Imaging Permanence: Professional Photography

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Abstract

The advent of digital imaging has fundamentally changed the workflow of the printing industry and the photographic industry. The media used for printing digital images span a wide range of archival and light stability. Photographic laser recorders expose photographic papers of similar stability performance than traditional photo papers, however other hard-copy technologies and especially ink-jet media have fundamentally different characteristics. Electrophotography, dye-sublimation and ink-jet compete in the photo-like imaging market and their light fastness, dark stability and mechanical permanence will be compared.

Ink-jet with its versatility is the most successful among the photo or successors. Depending on the layer system used, polymer or porous, and the inks, pigment or dye-based, aqueous or solvent, the permanence can vary over orders of magnitude. Dark and light stability for such systems need to be taken into considerations. Photo permanence can be surpassed, but only with some compromise in photo image quality or gamut.

All components in an ink-jet system, the base, the ink-receiving layer, the colorants and the ink formulation contribute to the overall stability. The environmental factors, light, temperature, humidity, abrasion and air pollution have different effect on the different ink/media combinations. The influence of the various components and their interaction with the environmental factors will be discussed.

The traditional test methods in graphic arts or photography needed to be supplemented by additional test that are still being developed. A short overview about the current state can be given.

Digital Hardcopy Technologies

Table 1 summarizes features of several hardcopy technologies. In table 2, the image forming components are described The size and media limitation of electro-photography restricts its use to document printing and amateur photo. The quality limitation of electrostatic allows its use in grand format outdoor and screen printing applications. For professional photography, ink-jet printing is the most successful and widely used technology and its permanence characteristics as well as the components influencing permanence will be shortly described.

Table 1.

Technology	Image Creation	Image quality
Photo	Dye generated inside layer	Photo
Dye-sublimation	Dye diffusion into layer	Photo
Electrostatic	Transfer to surface	Screen printing
Electro-photography	Transfer to surface	Near photo
Ink-jet	Dyes absorbed in layer, pigment on top	Photo

Table 2.

Technology	Base	Colorant
Photo	Glossy RC, film	Dyes
Dye-sublimation	Glossy RC, film	Dyes
Electrostatic	Conductive coated papers	Pigments
Electrophoto-graphy	(Matt) coated papers, film	Pigments
Ink-jet	Matt coated papers, RC paper and film	Dyes or pigment

Permanence Considerations in Digital Hardcopy

A majority of professional digital output is done via digital enlargers on special photo papers, which exhibit similar permanence properties to the analogue photo papers. In addition, the range of light and dark stability of color negative photo is only about a factor of 2-3 from the least stable to the most stable. Ink-jet prints on the other hand can vary by much more depending on the ink and media used.

Factors influencing ink-jet print stability are the type of colorants, the ink formulation, the components and the structure of the media, chemical composition, mineral content, redox properties, types of polymers, additives and stabilizers used.

The environmental factors needed to be considered are light, temperature, relative humidity, water, mechanical stress, and air pollutants.

Light Stability

The ink solvents, the dye selected as well as its dilution have a major influence on light stability. Figure 1 shows a graph for several magenta dyes printed on the same polymer media at varying ink dilutions. A trade-off has to be made between the dilution of an ink which is beneficial for tone reproduction and the print light stability. Best dye-based polymer media prints are still superior to dye-based prints on any kind of porous paper.

Ink-jet pigment prints as well as other hardcopy technologies using pigments are generally more stable than photography and depending on pigment type and size may rival the outdoor durability of screen printing.

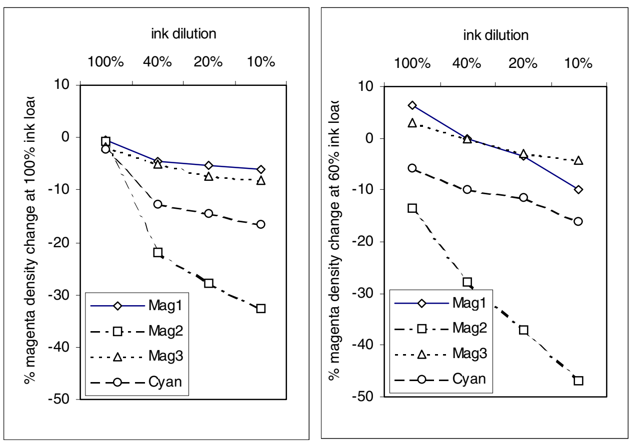


Figure 1. Density change after 10 Mluxh exposure as a function of ink dilution at an ink load of 100% (left) and 60% (right)

Archival and Humidity Stability

In thermal stability tests of hardcopy media as ink-jet or dye-sublimation prints humidity effects often override thermal effects. Color changes result from the diffusion of dots into neighboring white areas and make meaningful Arrhenius extrapolations difficult. Many hardcopy media show less thermal degradation than photo as long as a critical temperature of about 70°C is not attained. Dye-based ink-jet prints are very sensitive to relative humidity conditions above a certain threshold, whereby the threshold varies depending on the ink/media combination in the range of 60-90% r.h. Storage conditions as they are recommended for photo prints also apply to the storage of hardcopy media.

Water Fastness

As photographic prints are not weatherable full water fastness has not been a major concern in the development of digital hardcopy. Many of today's dye-based ink-jet prints will leave a mark when exposed to drops of water. Many pigment prints unless they are on a weatherable substrate, will show deformation of the base.

Pollutant Fading

Many prints porous media and especially nanoporous media show color degradation in full darkness due to the attack of air pollutants. This effect is very pronounced on dye-base media and especially strong with diluted inks. If printed samples of pollutant sensitive media are exposed to forced air flow in an atmosphere of normal air in total darkness, first loss of density maybe visible after several days or depending on the area in several weeks. The prints would be very stable in the same environment protected by frames or laminated. The mechanism of this process is the topic a lot of research and will be discussed in several papers of this conference. Pollutant fading is often the primary cause of failure before light or thermal degradation in unprotected nanoporous desk-top prints.

Abrasion and Mechanical Stress

As for light stability, pollutant fading and thermal degradation hardcopy prints with pigmented colorants often surpass the dye-based prints and photographic prints by far. They are, however, prone to abrasion, scuff and layer des-integration. On glossy media, they are only loosely bound on top of the surface by the pigment-binder of the ink, which may degrade faster than the pigments. Even in porous layers, pigments do not penetrate deep enough to be protected. When using laminates, pigment migration into the glue layer is sometimes observed at temperatures as low as 40° C.

Permanence Testing

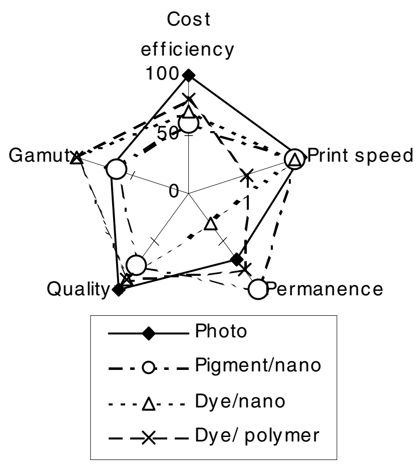
Several standard committees world–wide are concerned with the permanence of images. For the photographic industry, ANSI/PIMA expert group is working on updating the photographic color image standard[1] to extend to digital hardcopy, but a final suggestion for a standard or test methods are not available. There is general agreement that the following properties need to be tested: light stability, (covered and uncovered with glass), humidity fastness with very precise humidity control, thermal stability in the range of 40°-65° C and pollutant sensitivity. As all the degradation mechanisms run in parallel, the lowest life expectancy from any of the tests needs to be considered for the overall life expectancy of a print. Pollutant and humidity degradation will be very difficult to predict in absolute terms as the humidity conditions and pollutant concen-trations vary very much from location to location. A method for brittleness and abrasion is also under discussion.

Conclusion

Digital hardcopy technologies of full photographic image quality (dye sublimation, and dye-based ink jet) do reach or even surpass photographic permanence concerning light, but are more sensitive to temperature or humidity respectively. Hardcopy methods using pigments surpass photographic stability on most respect except for abrasion and mechanical resistance and cannot provide the same gamut or gloss as photographic prints.

Table 3.

Technology	Permanence light	Archival, air, thermal, humidity	Mechanical
Dye-subli.	= photo	< photo	= photo
Electrostatic	>> photo	>> photo	> photo
Electrophoto-Graphy	> photo	Depends on paper	< photo
Ink-jet, dye/polymer	= photo	< photo (humidity)	= photo
Ink-jet dye/porous	< photo	< photo (air, humidity)	< photo
Ink-jet pigment	> photo	> photo	< photo



References

1. American National Standards Institute, Inc., ANSI/NAPM IT9.)-1996, American National Standard for Imaging Materials- Stability of Color Photographic Images-Methods for measuring, American National Standards Institute, New York, NY, 1996 .

Biography

R. Hofmann has a degree in physical chemistry from the University of Goettingen. After postdoctoral studies in atmospheric sciences at the University of Colorado, she joined Ciba for research in the field of analytical chemistry and laser applications. Since she joined ILFORD in 1985 she has been involved in research and applications for digital photography, photographic colour science and image evaluation of hardcopy technologies. She is currently head of R&D for ILFORD focuses on the development of tests methods for ink-jet media.