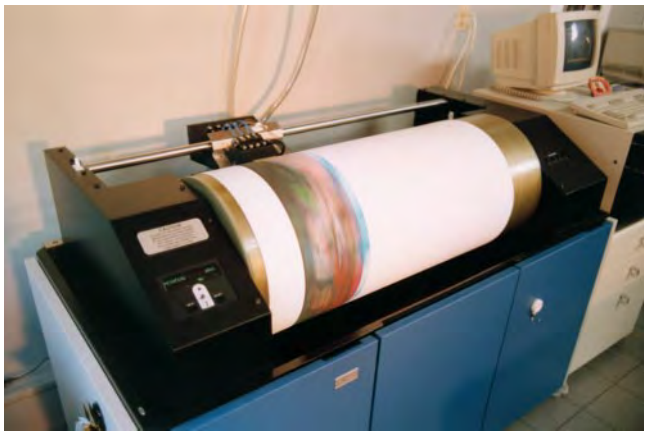
Introduction

Digital printing of fine art photographs – and a broad-based concern about the permanence of digital prints – can be traced to the founding of Nash Editions in Manhattan Beach, California, in 1991. At that time, the only printer capable of producing high-quality, large photographic prints (up to 34x46 inches) on a wide range of papers and canvas was the Iris Graphics Model 3047 inkjet printer made by Iris Graphics, Inc. in Bedford, Massachusetts. The Iris 3047, which had been designed for direct digital graphic arts proofing, was an expensive machine, costing $126,000. As recounted by Steve Boulter, then national sales manager for Iris Graphics: "The 3047 was developed for the Marubeni Corporation of Japan as an eight-up proofer. Hence, the A0 sheet size. The printer was introduced in 1989. I started working for Iris in 1988 and the development activity for the 3047 began shortly after that. Marubeni is kind of like the GE [General Electric Company] of Japan. They are a very large conglomerate and they functioned as a reseller for Iris. They funded the development of the 3047 with about $500,000."[2]

The Iris 3047 was not conceived of nor intended for printing valuable photographs and art reproductions that would be framed and displayed for long periods of time. Because long-term light stability was not of concern in the proofing business, the dye-based ink sets initially available for the printer had poor light stability. Instead, the design goal was to print direct-digital proofs that could match the color gamut and tone scale of the inks used in offset printing; the proofs had only short-term use.

It was rock musician Graham Nash and his concert tour road manager Mac Holbert, both accomplished photographers, who first recognized the potential of the Iris as a fine art printer when, on March 14, 1989, they watched a 3047 printing a color photograph. As Holbert wrote in a one of a series of diary entries: "The digital images are stored on a 1/4-inch recording tape that is inserted into an automatic tape reader. The color and image placement is controlled through a series of menus you access through a digital readout panel on the printer. They printed an image of a bride holding a bouquet of pink roses. Not exactly our type of image.... The print was about 16" x 20" and took about 20 minutes to complete. When the printer stopped spinning and they opened it, both Graham and I got chills. It was astounding! I couldn't believe what I was looking at! The paper they used was a little glossy for my taste, but the technology is there! Steve Boulter mentioned he's been printing painting reproductions on very heavy watercolor paper back in the lab and that had gotten encouraging results. Graham was excited about the prospect of printing a photograph on thick art paper. Graham asked the Iris operator about

A pioneer in the use of high-resolution color ink jet printers in the fine art field is Nash Editions. Located near Los Angeles in Manhattan Beach, California, Nash Editions was founded by British-born Graham Nash of the legendary 1960's rock group Crosby, Stills, Nash & Young. An accomplished photographer and collector, Nash was drawn to the inkjet process as a means of printing photographs that he had scanned and worked on with Adobe Photoshop software on his Apple Macintosh computer. Shown here are Nash Editions staff members (left to right) Jack Duganne, R. Mac Holbert, and Graham Nash. This photograph and the photographs on the following page were taken by the author during a visit to Nash Editions in February 1992, a little over six months after it opened for business. <www.nasheditions.com>



Iris ink jet printers lay down the cyan, magenta, yellow, and black images in a single pass with the print material attached to a rapidly rotating drum. With the cover removed, the leading band of the image printed by the cyan ink jet, which slowly moves across the image from left to right, is clearly visible.

Graham Nash (left) and Jack Duganne detach a completed monochrome print from one of the two Iris Model 3047 ink jet printers at Nash Editions. This photograph is a black-and-white self-portrait of Nash, which he made during the early days of Crosby, Stills, Nash & Young.

Bottles of the water-base inks employed in the Iris ink jet printers. Initially designed for graphic arts proofing, the standard Iris inks have very poor light fading stability. Inks made with dyes having improved light stability for fine art and photography applications started to become available in 1994.

Duganne and Holbert work on an image using Photoshop running on an Apple Macintosh computer with visiting New York City fashion photographer George Holz (center). Prints could be made from scanned transparencies and negatives or directly from a variety of Macintosh and IBM image file formats.

A high-resolution flatbed CCD scanner custom-built by Photometrics, Ltd. was used by Nash Editions to input images from color prints, paintings, and other art work. The scanner could accommodate originals of up to 4x4 feet.

Henry Wilhelm – 1992 (6)

Nash Editions was originally located in this picturesque building, not far from the Los Angeles International Airport.

Table 1 – WIR Display Permanence Ratings for Selected Digital Print Materials 1991–2006[a]

Type of Inkjet Printer/Ink/Paper Combination and Digital Silver-Halide or Digital Silver Dye-Bleach Color Papers Printed with RGB Laser/LED Digital Photo Printers (Year listed is the date stability tests were conducted by Wilhelm Imaging Research, Inc.)	Displayed Prints Framed Under Glass	Displayed Prints Framed With UV Filter
1991 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Iris ID Inks (4-ink dye-based inkjet prints)		
Arches BFK Heavy Watercolor Paper (uncoated 100% cotton fine art paper)	4 years	4 years
Iris Semi-Matte coated inkjet proofing photo paper	1.4 years	1.8 years
1994 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Lyson FA Inks (4-ink dye-based inkjet prints)		
Arches BFK Heavy Watercolor Paper (uncoated 100% cotton fine art paper)	14 years	17 years
Iris Semi-Matte coated inkjet proofing photo paper	4 years	5 years
1994 – Durst Lambda 130 digital printer (first large-format RGB laser silver-halide printer)		
Printed with Fujicolor SFA3 Color Negative Paper (silver-halide color prints)	36 years	40 years
Printed with Cibachrome print material (silver dye-bleach color prints)	29 years	33 years
Printed with Kodak Ektacolor Portra II Color Negative Paper (silver-halide color prints)	12 years	12 years
1994 – Epson Stylus Color printer (first "photo-quality" 720 dpi desktop inkjet printer)		
Printed with Epson Inks and Epson Inkjet Paper (4-ink dye-based inkjet prints)	<0.5 years	<0.5 years
1996 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with American Inkjet Corporation "NE" [Nash Editions] inks consisting of AIJ cyan and magenta inks and Lyson FA-I yellow and black inks printed on Somerset Velvet uncoated 100% cotton fine art paper (4-ink dye-based inkjet prints)	22 years	25 years
1997 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Iris Longevity inks (4-ink dye-based inkjet prints)		
Arches for Iris 100% cotton fine art paper	2 years	– na –
1997 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Lysonic FA II inks (4-ink dye-based inkjet prints)		
Somerset Velvet uncoated 100% cotton fine art paper	22 years	25 years
Liege Inkjet Fine Art Paper matte-coated fine art paper	2 years	3 years
1997 – Hewlett-Packard PhotoSmart printer (HP's first "photo-quality" desktop inkjet printer)		
Printed with HP PhotoSmart inks and HP PhotoSmart Paper (6-ink dye-based inkjet prints)	6 years	– na –
1998 – Hewlett-Packard DesignJet 2500 and 3500 printers (HP's first pigmented inkjet color printers)		
Printed with HP "UV" inks and matte-coated fine art papers (4-ink pigmented inkjet prints)	>200 years	>250 years
1999 – Roland Hi-Fi Jet printers (Roland's first large-format pigmented inkjet printers)		
Printed with Roland inks and Legion Concorde Rag paper (6-ink pigmented inkjet prints)	125 years	– na –
1999 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Lysonic i W2 inkset consisting of Lysonic i Cyan #006, i Magenta, i Yellow #005, and i Black (neutral) (4-ink dye-based inkjet prints)		
Lysonic Standard Fine Art Paper matte-coated fine art paper	30 years	– na –
Somerset Enhanced Velvet matte-coated fine art paper	4 years	– na –
2000 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with Iris Equipoise inks (4-ink dye-based inkjet prints)		
Arches Cold Press uncoated 100% cotton fine art paper	34 years	– na –
Somerst Velvet uncoated 100% cotton fine art paper	22 years	– na –
Iris Canvas	17 years	– na –
Lysonic Standard Fine Art Paper matte-coated fine art paper	8 years	– na –
Somerset Enhanced Velvet matte-coated fine art paper	3 years	– na –
2000 – Iris Graphics 3047 printer (introduced in 1989, the first large-format inkjet photo printer)		
Printed with American Ink Jet Pinnacle Gold Iris inks (4-ink dye-based inkjet prints)		
Somerst Velvet uncoated 100% cotton fine art paper	70 years	– na –
Arches for Iris 100% cotton fine art paper	32 years	– na –
Pinnacle Gold Enhanced Watercolor fine art paper	24 years	– na –
UltraStable Canvas	19 years	– na –
2000 – Epson Stylus Photo 870 and 1270 desktop printers ("improved stability" dye-based photo inks)		
Printed with Epson photo inks (6-ink dye-based inkjet prints)		
Epson Matte Paper – Heavyweight (matte-coated paper)	25 years	– na –
Epson Premium Glossy Photo Paper	10 years	– na –
Epson Photo Paper	7 years	– na –

Table 1 – WIR Display Permanence Ratings Continued[(a)]. . . . .

Type of Inkjet Printer/Ink/Paper Combination and Digital Silver-Halide or Digital Silver Dye-Bleach Color Papers Printed with RGB Laser/LED Digital Photo Printers (Year listed is the date stability tests were conducted by Wilhelm Imaging Research, Inc.)	Displayed Prints Framed Under Glass	Displayed Prints Framed With UV Filter
2000 – Epson Stylus Pro 7500, 9500, Stylus Photo P2000 printers (Epson's first pigmented inkjet printers)		
Printed with Epson Archival pigmented inks (6-ink pigmented inkjet prints)		
Epson Premium Luster Photo Paper	>225 years	>250 years
Epson Watercolor Paper – Smooth (matte-coated 100% cotton fine art paper)	>225 years	>250 years
2002 – Hewlett-Packard DesignJet 5000 printer (HP's first 6-ink pigmented inkjet printer)		
Printed with HP "UV" inks and select fine art papers (6-ink pigmented inkjet prints)	>200 years	>250 years
2002 – Epson Stylus Pro 4000, 7600, 9600, Stylus Photo 2200 printers (2-level pigmented black inks)		
Printed with Epson UltraChrome pigmented inks (7-ink pigmented inkjet prints)		
Epson UltraSmooth Fine Art Paper (matte-coated 100% cotton fine art paper)	108 years	175 years
Epson Premium Luster Photo Paper (250)	71 years	165 years
Somerset Velvet for Epson (matte-coated 100% cotton fine art paper)	61 years	125 years
2004 – Durst Lambda, Océ LightJet, and other RGB laser/LED digital printers		
Printed with Fujicolor Crystal Archive color negative paper (silver-halide color prints)	40 years	49 years
Printed with Ilfochrome Classic [Cibachrome] Material (silver dye-bleach color prints)	29 years	33 years
Printed with Kodak Edge Generations color negative paper (silver-halide color prints)	19 years	17 years
2004 – Hewlett-Packard DesignJet 130 printer (HP's first 18x24-inch desktop inkjet photo printer)		
Printed with HP 84/85 inks (6-ink dye-based inkjet prints)		
HP Premium Plus Photo Paper and other HP swellable RC-base photo papers	82 years	100 years
2004 – Canon i9900 and (in 2005) **PIXMA iP8500 printers** (Canon's first 8-ink desktop inkjet printers)		
Printed with Canon ChromaPLUS inks (8-ink dye-based inkjet prints)		
Canon Matte Photo Paper MP-101 [see Note B below]	10 years	12 years
Canon Photo Paper Pro PR-101 (glossy) [see Note B below]	6 years	8 years
2004 – Epson Stylus Photo R800 and (in 2005) **R1800 printers** (first use of clear "gloss-optimizer" ink)		
Printed with Epson UltraChrome Hi-Gloss pigmented inks (7-ink pigmented inkjet prints)		
Epson Watercolor Paper – Radiant White (matte-coated fine art paper)	200 years	>250 years
Epson Premium Glossy Photo Paper Paper	104 years	>175 years
Epson Premium Luster Photo Paper	64 years	>150 years
2005 – Hewlett-Packard Photosmart 8750 desktop printer (HP's first 9-ink inkjet printer)		
Printed with HP Vivera inks (9-ink dye-based inkjet prints)		
HP Premium Plus Photo Paper and other HP swellable RC-base photo papers	108 years	140 years
2005 – Epson Stylus Pro 4800, 7800, 9800, Stylus Photo R2400 printers (3-level pigmented black inks)		
Printed with Epson UltraChrome K3 pigmented inks (8-ink pigmented inkjet prints)		
Epson UltraSmooth Fine Art Paper (matte-coated 100% cotton fine art paper)	108 years	175 years
Epson Premium Luster Photo Paper (250)	71 years	165 years
Somerset Velvet for Epson (matte-coated 100% cotton fine art paper)	61 years	125 years
2006 – Canon PIXMA Pro9500 printer (Canon's first 10-ink desktop pigmented inkjet printer)		
Printed with Canon Lucia pigmented inks (9-ink pigmented inkjet prints)		
Canon Fine Art Photo Rag Paper and select other Canon matte-coated fine art papers	>100 years	>150 years
Canon Luster Photo Paper, Canon Photo Paper Pro, and select other Canon photo papers	>100 years	>150 years
2006 – HP Photosmart Pro B9180 printer (HP's first 8-ink desktop pigmented inkjet printer)		
Printed with HP Vivera Pigment inks (8-ink [7-inks w/ glossy papers] pigmented inkjet prints)		
HP Advanced Photo Paper Glossy (improved version with 10.5 mil paper thickness)	>230 years	>230 years
HP Photo Matte Paper (matte-coated fine art paper)	>230 years	>230 years
HP Hahnumühle Smooth Fine Art Paper (matte-coated fine art paper)	>230 years	>230 years
2006 – Canon imagePROGRAF iPF5000 and iPF9000 printers (Canon's first 12-ink inkjet printers)		
Printed with Canon Lucia pigmented inks (11-ink pigmented inkjet prints)		
Canon Fine Art Photo Rag Paper and select other Canon matte-coated fine art papers	>100 years	>150 years
Canon Luster Photo Paper, Canon Photo Paper Pro, and select other Canon photo papers	>100 years	>150 years

(a) The WIR Display Permanence Ratings given here were derived from accelerated glass-filtered cool white fluorescent light fading tests conducted at 24°C (75°F) and 60% relative humidity and are based on the "standard" indoor display condition of 450 lux for 12 hours per day employed by Wilhelm Imaging Research, Inc. Illumination conditions in homes, offices, and galleries do vary, however, and color images will last longer when displayed under lower light levels; likewise, the life of prints will be shortened when displayed under illumination that is more intense than 450 lux. The predictions given here are the years of display required for the changes in color balance, and/or staining specified in the visually-weighted WIR Ver. 3.0 Endpoint Criteria Set to occur; with most types of images, these changes are easily noticeable in side-by-side comparisons with an unfaded original. **(b)** Because of the disproportionately rapid light fading of the red (orange) ink in the 8-ink Canon ChromaPLUS dye-based inkset used in the Canon i9900 printer, which is not properly assessed by the Status A densitometrically-based WIR 3.0 Endpoint Criteria Set, the Display Permanence Ratings should in reality be lower than the figures given here. The disproportionately rapid fading of the red (orange) ink is particularly noticeable in skintones.

A Survey of Print Permanence in the 4x6-Inch Consumer Digital Print Market in 2004–2007

Henry Wilhelm, Wilhelm Imaging Research, Inc., Grinnell, Iowa U.S.A.

Abstract

This paper gives an overview of the various factors affecting the display permanence and dark-storage stability of many types of color prints commonly found in the consumer 4x6-inch print market. The similarities and differences between inkjet prints, made with dye-based inks, pigmented inks, dye-sub prints, and traditional silver-halide (chromogenic) color prints are discussed. Print permanence test methods are described for light stability, dark storage stability, ozone resistance, waterfastness, and humidity-fastness. The effects of ozone in polluted air, or "gas-fading" as it has come to be known, is an especially important factor to consider in evaluating the permanence of dye-based inkjet prints made with "instant dry" porous photo papers. In this study, both the Wilhelm Imaging Research "Display Permanence Ratings" and the WIR "Unprotected Ozone Resistance Ratings" were found to cover an extremely wide range – the most stable prints were rated to last more than 200 times longer than the least stable prints.

Introduction

An increasing variety of printing technologies are being used in the rapidly-growing market for prints made from digital camera files. Many consumers are making prints at home with inkjet and dye-sub printers; in retail outlets using digital silver-halide minilabs, dye-sub kiosks, and inkjet kiosks. In Japan, self-service dry-toner electrophotographic printers found in Seven-Eleven convenience stores are another means for making prints from digital cameras. Consumers can also obtain prints by uploading image files to online services that employ high-volume digital silver-halide minilabs, which produce prints that are then mailed to their homes.

Consumers display digitally-printed photographs framed under glass (or display prints unframed and freely exposed to the ambient air) in their homes and offices, post prints on refrigerator doors, and/or place them in albums in the same ways that photographs have always been used. Most consumers consider digital color prints to be "real photographs." They think about them in much the same way they have always thought about photographs, and they have the same high expectations about image permanence.

In terms of the total volume of prints being made in the consumer market, 4x6-inch format prints comprise the largest segment. A variety of compact 4x6-inch dye-sub and inkjet printers have been introduced in recent years for home use. Although 4x6-inch inkjet prints can be made with larger, U.S. letter-size (A4 size) printers, this study focuses on compact 4x6-inch home printers and on the 4x6-inch retail segment. As has been the case in the traditional analog silver-halide photofinishing market of past years, most consumers continue to prefer a glossy surface for their digital prints in the relatively small, 4x6-inch size range.

For the first time in the history of photography, digital era consumers are selecting and purchasing inks and papers for making

Equivalent time of ambient ozone exposure in an accelerated ozone resistance test with Hewlett-Packard Vivera 57+ inks and HP Premium Plus Photo Paper printed with a compact 4x6-inch Hewlett-Packard Photosmart 245 home inkjet printer.

Results of the accelerated ozone resistance test with an Office Depot refilled HP 57 ink cartridge and Office Depot Professional Photo Paper printed with a Hewlett-Packard Photosmart 245 printer. The Office Depot ink and paper were purchased in January 2007.

Results of the accelerated ozone resistance test with a Staples brand refilled HP 57 ink cartridge and Staples Photo Supreme Paper printed with a 4x6-inch Hewlett-Packard Photosmart 245 printer. The Staples ink and paper were purchased in January 2007.

Table 1

WIR Print Permanence Ratings for the 4x6-Inch Digital Printer Category in 2004–2007 (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[1]								
Printer/Ink/Photo Paper Printed With Inkjet, Dye-Sub, Silver-Halide Printers	**Displayed Prints Framed Under Glass[2]**	Displayed Prints Framed With UV Filter[3]	Displayed Prints Not Framed (Bare-Bulb)[4]	**Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[5]**	**Unprotected Resistance to Ozone[6]**	**Resistance to High Humidity[7]**	**Resistance to Water[8]**	**Are UV Brighteners Present?[9]**
HP Photosmart Express (retail inkjet kiosk printer) **HP Vivera pigment inks/HP RPS Photosmart Paper**	**>200 years**	>250 years	102 years	>200 years	>100 years	very high	high	no
Lexmark P350 Portable (4x6-inch inkjet printer) **Lexmark Evercolor 2 pigment inks/PerfectFinish Paper**	**>100 years**	>100 years	now in test	now in test	now in test	very high	high	no
Epson PictureMate (original) (4x6-inch inkjet printer) **Epson PictureMate pigment inks/PictureMate Paper**	**104 years**	124 years	65 years	>200 years	>100 years	very high	high	yes
Epson PictureMate PM-200 (4x6-inch inkjet printer) **Epson PictureMate dye-based inks/PictureMate Paper**	**96 years**	147 years	17 years	>200 years	17 years	now in test	high	no
HP Photosmart 325 and 475 (4x6-inch inkjet printer) **HP Vivera 95 dye-based inks/Premium Plus Photo Paper**	**82 years**	105 years	42 years	>200 years	>100 years	now in test	low	no
HP Photosmart 145 and 245 (4x6-inch inkjet printer) **HP Vivera 57+ dye-based inks/Premium Plus Photo Paper**	**68 years**	77 years	32 years	>200 years	>100 years	now in test	low	no
HP Photosmart A616/A717 (5x7-inch inkjet printer) **HP Vivera 110 dye-based inks/Advanced Photo Paper**	**51 years**	53 years	16 years	>200 years	16 years	now in test	high	no
Canon PIXMA 260 (4x6-inch inkjet printer) **Canon ChromaLife 100 dye-based inks/Photo Paper Pro**	**now in test**	now in test	now in test	>200 years	now in test	now in test	high	no
Canon Selphy DS700 (4x6-inch inkjet printer) **Canon BCI-16 dye-based inks/Photo Paper Pro**	**41 years**	44 years	2 years	>200 years	2 years	now in test	high	no
Fujicolor Crystal Archive (silver-halide color print) **Fuji Frontier 370 minilab/Fuji washless chemicals**	**40 years**	50 years	26 years	>100 years	>100 years	very high	high	no
Kodak PictureMaker (retail kiosk dye-sub printer) **Kodak Xtralife dye-sub printer ribbon and paper**	**26 years**	29 years	10 years	now in test	>100 years	very high	high	no
Kodak EasyShare Printers (4x6-inch dye-sub printer) **Kodak Xtralife 4x6-inch dye-sub printer ribbon and paper**	**26 years**	29 years	10 years	now in test	>100 years	very high	high	no
Dell Photo Printer 540 (4x6-inch dye-sub printer) **Dell 4x6-inch dye-sub printer ribbon and paper**	**26 years**	29 years	10 years	now in test	>100 years	very high	high	no
Fuji Xerox 7/11 (retail kiosk xerographic photo printer) **Fuji Xerox color toner/Fuji Xerox glossy photo paper**	**23 years**	25 years	21 years	now in test	>100 years	very high	high	no
Agfacolor Sensitas (silver-halide color print) **Agfa d-lab.2plus minilab/Agfa washless chemicals**	**22 years**	26 years	14 years	>100 years	>100 years	very high	high	no
Kodak Edge Generations (silver-halide color print) **Noritsu QSS-3011SM minilab/Kodak washless chemicals**	**19 years**	18 years	18 years	>100 years	>100 years	very high	high	no
Sony PictureStation (retail kiosk dye-sub printer) **Sony dye-sub printer ribbon and paper**	**18 years**	28 years est.	13 years	now in test	>100 years	very high	high	no
HP Photosmart 145 and 245 (4x6-inch inkjet printer) **HP 57 dye-based inks/HP Premium Plus Photo Paper**	**18 years**	20 years	15 years	>200 years	>100 years	now in test	low	no
Konica Minolta Impressa (silver-halide color print) **Konica R2 Super 1000 minilab/Konica washless chemicals**	**17 years**	19 years	16 years	>100 years	>100 years	very high	high	no
Lexmark SnapShot P315 (4x6-inch inkjet printer) **Lexmark 33 dye-based inks/Lexmark Premium Photo Paper**	**16 years**	18 years	10 years	>200 years	now in test	now in test	low	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **HP 57 dye-based inks/Kodak "100 Year" Ultima Picture Paper**	**11 years**	13 years	10 years	now in test	>100 years	now in test	low	no
Sony DPP-FP55 PictureStation (4x6-inch dye-sub printer) **Sony 4x6-inch dye-sub printer ribbon and paper**	**10 years**	18 years	6 years	now in test	>100 years	very high	high	no
Olympus P-10 Printer (4x6-inch dye-sub printer) **Olympus 4x6-inch dye-sub printer ribbon and paper**	**8 years**	10 years	6 years	now in test	>100 years	very high	high	no
Canon CP500 Printer (4x6-inch dye-sub printer) **Canon 4x6-inch dye-sub printer ribbon and paper**	**7 years**	9 years	6 years	now in test	>100 years	very high	high	no
Sony DPP-FP30 PictureStation (4x6-inch dye-sub printer) **Sony 4x6-inch dye-sub printer ribbon and paper**	**6 years**	6 years	5 years	now in test	>100 years	very high	high	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **Staples refilled HP 57 ink cartridge/Photo Supreme Paper**	**3 years**	3 years	3 months	now in test	3 months	now in test	high	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **OfficeMax refilled HP 57 ink cartridge/Professional Photo Paper**	**2 years**	2 years	2 months	now in test	2 months	now in test	high	no
***HP Photosmart 145 and 245** (4x6-inch inkjet printer) **Office Depot refilled HP 57 ink cartridge/Professional Paper**	**4 months**	4 months	2 months	now in test	2 months	now in test	high	yes

***Note:** Products listed with an "*" have been tested with non-recommended, third-party inks and/or papers and do not represent the performance of OEM inks and papers supplied by that printer's manufacturer.

The difference in light-stability between the most stable and the least stable of current inkjet inks is greater than 1000 to 1.

Epson SureColor P10000 and P20000 – Print Permanence Ratings[1]

David Adamson and his staff at Adamson Editions in Washington, DC making a large print of a 2004 Richard Avedon photograph. Above is a 2005 black-and-white portrait by Chuck Close of the model Kate Moss which Adamson scanned from a daguerreotype plate.

Ink System: Ten new-generation pigment inks are provided, with nine inks used at any given time as determined by the paper type and print mode selected. The new Epson UltraChrome PRO pigment inks include Cyan, Light Cyan, Vivid Magenta, Vivid Light Magenta, Yellow, Photo Black (for glossy and luster papers) or Matte Black (matte papers), Dark Gray, Gray, and Light Gray. This is the only Epson inkset featuring four-level black/gray inks. Depending on the type of paper, the greatly improved light stability of the new yellow ink provides a 2X to 3X improvement in WIR Display Permanence Ratings compared with previous Epson UltraChrome K3 and HDR inks.

Maximum Paper Width: 44 inches (112 cm) for the SureColor P10000 and 64 inches (163 cm) for the P20000. Cut sheet paper thickness up to 500 gsm and 1.5 mm poster board can be accommodated. Rolls and sheets are easily top-loaded from the front.

Special Feature: Epson's "Advanced Black and White Print Mode" for printing exceptional and extremely long-lasting B&W prints with nuanced control over the hue of the image.

Price: $6,995 (USA) for the Epson SureColor P10000 (44-inch/112 cm) and $11,995 for the P20000 (64-inch/163 cm). These two printers and the improved-stability PRO pigment inks were first introduced in 2016.

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Photo Paper, Fine Art Media, or Canvas Printed With Epson UltraChrome PRO Pigment Inks	Displayed Prints Framed Under Glass[3]	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]	Unprotected Resistance to Ozone[7]	Resistance to High Humidity[8]	Resistance to Water[9]	Are Optical Brighteners Present?[10]
Epson Exhibition Canvas Satin	**208 years**	>360 years	108 years	>300 years	>100 years	very high	moderate[11]	yes
Epson Premium Luster Photo Paper (260)	**138 years**	289 years	66 years	>300 years	>100 years	very high	high	yes
Epson Ultra Premium Luster Photo Paper	**138 years**	289 years	66 years	>300 years	>100 years	very high	high	yes
Epson Legacy Baryta Paper	**116 years**	190 years	64 years	>400 years	>100 years	very high	moderate[11]	some
Epson Legacy Textured Paper	now in test	now in test	now in test	now in test	now in test	now in test	now in test	no
Epson Legacy Etching Paper	**112 years**	249 years	53 years	>400 years	>100 years	very high	moderate[11]	no
Epson Legacy Platine Paper	**107 years**	245 years	54 years	>400 years	>100 years	very high	moderate[11]	no

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Epson SureColor P10000 and P20000 – Print Permanence Ratings[1]

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]								
Photo Paper, Fine Art Media, or Canvas Printed With Epson UltraChrome PRO Pigment Inks	**Displayed Prints Framed Under Glass[3]**	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	**Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]**	**Unprotected Resistance to Ozone[7]**	**Resistance to High Humidity[8]**	**Resistance to Water[9]**	**Are UV Brighteners Present?[10]**
Epson Legacy Fibre Paper	**92 years**	237 years	53 years	>400 years	>100 years	very high	moderate[11]	no
Epson Exhibition Fiber Paper	**108 years**	192 years	65 years	>200 years	>100 years	very high	moderate[11]	yes
Epson Hot Press Bright Paper	**73 years**	141 years	42 years	>400 years	>100 years	very high	moderate[11]	yes
Epson Hot Press Natural Paper	**62 years**	129 years	38 years	>400 years	>100 years	very high	moderate[11]	no
Epson Cold Press Bright Paper	**72 years**	135 years	42 years	>400 years	>100 years	very high	moderate[11]	yes
Epson Cold Press Natural Paper	**62 years**	122 years	38 years	>400 years	>100 years	very high	moderate[11]	no

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Epson SureColor P10000 and P20000 – Print Permanence Ratings[1]

Black-and-White prints made with Epson UltraChrome PRO inks printed with the Epson "Advanced Black and White Print Mode"

Note: The Display Permanence Ratings given here are based on long-term testing with the new generation of Epson UltraChrome PRO pigment inks. These tests show that significant increases in Display Permanence Ratings for black-and-white prints can be expected because the three-level, extremely-stable carbon pigment based black inks in Epson UltraChrome HD, HDX, and PRO inksets largely replace the cyan, magenta, and yellow color inks in B&W prints when they are made with the "Advanced Black and White Print Mode" (see printer dialog box to the right) Very high stability inks such as these require extended test times. ">400 Years" means "greater than 400 years" and that the tests are continuing.

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Photo Paper, Fine Art Media, or Canvas Printed With Epson UltraChrome PRO Pigment Inks	Displayed Prints Framed Under Glass[3]	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]	Unprotected Resistance to Ozone[7]	Resistance to High Humidity[8]	Resistance to Water[9]	Are UV Brighteners Present?[10]
Epson Exhibition Canvas Satin	**>400 years**	>400 years	>250 years	>300 years	>100 years	very high	moderate[11]	yes
Epson Premium Luster Photo Paper (260)	**>400 years**	>400 years	>250 years	>300 years	>100 years	very high	high	yes
Epson Ultra Premium Luster Photo Paper	**>400 years**	>400 years	>250 years	>300 years	>100 years	very high	high	yes
Epson Legacy Baryta Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	some
Epson Legacy Textured Paper	now in test	now in test	now in test	now in test	now in test	now in test	now in test	no
Epson Legacy Platine Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	no
Epson Legacy Etching Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	no
Epson Legacy Fibre Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	no
Epson Exhibition Fiber Paper	**>300 years**	>400 years	>250 years	>200 years	>100 years	very high	moderate[11]	yes
Epson Hot Press Bright Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	yes
Epson Hot Press Natural Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	no
Epson Cold Press Bright Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	yes
Epson Cold Press Natural Paper	**>400 years**	>400 years	>250 years	>400 years	>100 years	very high	moderate[11]	no

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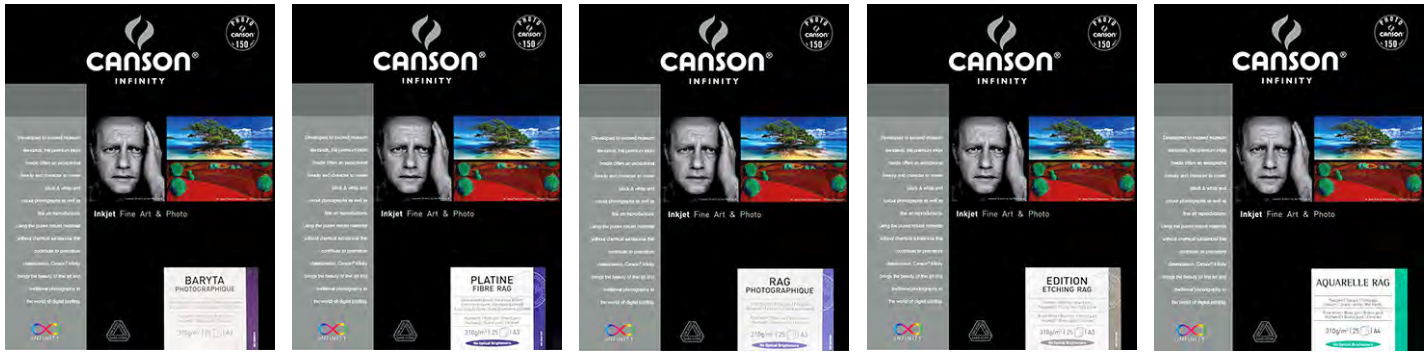
Canson Infinity Papers with Epson HDX Inks – Print Permanence Ratings[1]



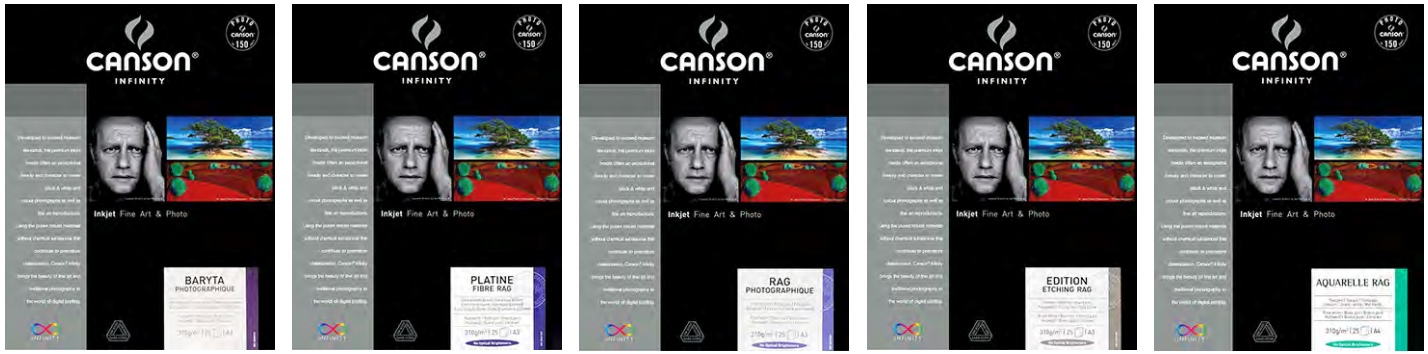
The print permanence data given here are based on tests with samples printed with an Epson SureColor P9000 printer and Epson UltraChrome HDX 11-color pigment inks. Canson Infinity fine art papers, fine art canvas, and photo papers are supplied by Canson SAS, 67, Rue Louis et Laurent Seguin, CS 70139, 07104 Annonay, Cedex, France. Canson Infinity papers are available from suppliers and dealers in countries throughout the world. www.cansoninfinity.com

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Photo Papers, Fine Art Papers, and Canvas Printed With Epson UltraChrome HDX inks	Displayed Prints Framed Under Glass[3]	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]	Unprotected Resistance to Ozone[7]	Resistance to High Humidity[8]	Resistance to Water[9]	Are Optical Brighteners Present?[10]
Canson Infinity PrintMaKing Rag	**136 years**	345 years	77 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Edition Etching Rag	**115 years**	258 years	63 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Velin Museum Rag	**138 years**	314 years	73 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique	**116 years**	253 years	64 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Baryta Photographique	**115 years**	240 years	64 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Baryta Prestige	**106 years**	215 years	58 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Platine Fibre Rag	**96 years**	215 years	51 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Aquarelle Rag	**132 years**	347 years	68 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Photo Luster Premium RC	**127 years**	241 years	72 years	>200 years	>100 years	very high	high	yes

See page 2 for Canson Infinity print permanence data with new Canon LUCIA PRO inks and page 3 for HP Vivera pigment inks.

Canson Infinity Papers with Canon LUCIA PRO Inks – Print Permanence Ratings[1]



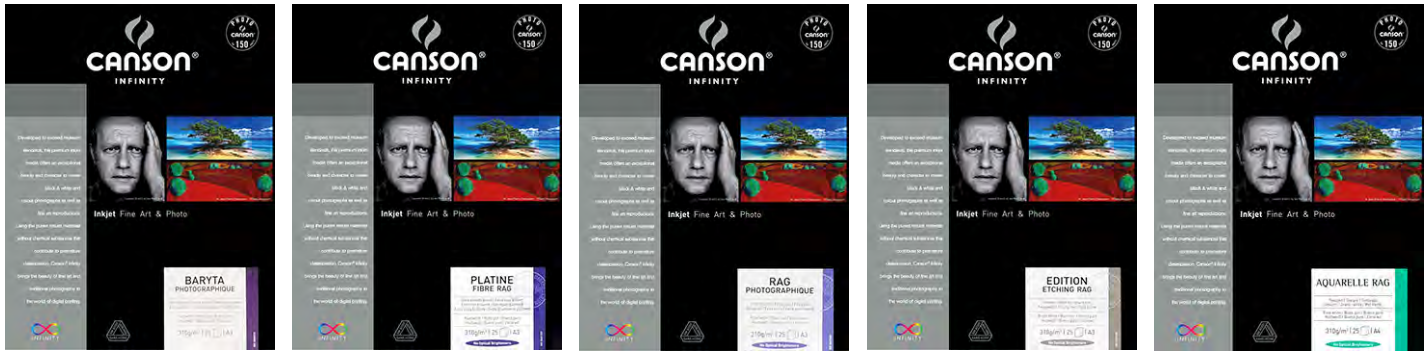
The print permanence data given here are based on tests with samples printed with a Canon 12-ink imagePROGRAF PRO-1000 printer with Canon LUCIA PRO pigment inks with LUCIA PRO Chroma Optimizer clear ink. Canon LUCIA PRO inks and the inkjet head used in the PRO-1000 are also used in the Canon PRO-2000, PRO-4000, and PRO-6000 printers and the print permanence ratings given here are expected to be similar with these printers.
www.cansoninfinity.com

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Photo Papers, Fine Art Papers, and Canvas Printed with Canon LUCIA PRO Pigment Inks	Displayed Prints Framed Under Glass[3]	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]	Unprotected Resistance to Ozone[7]	Resistance to High Humidity[8]	Resistance to Water[9]	Are Optical Brighteners Present?[10]
Canson Infinity PrintMaKing Rag	**72 years**	153 years	39 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Edition Etching Rag	**60 years**	124 years	33 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Velin Museum Rag	**78 years**	166 years	41 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique	**60 years**	130 years	31 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Baryta Photographique	**43 years**	88 years	25 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Baryta Prestige	**44 years**	88 years	28 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Platine Fibre Rag	**37 years**	80 years	20 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Aquarelle Rag	**86 years**	188 years	50 years	>200 years	>100 years	very high	moderate[11]	no
Canson Infinity Photo Luster Premium RC	**49 years**	92 years	26 years	>200 years	>100 years	very high	high	yes

See page 3 for Canson Infinity print permanence data with HP Vivera pigment inks and page 4 for previous-generation Epson UltraChrome K3 inks..

Canson Infinity Papers with HP Vivera Inks – Print Permanence Ratings[1]



The print permanence data given here are based on tests with samples printed with HP DesignJet Z3100 and Z3200 printers with HP Vivera 12-color pigment inks, and with HP DesignJet Z6200 printers. Canson Infinity fine art papers, fine art canvas, and photo papers are supplied by Canson SAS, CS 70139, 07104 Annonay, Cedex, France. Canson Infinity papers are available from suppliers and dealers in countries throughout the world.
www.cansoninfinity.com

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Photo Papers, Fine Art Papers, and Canvas Printed with HP Vivera Pigment Inks	Displayed Prints Framed Under Glass[3]	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]	Unprotected Resistance to Ozone[7]	Resistance to High Humidity[8]	Resistance to Water[9]	Are Optical Brighteners Present?[10]
Canson Infinity PrintMaKing Rag	**199 years**	361 years	83 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Edition Etching Rag	**235 years**	370 years	88 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Velin Museum Rag	**218 years**	360 years	90 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique	**219 years**	384 years	85 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique DUO	**246 years**	434 years	87 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Baryta Photographique	**160 years**	392 years	56 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Platine Fibre Rag	**117 years**	318 years	39 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Aquarelle Rag	**228 years**	417 years	90 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Photo High Gloss Premium RC	**156 years**	390 years	57 years	>300 years	>100 years	very high	high	yes
Canson Infinity PhotoGloss Premium RC	**222 years**	453 years	70 years	>300 years	>100 years	very high	high	yes
Canson Infinity PhotoSatin Premium RC	**220 years**	442 years	68 years	>300 years	>100 years	very high	high	yes

See page 4 for Canson Infinity print permanence data with previous-generation Epson UltraChrome K3 inks, and page 5 for older-generation Canon LUCIA 12-color inks.

Canson Infinity Papers with Epson K3 Inks – Print Permanence Ratings[1]

The print permanence data given here are based on tests with samples printed with an Epson Stylus Pro 9880 printer and Epson UltraChrome K3 with Vivid Magenta pigment inks. Canson Infinity fine art papers, fine art canvas, and photo papers are supplied by Canson SAS, CS 70139, 07104 Annonay, Cedex, France. Canson Infinity papers are available from suppliers and dealers in countries throughout the world.

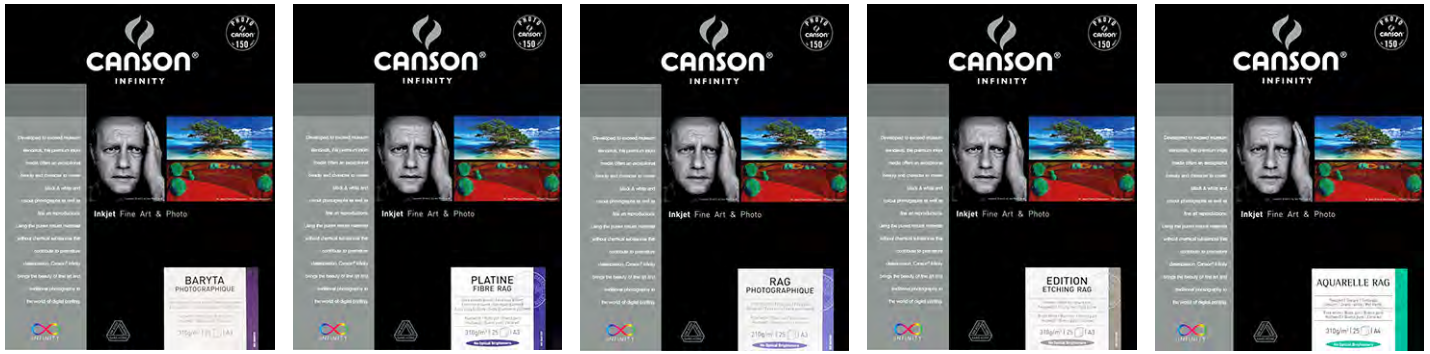
www.cansoninfinity.com

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Paper, Canvas, or Fine Art Media Printed With Epson UltraChrome K3 Pigment Inks	Displayed Prints Framed Under Glass[3]	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]	Unprotected Resistance to Ozone[7]	Resistance to High Humidity[8]	Resistance to Water[9]	Are Optical Brighteners Present?[10]
Canson Infinity PrintMaKing Rag	**72 years**	140 years	39 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Edition Etching Rag	**69 years**	132 years	36 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Velin Museum Rag	**67 years**	129 years	39 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique	**69 years**	125 years	36 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique DUO	**65 years**	123 years	37 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Baryta Photographique	**45 years**	99 years	28 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Platine Fibre Rag	**53 years**	113 years	32 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Photo High Gloss Premium RC	**60 years**	104 years	36 years	>300 years	>100 years	very high	high	yes
Canson Infinity PhotoGloss Premium RC	**87 years**	145 years	49 years	>300 years	>100 years	very high	high	yes
Canson Infinity PhotoSatin Premium RC	**88 years**	147 years	48 years	>300 years	>100 years	very high	high	yes
Canson Infinity Aquarelle Rag	**67 years**	129 years	36 years	>300 years	>100 years	very high	moderate[11]	no

See page 5 for Canson Infinity print permanence data with older-generation Canon LUCIA 12-color pigment inks.

Canson Infinity Papers with Older Canon Inks – Print Permanence Ratings[1]

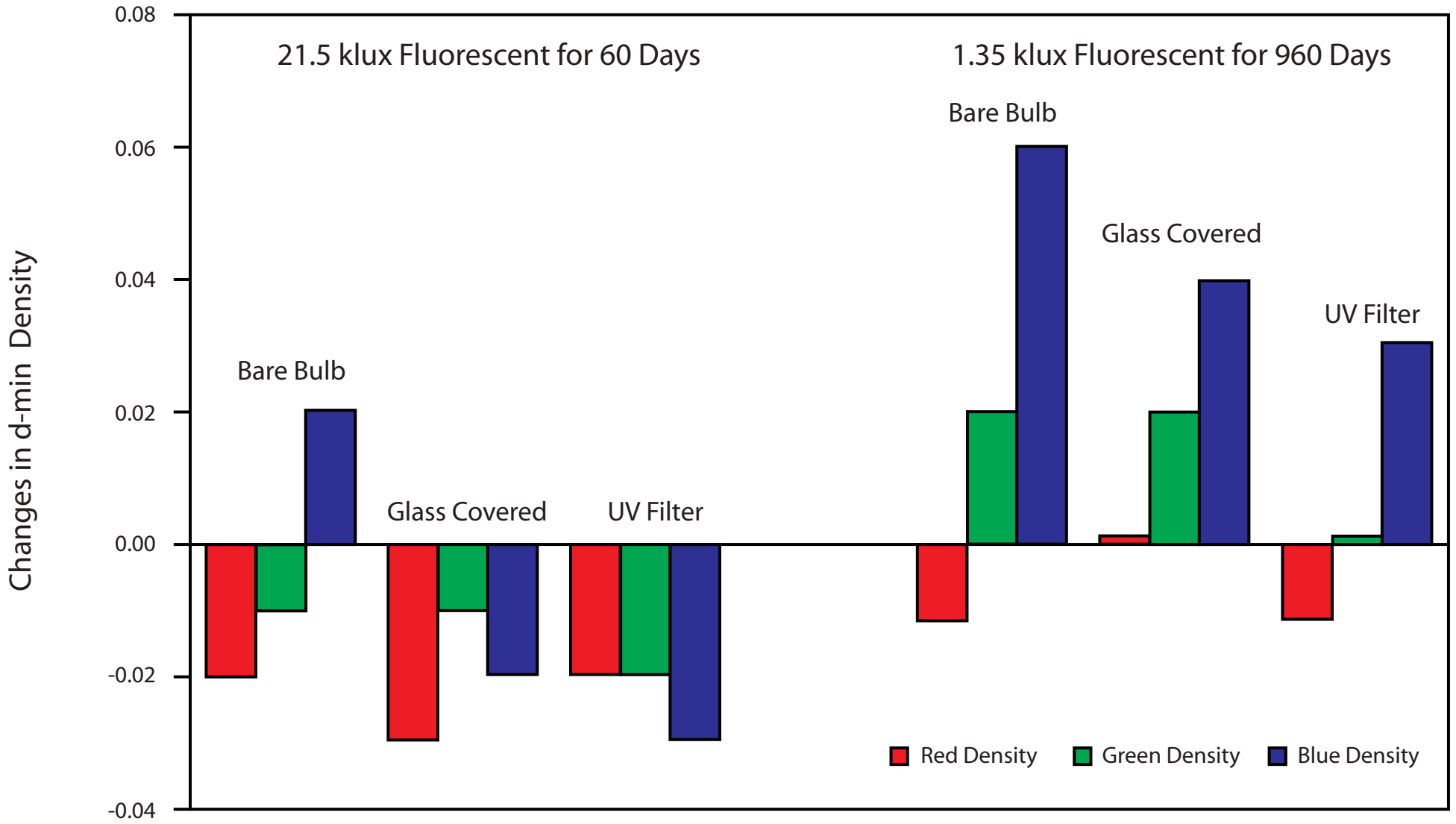


The print permanence data given here are based on tests with samples printed with a Canon imagePROGRAF iPF5100 and Canon LUCIA 12-color pigment inks. Canson Infinity fine art papers, fine art canvas, and photo papers are supplied by Canson SAS, CS 70139, 07104 Annonay, Cedex, France. Canson Infinity papers are available from suppliers and dealers in countries throughout the world.

www.cansoninfinity.com

Display Permanence Ratings and Album/Dark Storage Permanence Ratings (Years Before Noticeable Fading and/or Changes in Color Balance Occur)[2]

Paper, Canvas, or Fine Art Media Printed With Older Canon LUCIA Pigment Inks	Displayed Prints Framed Under Glass[3]	Displayed Prints Framed With UV Filter[4]	Displayed Prints Not Framed (Bare-Bulb)[5]	Album/Dark Storage Rating at 73°F & 50% RH (incl. Paper Yellowing)[6]	Unprotected Resistance to Ozone[7]	Resistance to High Humidity[8]	Resistance to Water[9]	Are Optical Brighteners Present?[10]
Canson Infinity PrintMaKing Rag	**116 years**	212 years	59 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Edition Etching Rag	**96 years**	199 years	57 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Velin Museum Rag	**119 years**	226 years	61 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique	**108 years**	199 years	56 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Rag Photographique DUO	**104 years**	198 years	54 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Baryta Photographique	**69 years**	146 years	39 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Platine Fibre Rag	**73 years**	130 years	41 years	>300 years	>100 years	very high	moderate[11]	no
Canson Infinity Photo High Gloss Premium RC	**106 years**	175 years	60 years	>300 years	>100 years	very high	high	yes
Canson Infinity PhotoGloss Premium RC	**122 years**	185 years	69 years	>300 years	>100 years	very high	high	yes
Canson Infinity PhotoSatin Premium RC	**116 years**	191 years	64 years	>300 years	>100 years	very high	high	yes
Canson Infinity Aquarelle Rag	**128 years**	238 years	65 years	>300 years	>100 years	very high	moderate[11]	no



Reciprocity failures in light-induced staining with Kodak Ektacolor 74 RC Paper

Table 1. WIR Visually-Weighted Endpoint Criteria Set v3.0 for Color Image Print Stability Tests

Ref. No.	Allowed Percentage of Change in Initial Status A Densities of 0.6 and 1.0[1]	Image Change Parameter
1	25%	Loss of cyan (red density) in neutral patches
2	20%	Loss of magenta (green density) in neutral patches
3	35%	Loss of yellow (blue density) in neutral patches
4	30%	Loss of cyan (red density) in pure color cyan patches
5	25%	Loss of magenta (green density) in pure color magenta patches
6	35%	Loss of yellow (blue density) in pure color yellow patches
7	12%	Cyan minus magenta (R – G) color imbalance in neutral patches
8	15%	Magenta minus cyan (G – R) color imbalance in neutral patches
9	18%	Cyan minus yellow (R – B) color imbalance in neutral patches
10	18%	Yellow minus cyan (B – R) color imbalance in neutral patches
11	18%	Magenta minus yellow (G – B) color imbalance in neutral patches
12	18%	Yellow minus magenta (B – G) color imbalance in neutral patches
Change Limits in Minimum-Density Areas (Paper White) Expressed in Density Units		
13	.06	Change [increase] in red or green density
14	.15	Change [increase] in blue density
15	.05	Color imbalance between red and green densities
16	.10	Color imbalance between red and blue densities
17	.10	Color imbalance between green and blue densities

[1]Initial (starting) densities are absolute measurements (not measured "above d-min"). A weighted criteria set for fading, color balance shifts, and d-min stain was first developed by H. Wilhelm in 1978–83 and was slightly modified in 1990, 1992, and 1996. Version 3.0 above was implemented on August 25, 2001 and for the first time included 0.6 starting densities for pure color cyan, magenta, and yellow in addition to the 1.0 starting densities for the pure color primaries that had been employed in earlier versions of the weighted criteria set. From the outset, the neutral scale parameters have always included both 0.6 and 1.0 starting densities.

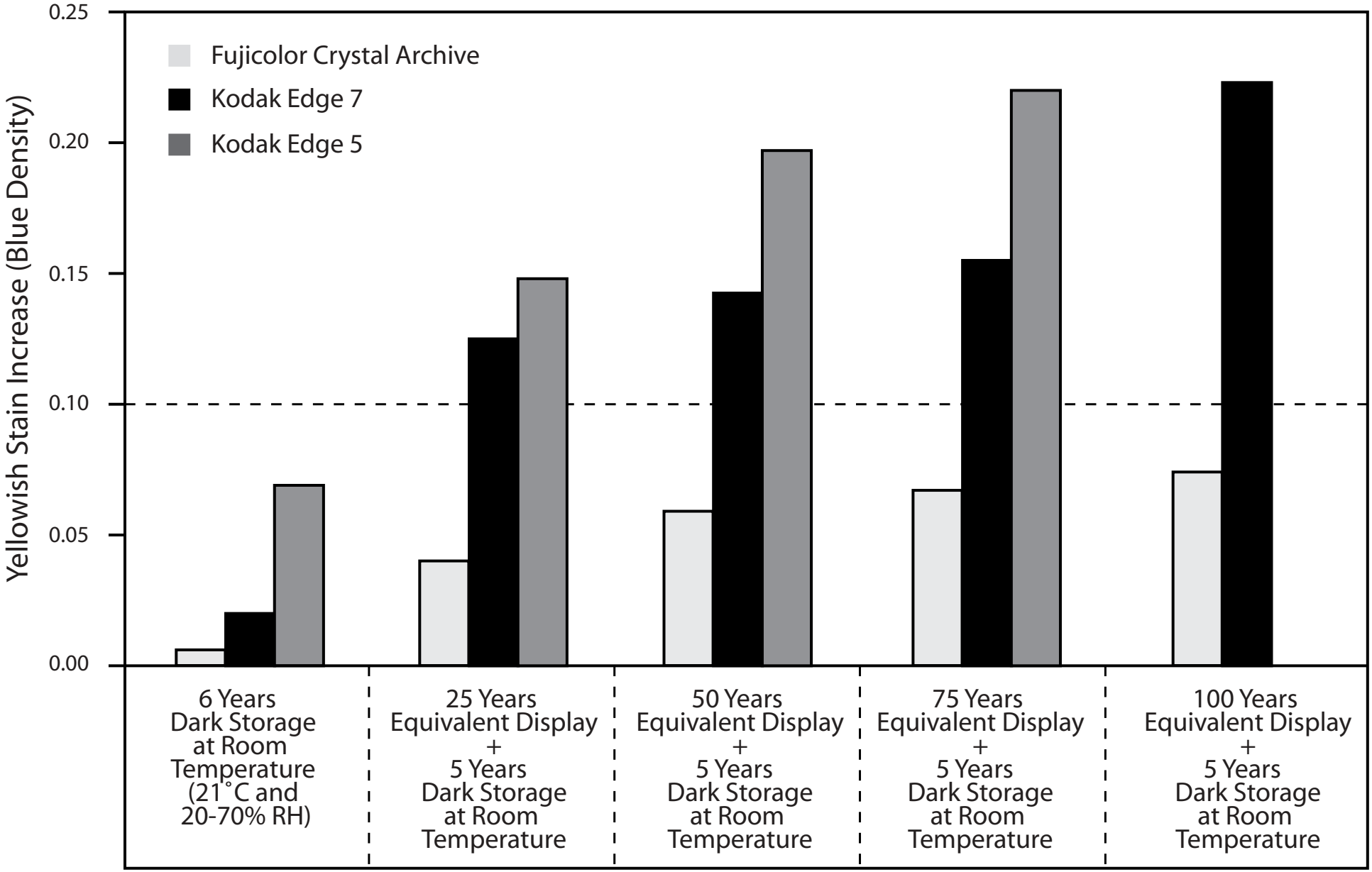


Fig. 2. Light-induced "dark staining" with chromogenic prints (traditional silver-halide).

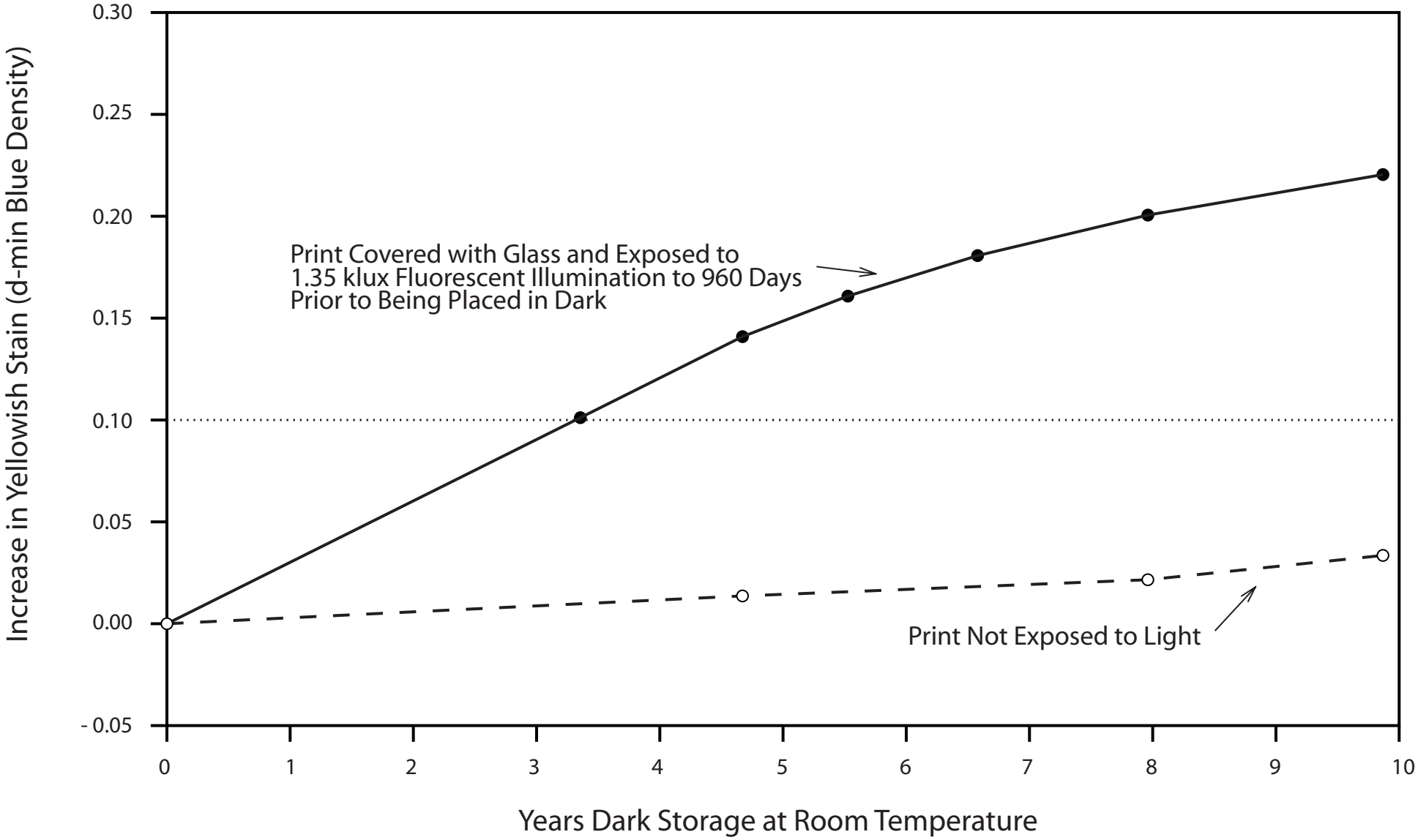
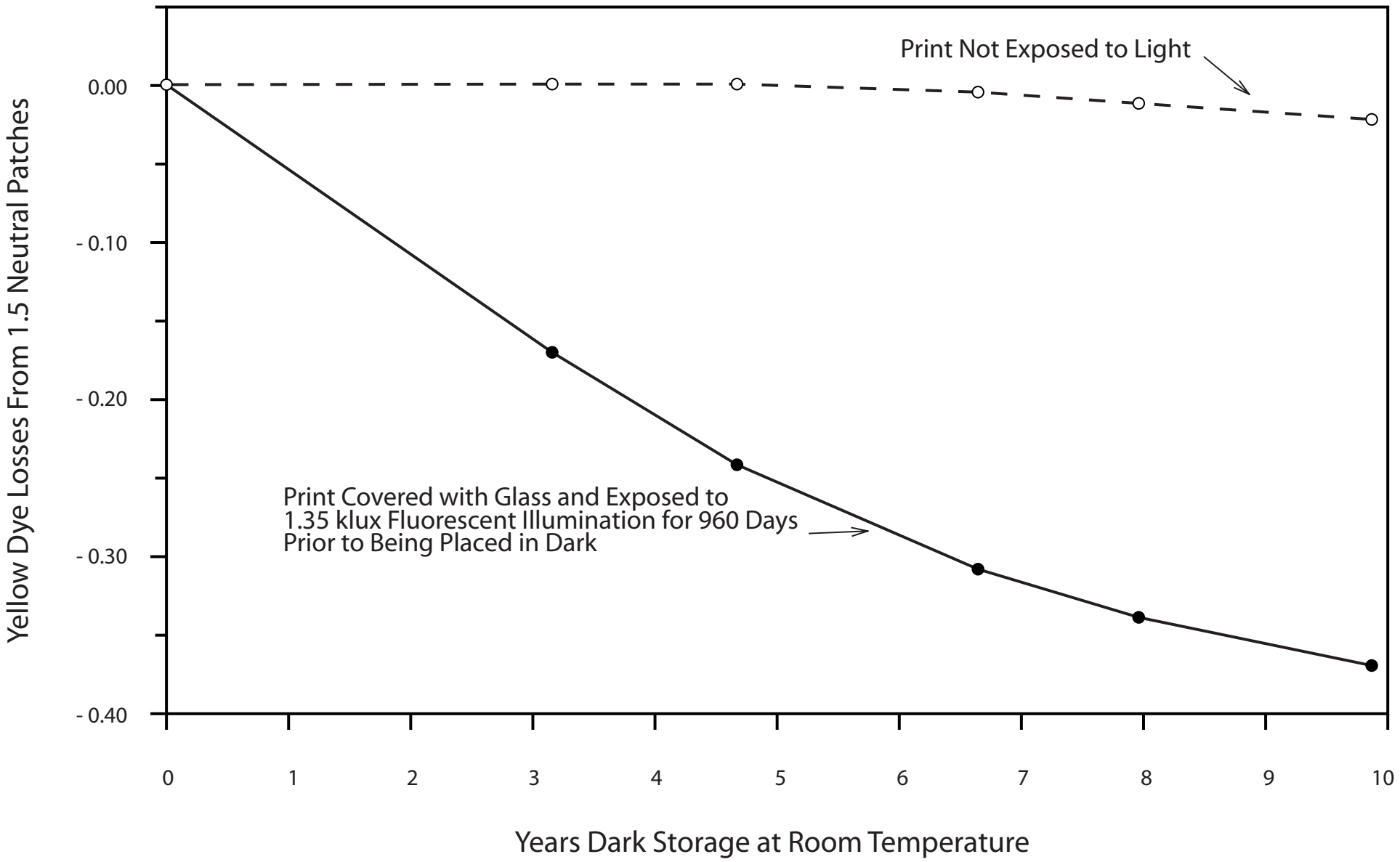


Fig. 3. Light-induced "dark staining" of an Ektacolor 74 RC chromogenic print.



Light-induced “dark fading” of an Ektacolor 74 RC chromogenic print.

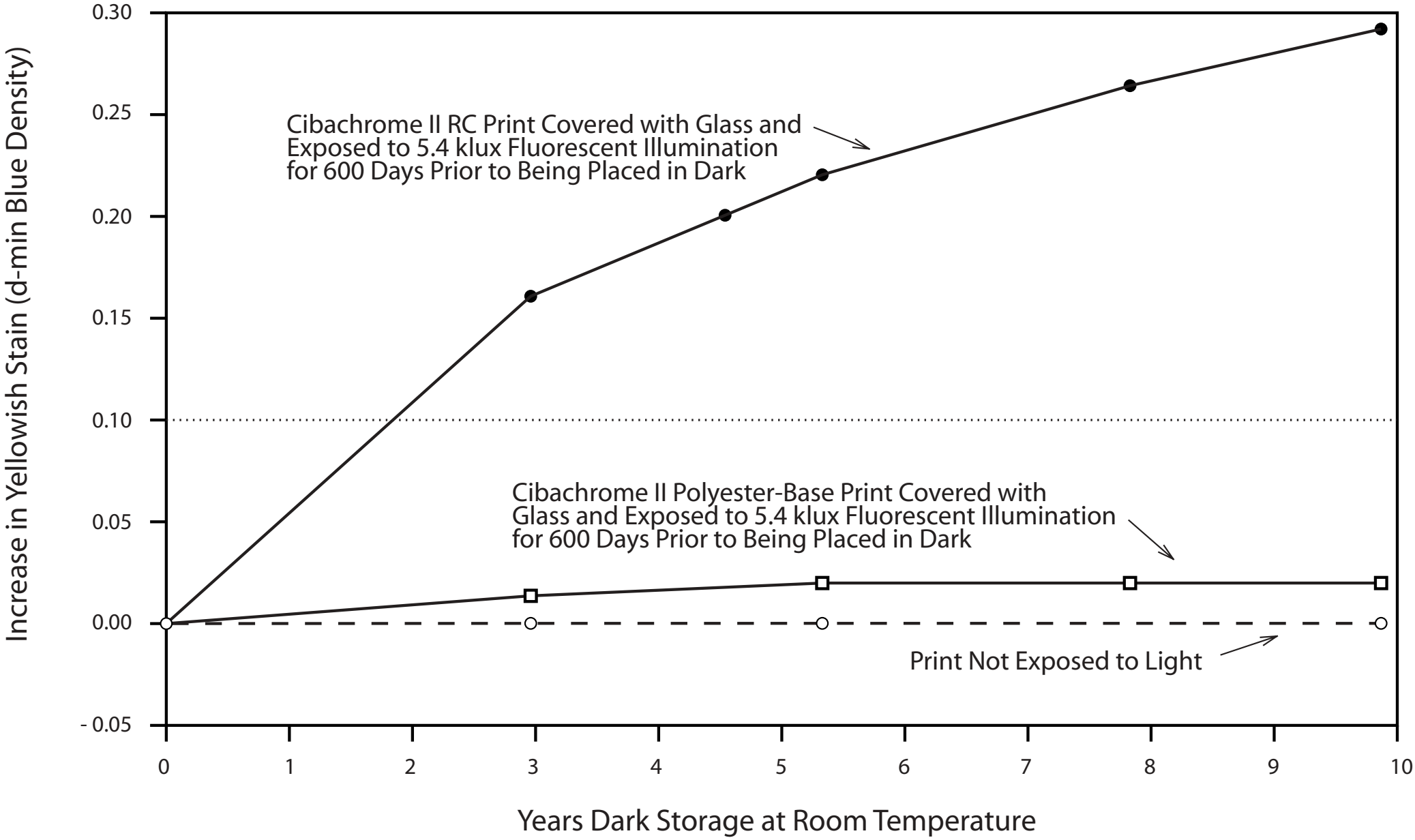


Fig. 4. Light-induced "dark staining" of Cibachrome II RC and polyester-base prints.

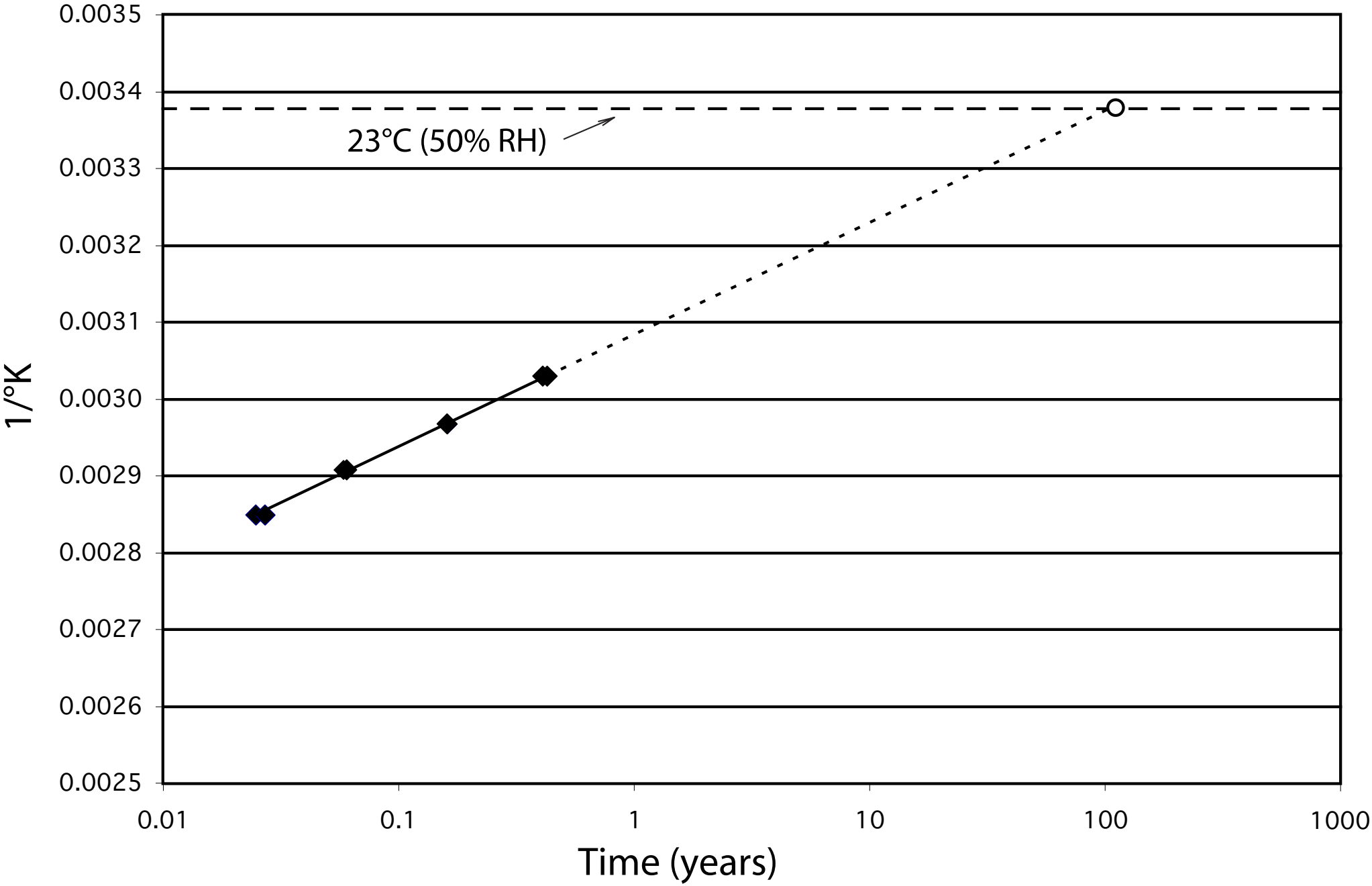


Fig. 5. Arrhenius test with a matte surface inkjet paper (prediction: 110 years at 23°C/50% RH)

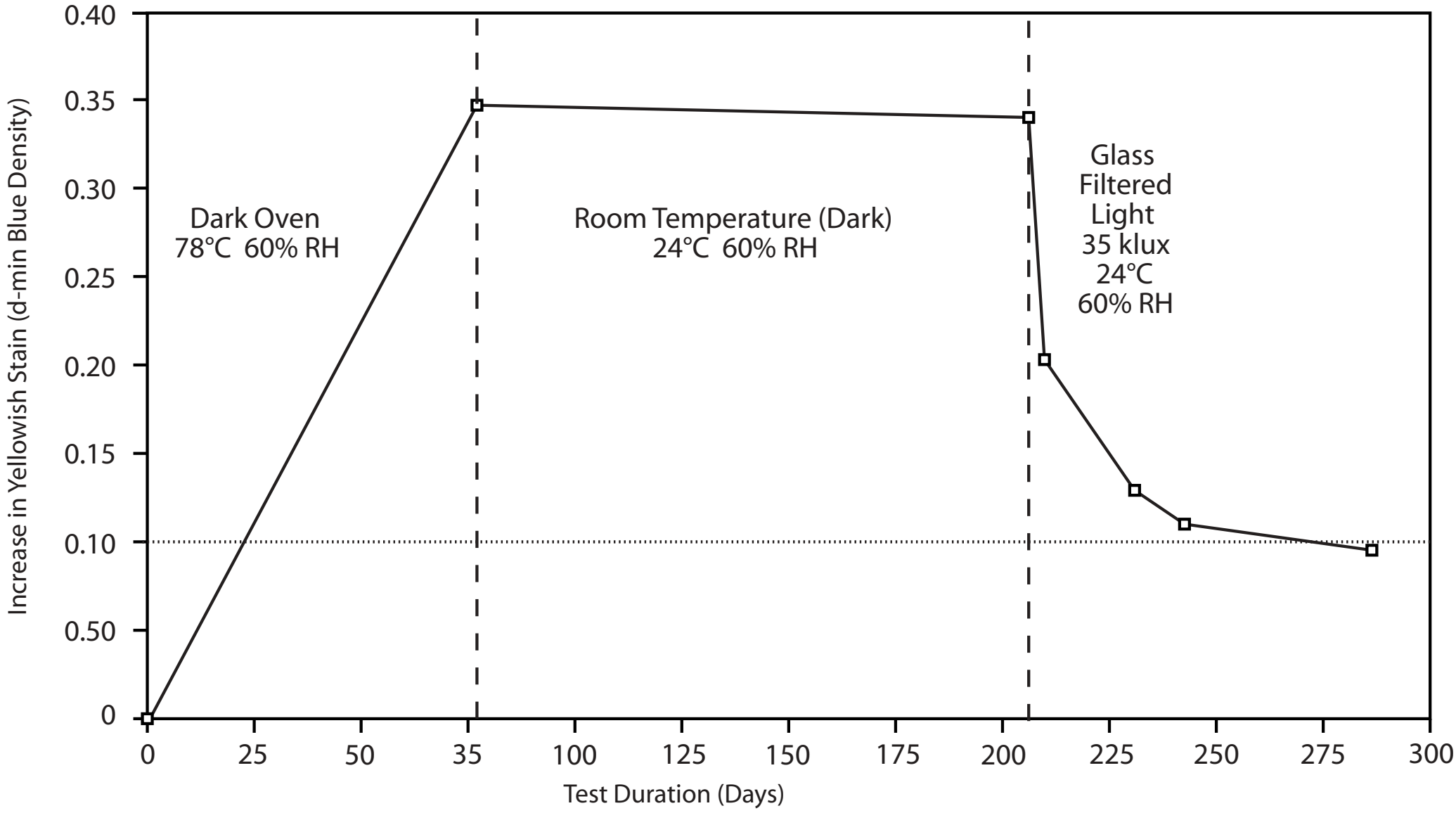


Fig. 6. Microporous inkjet paper printed with pigmented inks.

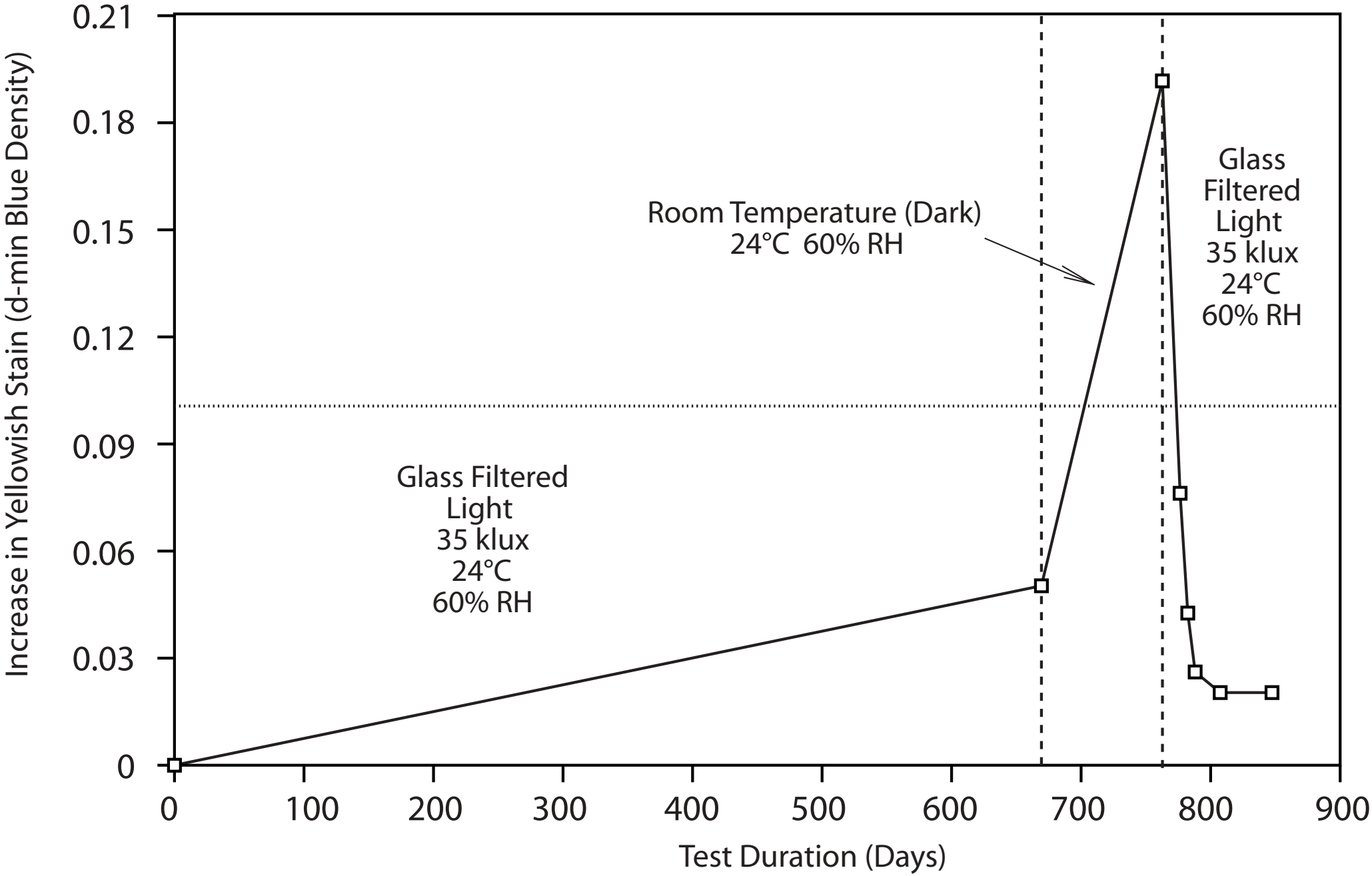


Fig. 7. Light-induced "dark staining" of a glossy microporous inkjet paper (pigmented inks).

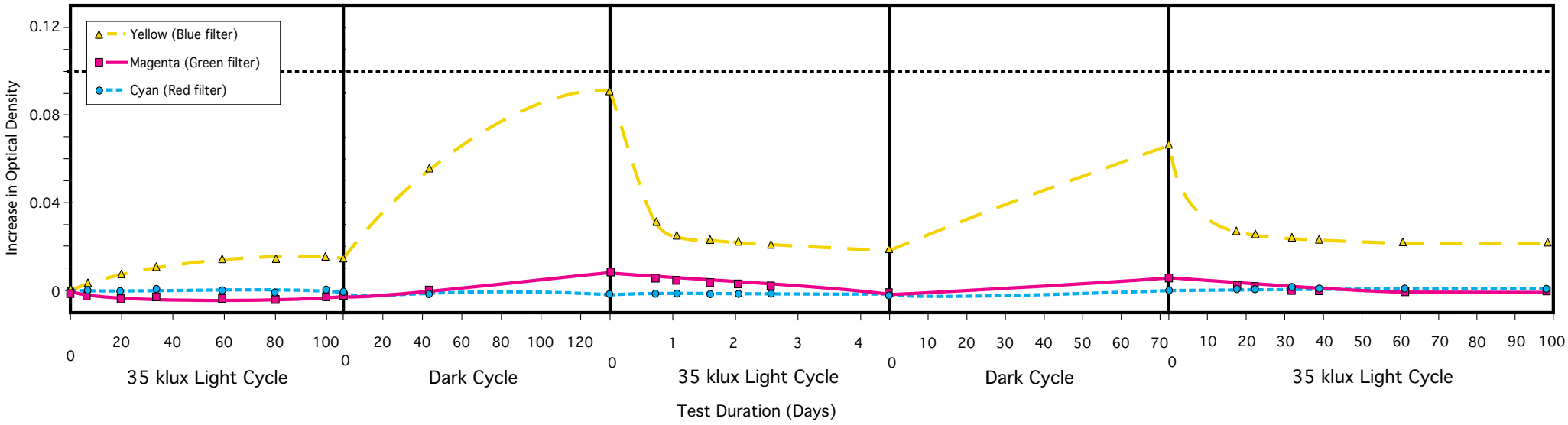
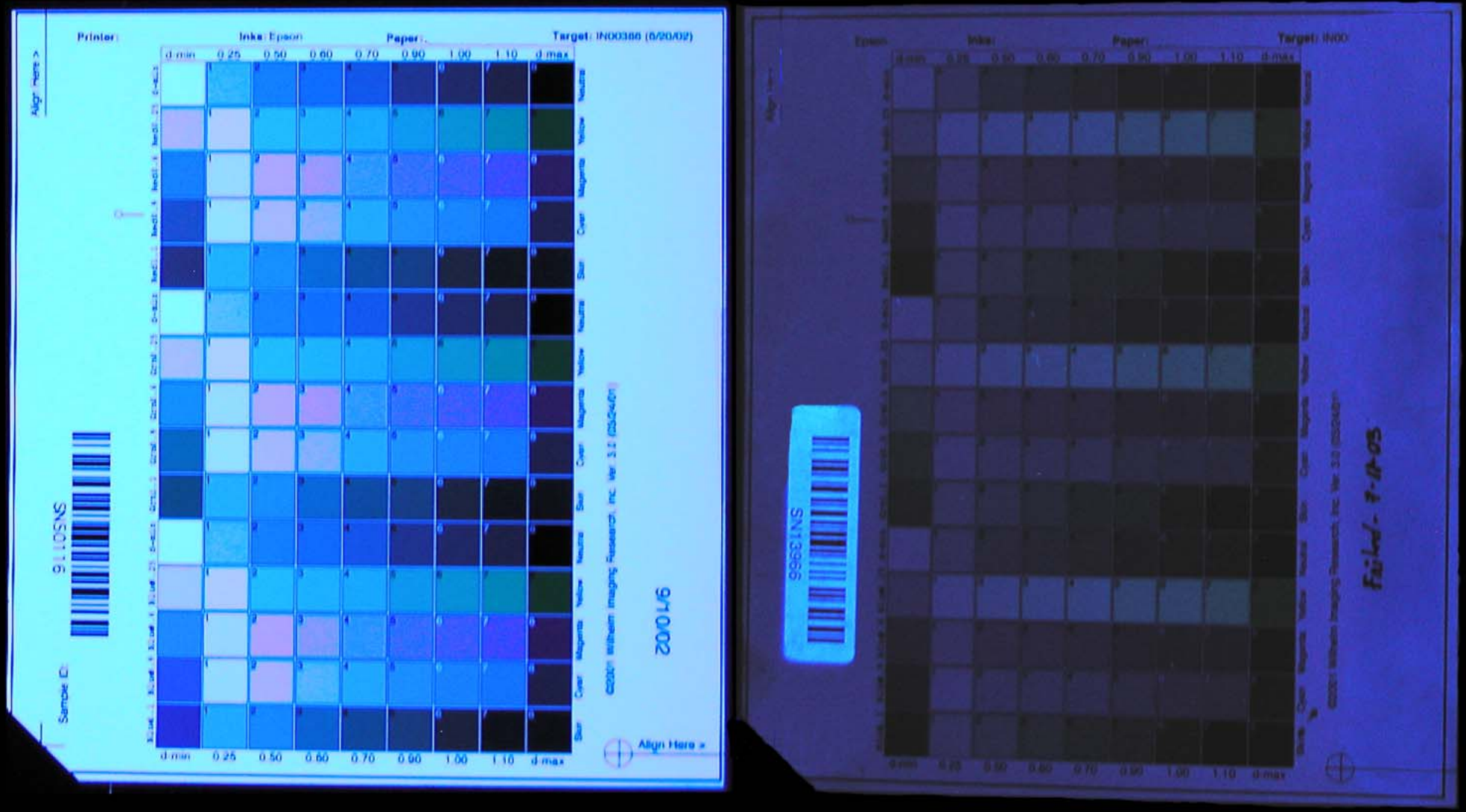


Fig. 9. Light-induced "dark staining" of a semi-gloss microporous inkjet paper printed with pigmented inks (initial bare-bulb cool white fluorescent exposure).

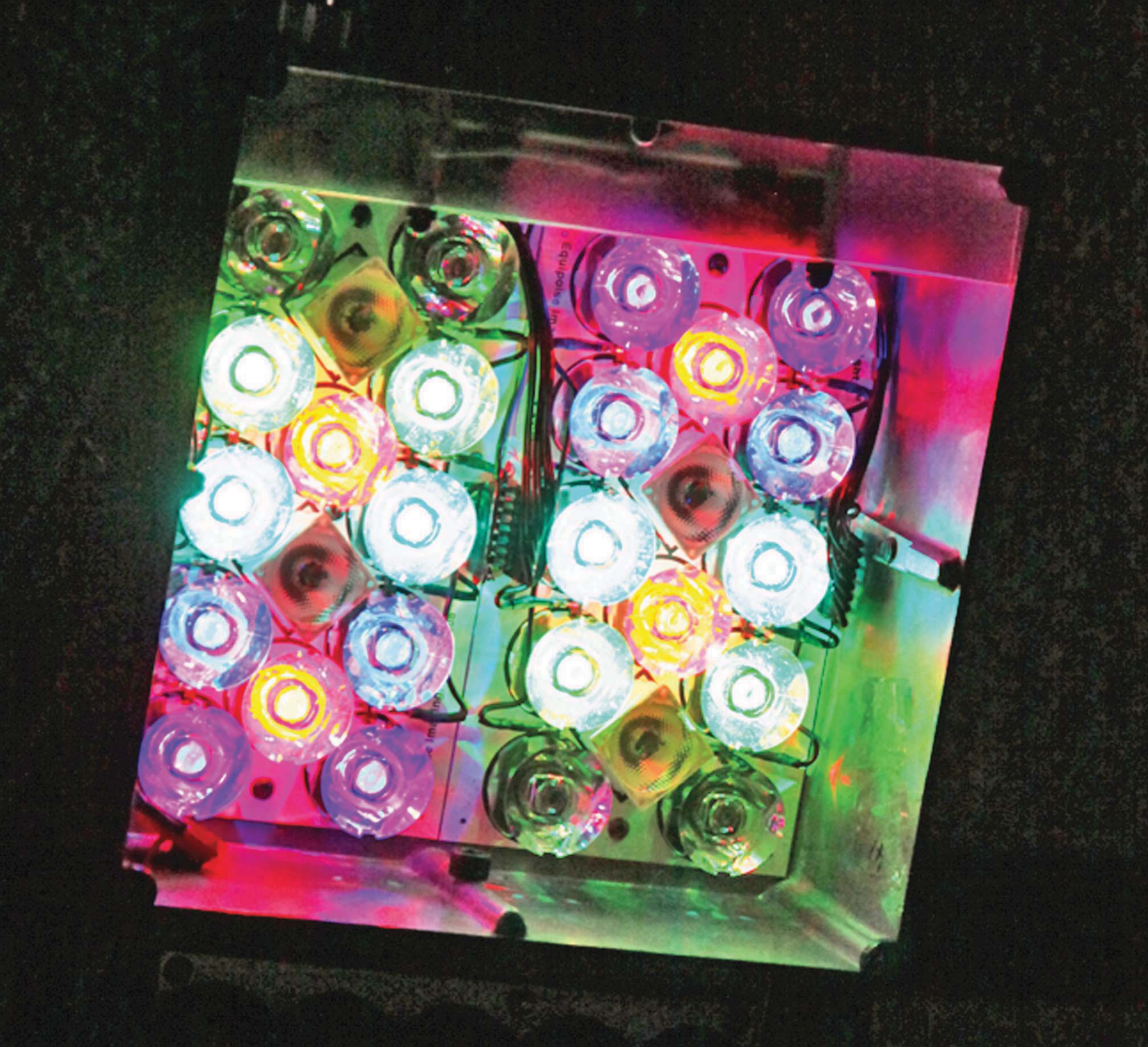
Control Print

After 210 days/35 klux



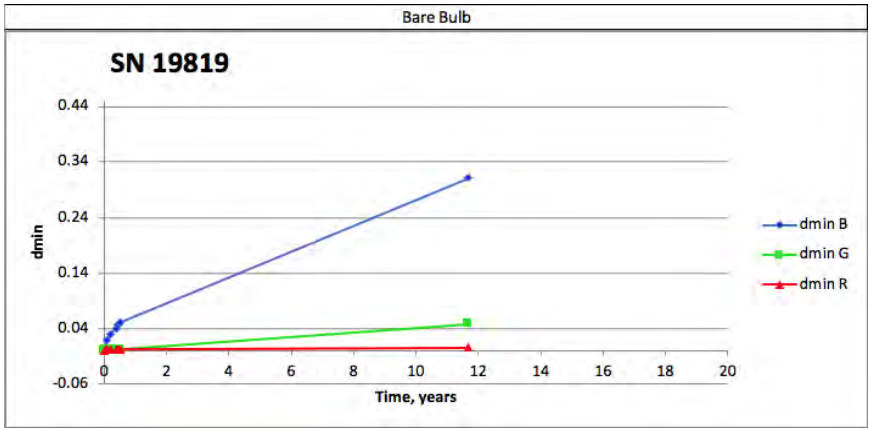
Viewed with UV radiation

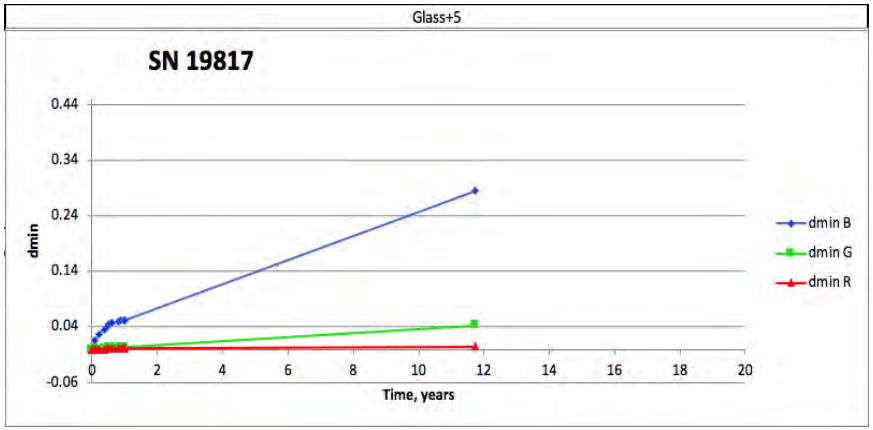
(365 nm)

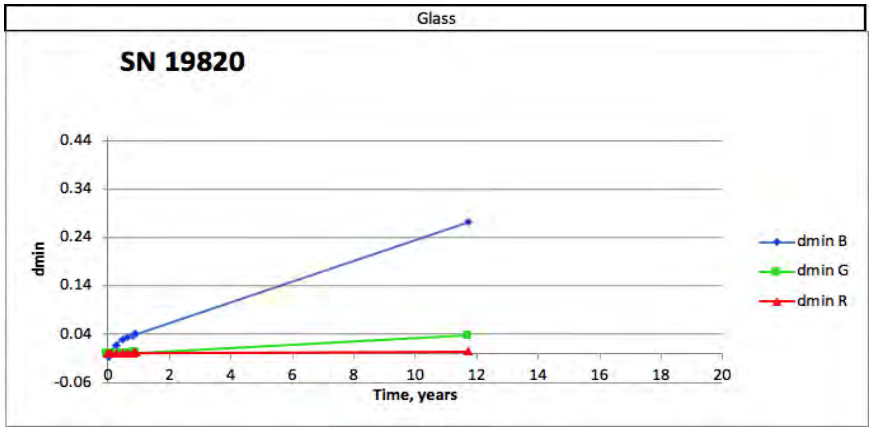


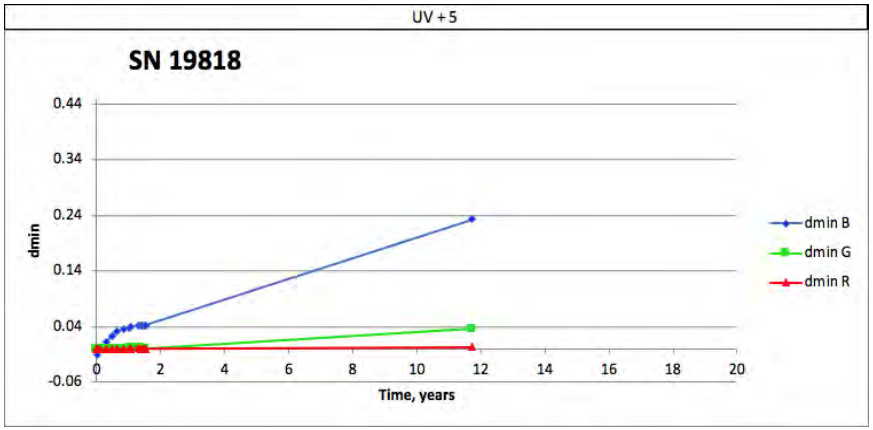

SN20680
P0000000482
Target1
4.5 hours

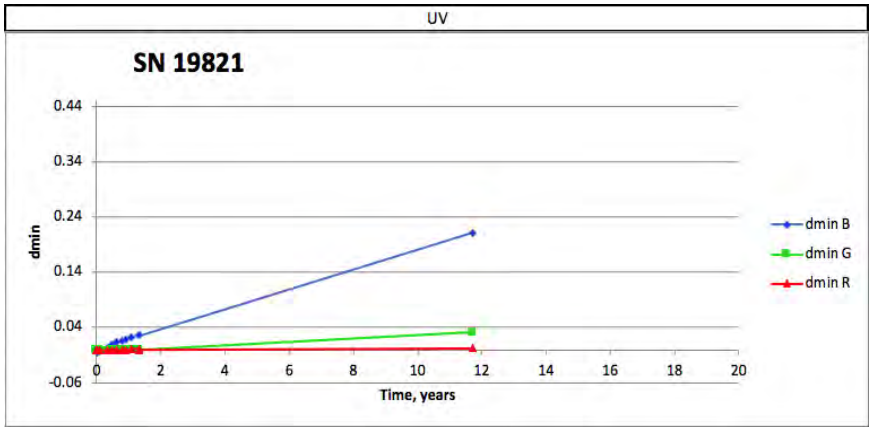
RC Glossy Photo Paper <u>With</u> OBAs in the Base Paper and in the Ink-Receptive Coating



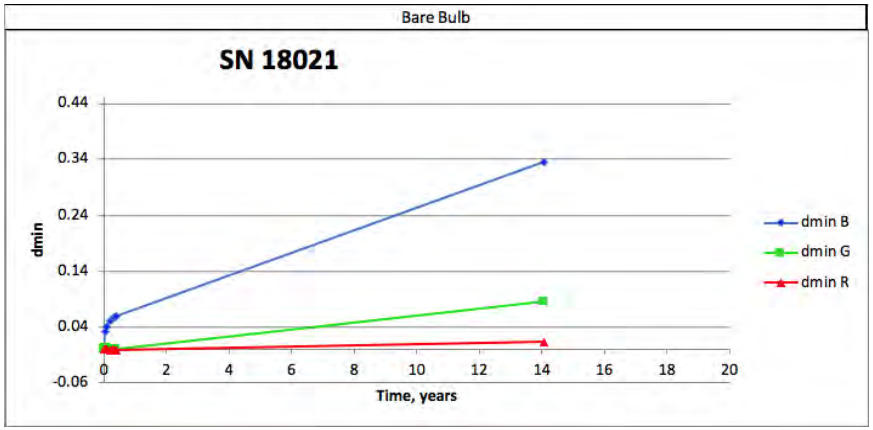


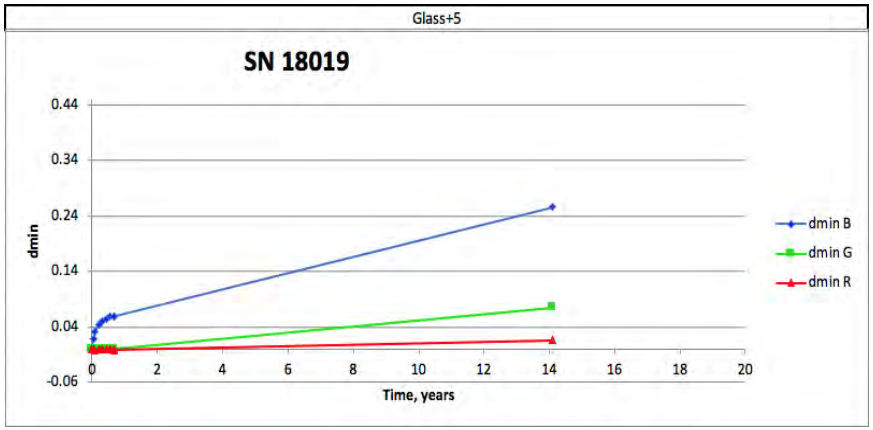


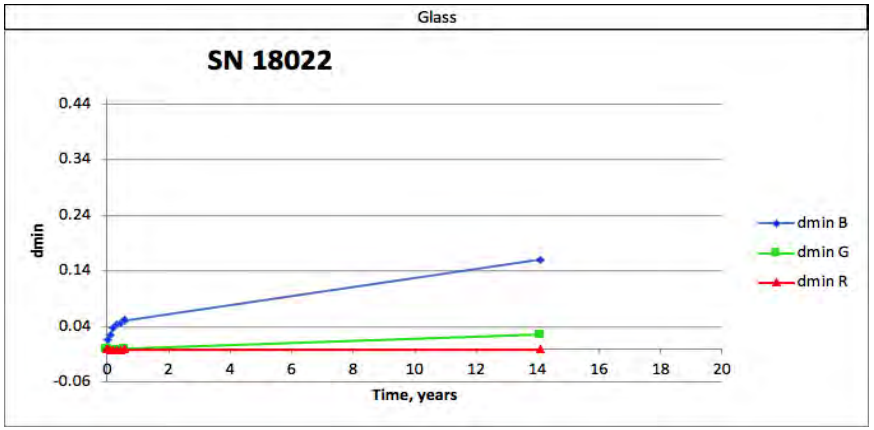


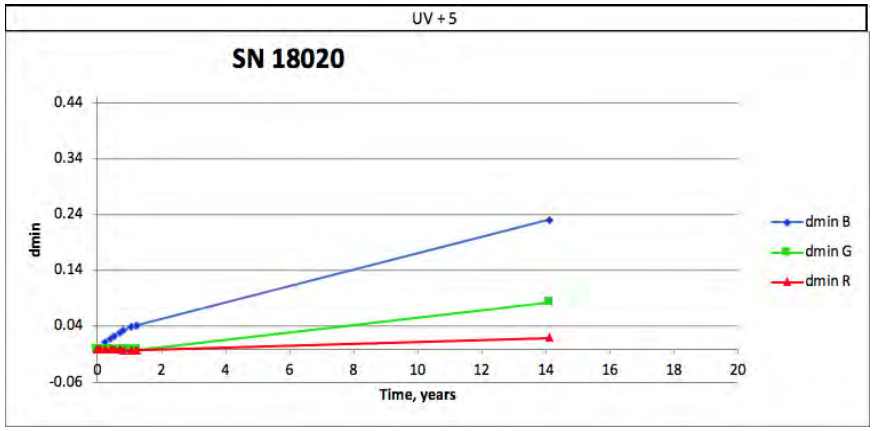


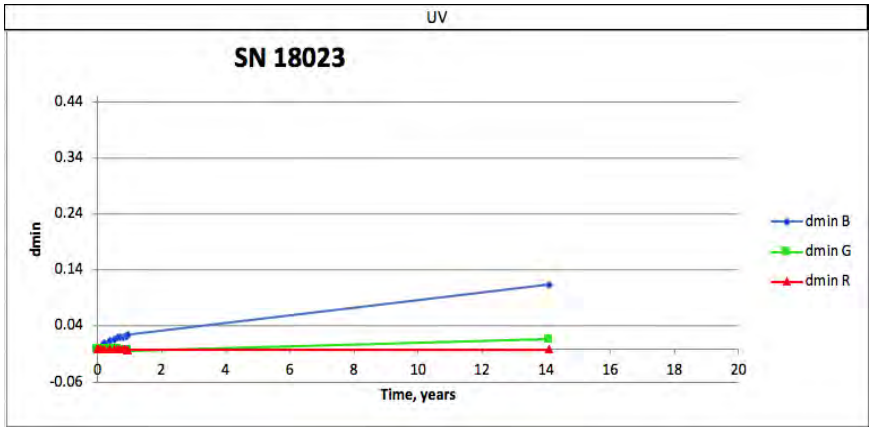
Non-RC Matte Paper With OBAs in the Base Paper and in the Ink-Receptive Coating



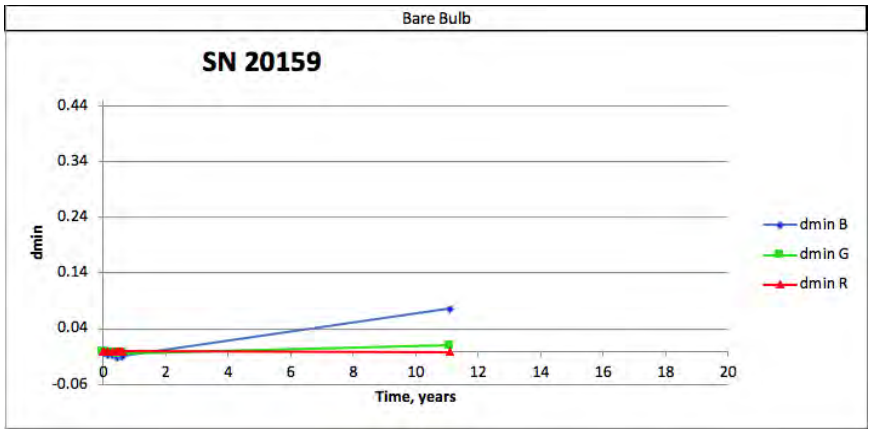


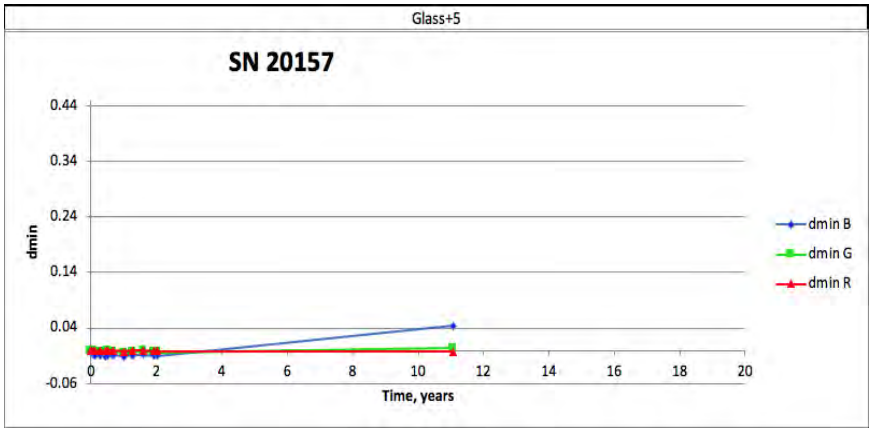


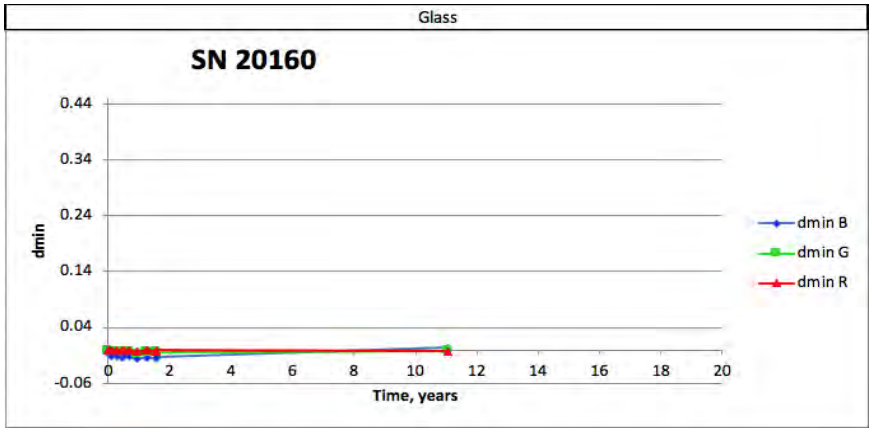


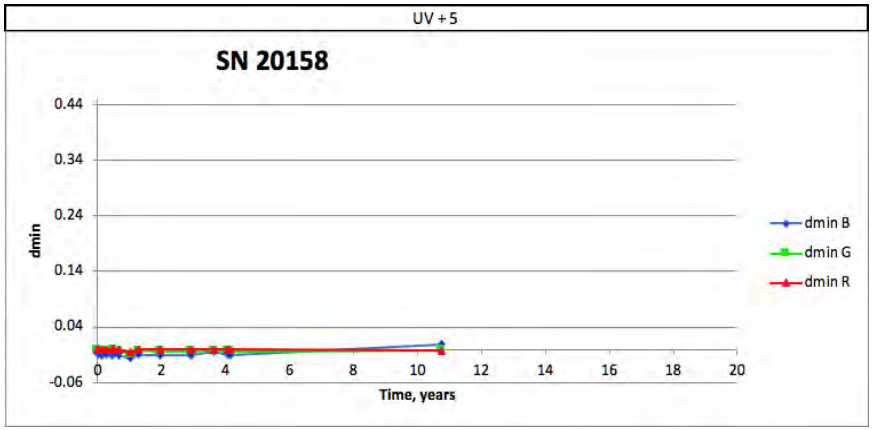


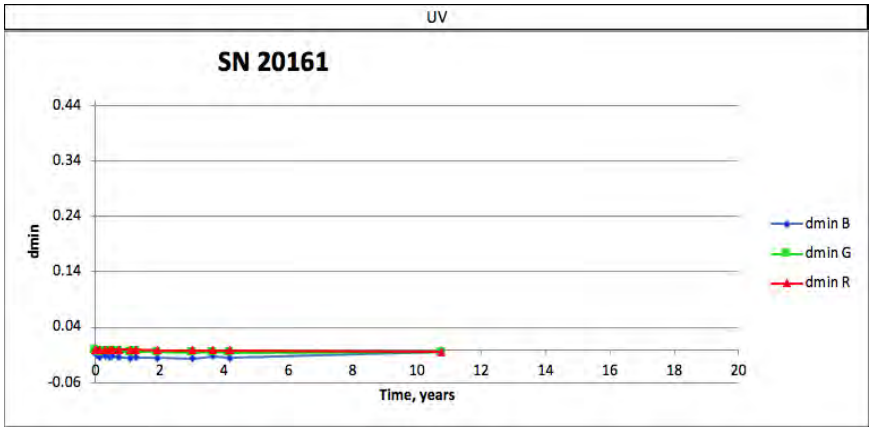
Satin Alpha Cellulose Paper With No OBAs in the Base Paper or in the Ink-Receptive Coating



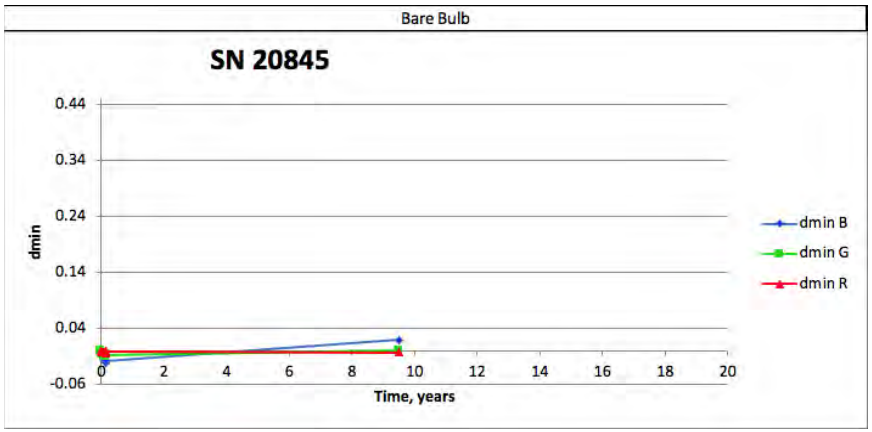


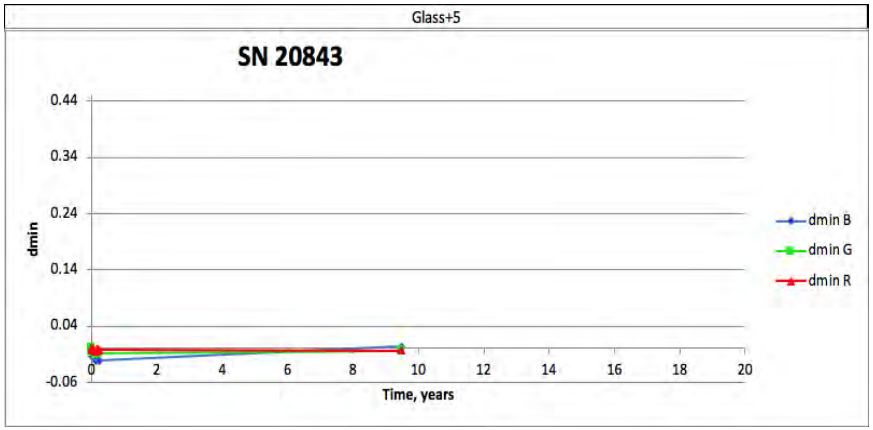


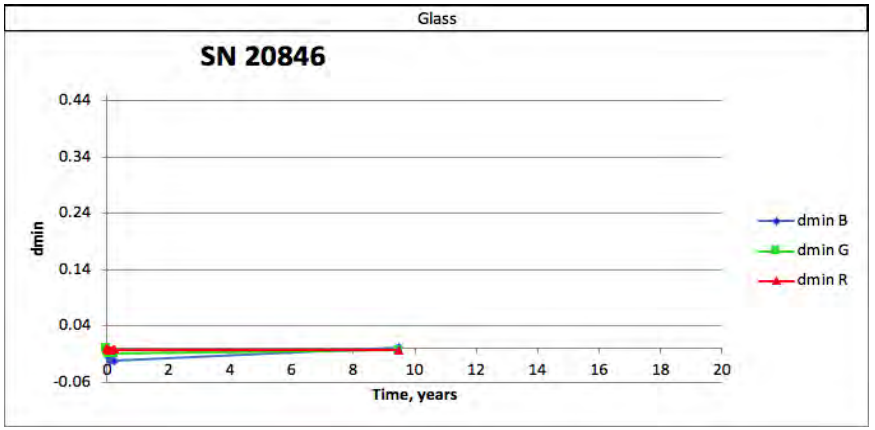


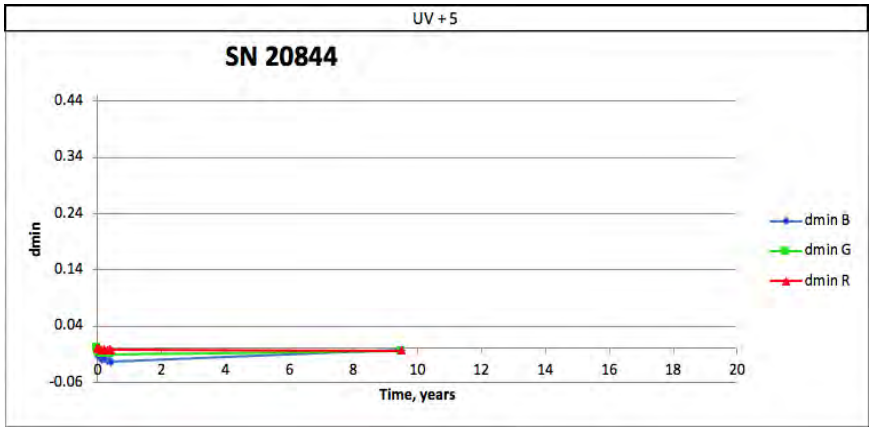


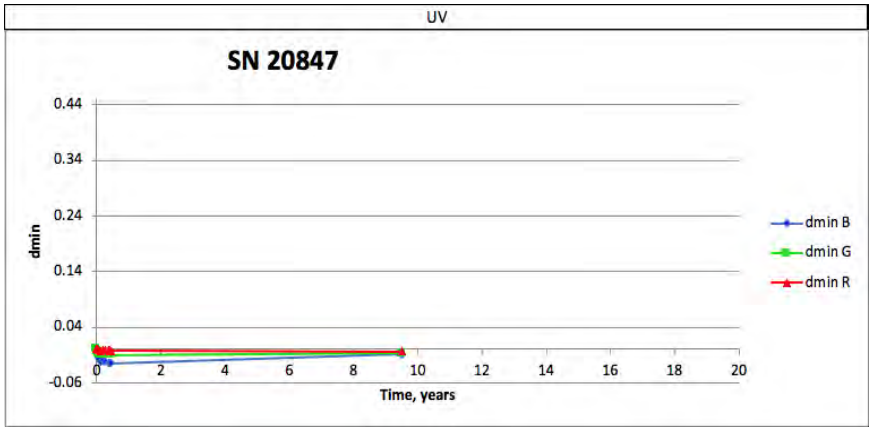
Matte Cotton Cellulose Paper With No OBAs in the Base Paper or in the Ink-Receptive Coating



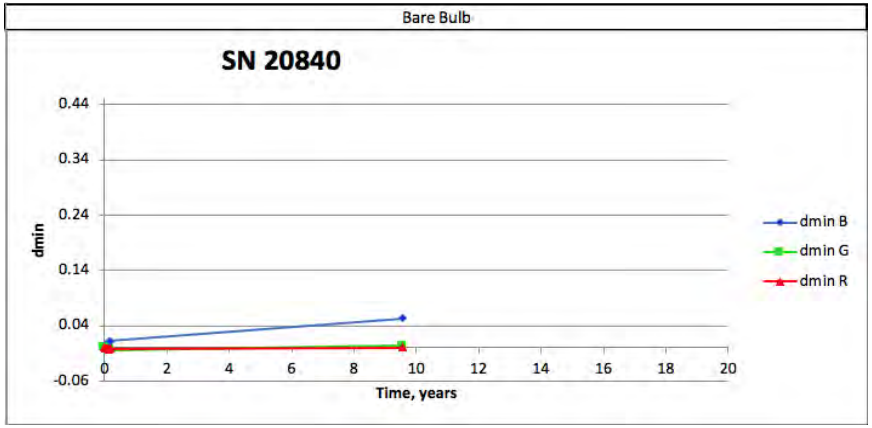


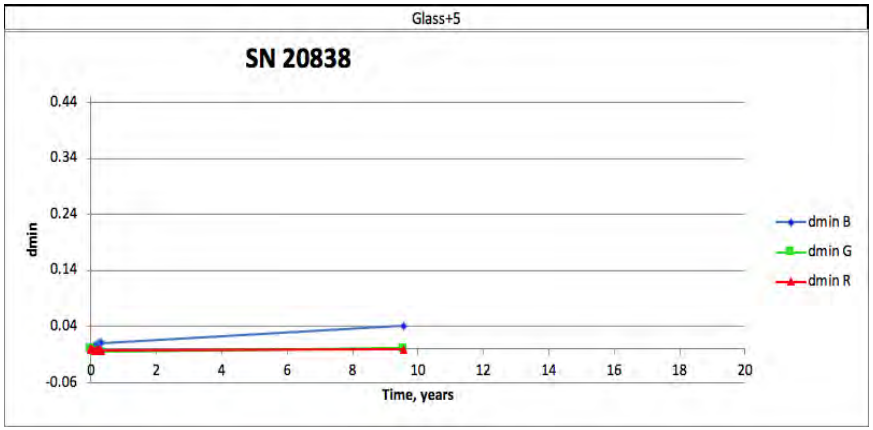


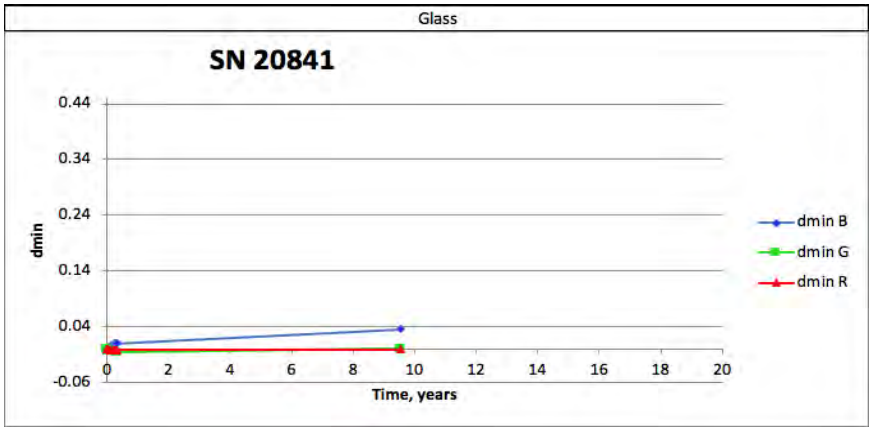


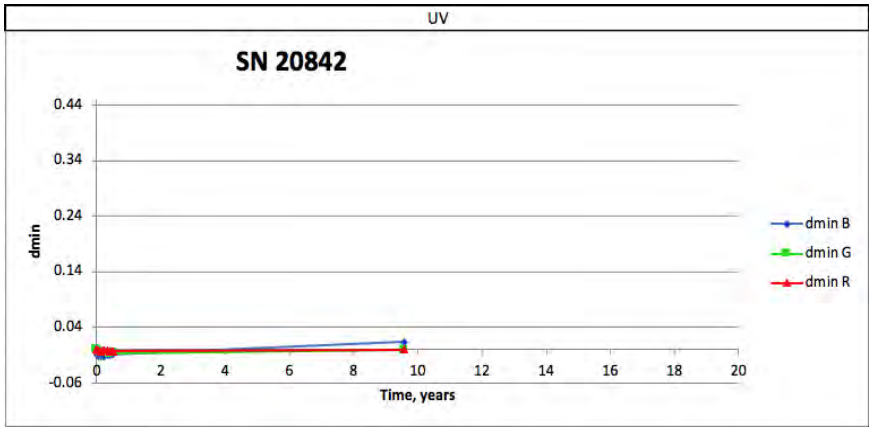


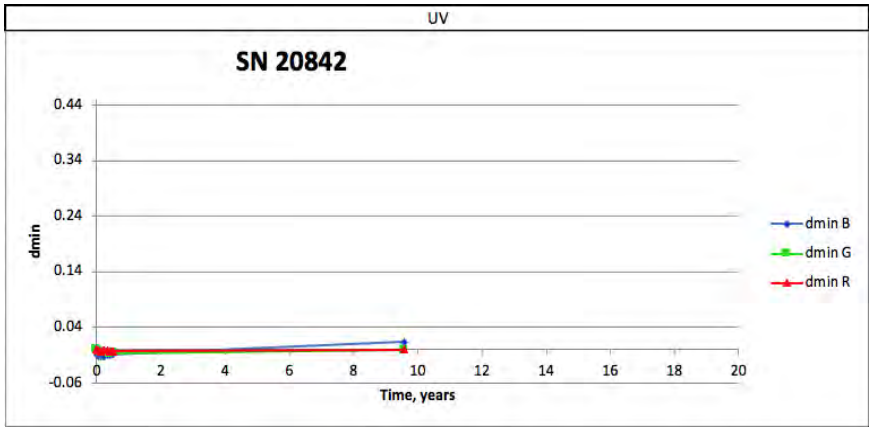
Matte Cotton Cellulose Paper With OBAs in the Base Paper and in the Ink-Receptive Coating











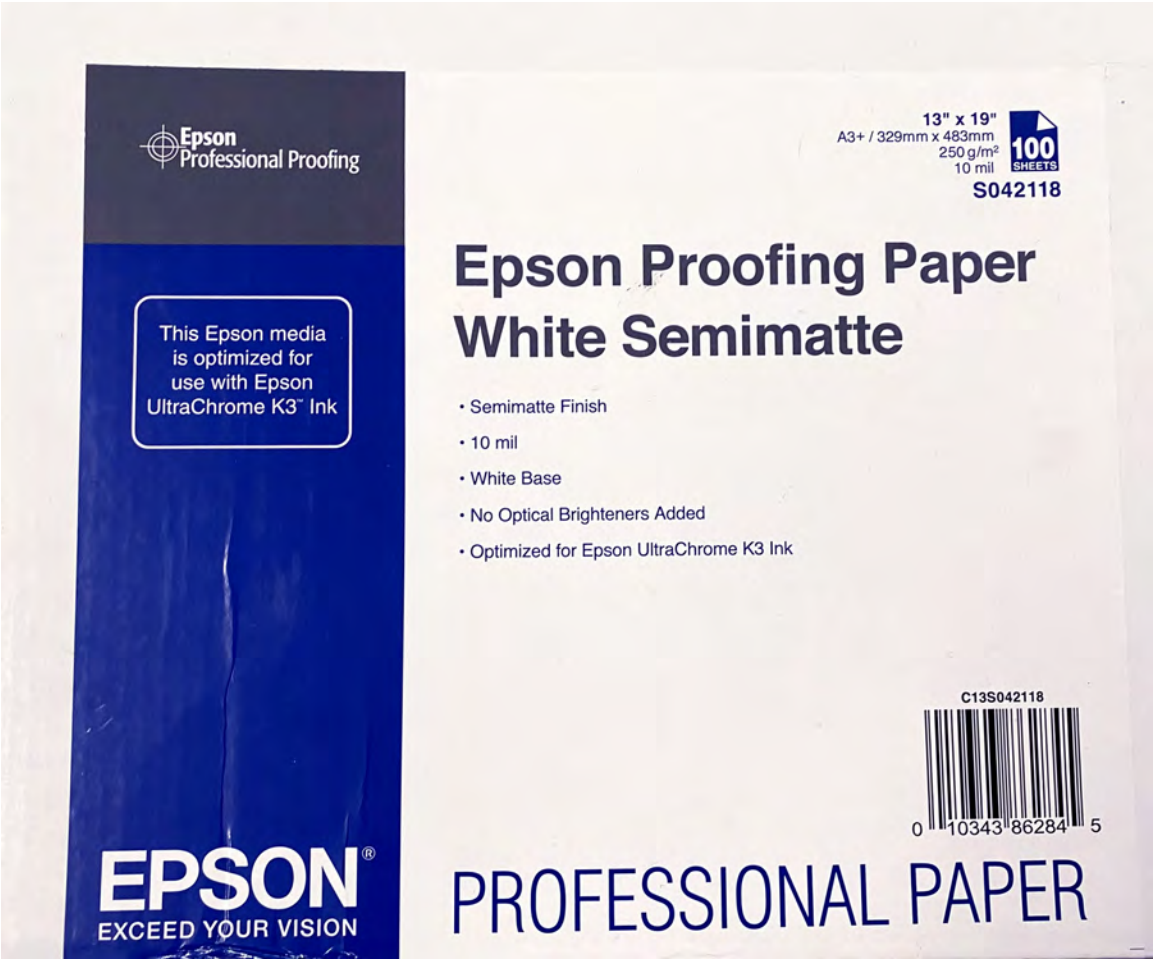
Preliminary Conclusions and Recommendations

1. OBAs should be avoided in ALL print materials, including inkjet prints, chromogenic prints (silver-halide color prints), and in traditional silver-gelatin B&W fiber-base and RC-base prints. OBAs serve NO useful purpose and are in general harmful to the permanence of prints.

2. Titanium Dioxide (TiO_2) should not be used as a whitening agent in either base paper or ink-receptive coatings of inkjet prints.

3. Barium Sulfate ($BaSO_4$) appears to be a satisfactory whitening agent for inkjet prints.

4. Inkjet prints and chromogenic prints should be protected from exposure to UV radiation by framing them with UV-absorbing acrylic glazing (e.g, Acrylite OP-3), or by illuminating exhibition areas with high-CRI LEDs, in which case traditional types of UV-absorbing glazing is not required. It is especially important to protect prints from exposure to daylight through window glass (>330nm.)



If a photographer prefers to make prints on a RC-base inkjet paper because of aesthetic or for certain practical reasons, the author tentatively recommends Epson Proofing Paper White Semimatte. This paper contains NO OBAs in either the ink receptive coating or in the RC base paper. The RC base paper does, however, contain TiO_2 in the top polyethylene layer, as all RC (PE) papers do. With a surface similar to many “Lustre” papers, it is available in a 13x19-inch sheet size and in rolls up to 60-inches wide. The paper is currently being tested at WIR.

“Archival Pigment Print”

1. The term “Archival Pigment Print” has in recent years become widely used in the gallery and fine art markets:

   a) The term is generally taken to mean that an inkjet print has been made with a 100% cotton cellulose paper containing no OBAs.

   b) RC-base inkjet papers are in general avoided, but there are some exceptions to this.

   c) Pigment inkjet inks have been used to make the prints. Usually with large-format printers made by Epson, Canon, or HP, and the prints are often made by the photographers themselves.

   d) Dye-based inkjet inks are NOT acceptable.

   e) The gallery and fine art markets strenuously avoid the use of the two words “inkjet” and “digital” in the naming of print processes. There are a few exceptions to this, although they are rare.

Papers that are Believed to be Suitable for “Archival Pigment Prints”

1) Most Canson Fine Art Papers that are advertised as being “100% Cotton and OBA-Free.”

2) Epson Legacy Fine Art Papers that are advertised as being “100% Cotton and OBA-Free.”

3) Most Hahnemühle Fine Art Papers that are advertised as being “100% Cotton and OBA-Free.”

References

1. *"The Wilhelm Analog and Digital Color Print Materials Reference Collection – 1971 to 2021."* Wilhelm Imaging Research, Inc., Rev. 20, March 10, 2021. The 261-page document is available in PDF format and may be downloaded at no cost from: www.wilhelm-research.com

2. Henry Wilhelm and Carol Brower (contributing author), "*The Permanence and Care of Color Photographs: Traditional and Digital Color Prints, Color Negatives, Slides, and Motion Pictures"* (pp. 69–77), Preservation Publishing Company, Grinnell, Iowa, U.S.A., 1993. The 761-page book is available in PDF/A format and may be downloaded at no cost from: www.wilhelm-research.com

3. Henry Wilhelm, *"A 15-Year History of Digital Printing Technology and Print Permanence in the Evolution of Digital Fine Art Photography – From 1991 to 2006,"* Final Program and Proceedings: IS&T's NIP22: The 22nd International Conference on Digital Printing Technologies (pp. 308–315), The Society for Imaging Science and Technology, Denver, Colorado, September 19, 2006. May be downloaded from: www.wilhelm-research.com

4. Henry Wilhelm, *"A Survey of Print Permanence in the 4x6-Inch Consumer Digital Print Market in 2004–2007,"* Technical Program, Abstracts, and Proceedings, IS&T's International Symposium on Technologies for Digital Fulfillment (pp. 43–47), The Society for Imaging Science and Technology. Las Vegas, Nevada, March 5, 2007. May be downloaded from: www.wilhelm-research.com

5. Henry Wilhelm, "*Light-Induced and Thermally-Induced Yellowish Stain Formation in Inkjet Prints and Traditional Chromogenic Color Photographs,"* Japan Hardcopy 2003: Proceedings of the Annual Conference of the Imaging Society of Japan (pp. 213–216), Tokyo, Japan, June 12, 2003. May be downloaded from www.wilhelm-research.com

6. Henry Wilhelm, "*Yellowish Stain Formation in Inkjet Prints and Traditional Silver-Halide Photographs,"* IS&T's NIP19: International Conference on Digital Printing Technologies: Final Program and Proceedings, pp. 444–449, The Society for Imaging Science and Technology, New Orleans, Louisiana U.S.A., September 28–October 3, 2003. May be downloaded from: www.wilhelm-research.com

7. Henry Wilhelm, Ken Boydston, Kabenla Armah, and Barbara C. Stahl, "*Use of a Multispectral Camera System and Very Small, Comprehensive 'Micropatch' Test Targets for Full Tonal Scale Colorimetric Evaluation of the Permanence of Digitally-Printed Color and B&W Photographs,"* Proceedings of the Imaging Conference Japan 2011, p. 131-134, The Imaging Society of Japan, Tokyo, Japan, 2011. May be downloaded from: www.wilhelm-research.com

8. Wilhelm Imaging Research, Inc., "WIR Print Permanence Ratings for a Broad Range of OBA-Free Canson Infinity Photo and Fine Art Papers Printed with the Latest Epson UltraChrome HDX Inks, the Latest Canon LUCIA PRO Inks, and HP Vivera Pigment Inks. This Comprehensive Report Also Includes WIR Print Permanence Ratings for Previous Generation Epson UltraChrome K3 Inks and Previous Generation Canon LUCIA Inks," June 1, 2020. May be downloaded from: www.wilhelm-research.com

9. Wilhelm Imaging Research, Inc., "*WIR Print Permanence Ratings for Epson SureColor P10000 and P20000 Printers with UltraChrome PRO Pigment Inks,"* February 15, 2019. May be downloaded from: www.wilhelm-research.com

10. Mark McCormick-Goodhart, "*TRACKING LILIS"* [Light Induced Low-Intensity Staining], Aardenburg Imaging and Archives, Lee, Massachusetts, May 18, 2020. May be downloaded from: www.aardenburg-imaging.com

11. Mark McCormick-Goodhart, "*LILIS REDUX*" [Light Induced Low-Intensity Staining], Aardenburg Imaging and Archives, Lee, Massachusetts, July 11, 2020. May be downloaded from: www.aardenburg-imaging.com

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