PHOTOGRAPHS

5.4 Creating Long-Lasting Inkjet Prints

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INTRODUCTION

Tremendous growth has been made in digital photography during the past decade. Now one can buy affordable scanners, digital cameras, high-quality inkjet printers, and many other output devices for creating color prints (Wilhelm, February 2002: 32). Fortunately, as the technology is rapidly changing, the quality of materials is improving. Both professional and amateur photographers can benefit from this technology to create color prints from digitized files that are now, according to the research of Henry Wilhelm, as long lasting as chromogenic color photographs (Wilhelm, February 2002: 33).

Currently, color prints made from digital files are not considered preservation quality, and it is difficult to ensure long-term preservation of and access to the digital images themselves without a formal digital preservation program. There are ways of creating long-lasting prints, however, by understanding the materials employed and controlling the conditions under which the prints are stored. The three most important factors that affect the life of a digital print are the quality of materials used such as the colorant (dye vs. pigment) and paper; the combination of materials used; and afterwards, the storage and display of the prints.

PRINTING TECHNOLOGIES

Digital artists can use many output devices to create their work. The most common ones include the digital photo process, dye sublimation, electrography, and the inkjet, which came into significant use in 1998.

The digital photo processor (examples include the Fuji Pictrography and Kodak Pegasus) is a high-end, large-format device used in many photo labs to print snapshots. The process, a combination of photographic and thermal dye diffusion methods, involves exposing a sheet of photosensitive "donor" paper to laser diodes (LD). Small amounts of water and heat are applied to create the dye image on the donor paper, which is then transferred to the "receiving" paper with a combination of heat and pressure. The receiving paper with its transferred dyes is peeled off and separated from the donor paper.

Dye sublimation, used by the Kodak 8500 dye-sub printer, works with a single-color ribbon containing dye heated by a special head that runs the width of the paper. When the head heats up, it vaporizes (sublimates) the dye in that location. The dye, now in gaseous form, is absorbed into the paper. Since the paper receives the dye layers separately, the print can result in a smooth, seamless image. Unfortunately, only a small amount of information about the permanence of these prints is available (Image Permanence Institute, 2004).

Electrography includes laser prints and photocopies. In this process, the toner is transferred to an uncoated paper base then fused into place. The images composed of pigment particles are generally stable but are not often used for photo-quality printing.

Of the four processes mentioned, inkjet is the most widely used printing technology for digital artists. Inkjet systems are based on the flow of colored ink from a nozzle that is deposited on a support to form an image. There are two types of technologies for inkjet printers: continuous flow and drop-on-demand or impulse jet. The Iris printer and popular Epson Stylus® Photo printers are the best known of these systems.

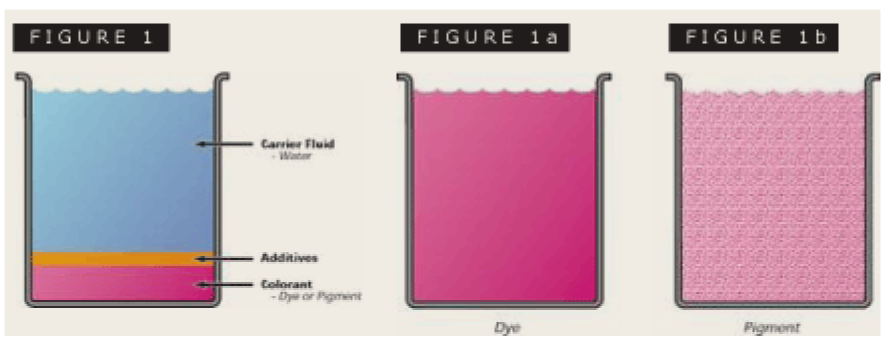
Continuous-flow inkjet printers use an electrostatic charge to push ink out of the printhead reservoir. As the ink droplets are released, charged droplets are deflected and recycled while the uncharged particles spray a continuous stream of microscopic ink droplets onto a flat substrate. The IRIS printer is an example of the continuous-flow printer.

The other type of printer, drop-on-demand, uses only ink droplets needed to form the image produced. There are two main types: thermal and piezoelectric. The thermal process, used by the Canon Bubble Jet Printer, is based on heating a resister in the printhead. As the printhead heats up, a bubble is produced and the increased pressure inside the printhead chamber forces the ink droplet out. After the bubble collapses, more ink is drawn from the reservoir. The piezoelectric effect (employed by Epson printers) uses a crystalline material inside the printhead reservoir to create an electric field, which produces the pressure instead of heat to release the ink. [1]

MATERIALS

Ink

For inkjet printing, colorants come in two basic types: dye-based and pigment-based. The dye or pigment is primarily suspended in water. Another solvent, such as glycol or glycerin, is added to the mixture to control the ink's drying time and thickness during manufacturing. Small amounts of proprietary products (additives) are included to help control ink-drop formation, printhead corrosion, pH level, lightfastness, and color intensity (Martin 2004: 49). *See* Figure 1. Both have their advantages and disadvantages.



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Dyes, composed of single molecules, can be easily dissolved in water (*see* Figure 1a *)* and, being transparent, can provide brilliant saturated color. They are able to refract or scatter very little light. But they fade more quickly than pigments, are very sensitive to water and humidity, and are more vulnerable to environmental gasses such as ozone.

Pigments, made up of a thousand molecules, are much *larger than their dye counterparts. Thus, pigment-based* inks have the advantage of being more stable, significantly more lightfast, and less affected by environmental factors. The disadvantage of these types of inks is that they do not dissolve easily in water (*see* Figure1b), as the pigment remains dispersed in the carrier. Their color range is smaller, producing less saturated and duller colors, and they have a greater tendency toward metamerism (shifting of colors under different light sources).

Paper

There are four broad categories of paper: bond paper, inkjet paper, fine art papers, and coated papers.

Bond paper is the plain paper used in laser printers and office copiers. This paper is made of wood pulp, which contains cellulose fibers, and lignin and is sized with rosin. The sizing and the lignin eventually destroy the image.

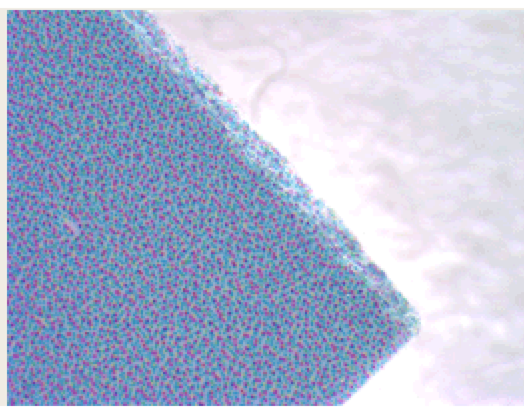
Inkjet paper , of slightly better quality than bond paper, has improved external sizings such as starches, polymers, and pigments. These sizes make the surface of the paper whiter and more receptive to inkjet output.

Fine art papers such as Arches, Rives, and Somerset have been used for watercolors, drawings, and traditional printmaking. The papers are made from 100 percent cotton rag (alpha-cellulose), and there is no rosin sizing or lignin. Sometimes an alkaline buffering agent is added such as calcium carbonate. The fine art papers are usually combined with dye-based inks and used with IRIS printers.

Coated inkjet papers have a receptor coating to aid in receiving the inks. Coated papers can closely resemble traditional color print supports. These coatings create a higher-color range (especially for pigment-based inks), better image quality, greater brightness, and ink stability, which make them less likely to bleed. *See*Figure 2.Coatings may include materials such as silica, clay, titanium dioxide, calcium carbonate, and various polymers (Johnson 2003: 235, and Jürgens 1999: 43). There are many types of coated papers on the market. In general, one of the coatings listed below can be applied to a standard resin-coated paper (a paper base sandwiched between two polyethylene layers), which reduces curling from heavy ink or a paper-based support. One can categorize these coatings as follows:

FIGURE 2

Magnified view of Hewlett Packard swellable paper (glossy) printed with dye-based inks



- Swellable polymer: a nonporous coating made with organic polymers that expands and encapsulates the ink after it strikes the paper. The coating increases brightness by keeping the colorants from spreading and protects the image from atmospheric pollutants. These papers are best used with dye-based inks. (Johnson 2003: 237)
- Microporous: these coatings were developed for rapid ink uptake since swellable papers have the disadvantage of slow ink drying, loss of gloss after printing and curling before and after printing. Microporous coatings contain small, inorganic particles dispersed in a synthetic binder such as polyvinyl acetate (Tarrant 2002: 30) or polyvinyl alcohol (Kasahara 1998:151) which create holes in the coating. The ink is absorbed into these holes, which results in faster drying and prevents the ink from smearing. The paper has a higher resistance to moisture and humidities. However, the colorants are susceptible to atmospheric pollutants and cause the color in the print to shift.[2] These papers offer excellent image quality and can have a glossy, luster, or matte finish. They are best used with pigment-based inks.

In short, a swellable paper is slower to dry and remains sensitive to high humidity levels. However, it offers protection to dye colorants by fixing them within the coating. A microporous paper dries quicker, is less sensitive to humidity change and provides less protection to dye-based inks. Pigment-based inks should be used with microporous papers.

LONG-LASTING COMBINATIONS

The following combinations are based on the research of Henry Wilhelm and The National Register of Historic Places and National Historic Landmarks Survey Photo Policy Expansion (NR-NHL),[3] which has requirements for photographs that are submitted as official documentation.

The images are expected to last 75 years or longer before showing signs of considerable fading, deterioration, or discoloration. Black-and-white silver-gelatin fiber-based papers meet the NR-NHL standards. Recently, color prints from digitized files prepared with specific papers and colorants have been included. (Please note that photographs processed with chromogenic processing [C-41] or printed on chromogenic papers do not meet these requirements.)

Some examples include the following:

1. Epson's UltraChrome pigmented-based inks with Epson Premium Photo Papers (glossy, semigloss, luster, and semimatte finishes); Epson Fine Art Papers (UltraSmooth, Velvet, and Textured), Epson Enhanced Matte Papers, and Somerset Velvet for Epson.
2. Epson Picture Mate Inks with Epson Picture Mate Photo Papers.
3. Hewlett-Packard (HP) Vivera dye-based ink set (97) combined with HP Premium Plus Papers and HP Premium Photo Papers (high gloss, glossy, and soft gloss finishes).

STORAGE CONDITIONS

Controlling the relative humidity (RH) is one of the most important factors in preserving digital prints from deterioration. High relative humidity acts to speed up the detrimental chemical reactions (paper and plastics all absorb moisture from the air) and can lead to the fading and discoloration. Inks in digital prints can bleed through the paper support or the dyes can easily bleed at high humidities. Color shift and changes in density can also occur. Relative humidity should be kept at a stable point below 50%. Whenever possible the RH should be maintained between 30%-40% with minimal fluctuations, though never below 15%-20%. Relative humidities above 60% can quickly lead to noticeable deterioration.

Control of temperature is also very important. Like RH, elevated temperatures speed up deterioration. High temperatures can cause rapid color fading, increased yellowing, especially in light or white areas and dye degradation and diffusion. Temperature should be maintained between 65° and 70°F and seasonal fluctuations should be kept to a minimum. Such changes cause stresses and lead to warping of the support.[4]

Light is another factor that causes deterioration. Most dangerous is ultraviolet radiation, which is present in natural daylight, artificial fluorescent light, and the tungsten halogen track lights that are popular in the museums. All light can cause the paper support to become weak, and discolor, as well as yellow the coatings. Image fading, color-balance changes, and yellow stain formation can also occur. (WilhelmOctober 2003:446)

Air purity is critical in the life span of inkjet prints since the dyes and pigments are much more susceptible to air pollution than a traditional photograph (color or black and white), document or watercolor. Sulfur, particulate matter, and other substances abound in urban air. All of these do irreparable damage. Sulfur dioxide, nitrogen dioxide, ozone, peroxides, and formaldehyde can react with the digital print causing fading and staining. Particulate matter can settle on prints and cause abrasion on coated papers.

SUGGESTIONS ON CREATING AND MAINTAINING PERMANENCE

- Understand outside permanence testing results. For example visit Henry Wilhelm's Web site (www.wilhelm-research.com) or Aardenburg Imaging (www.aardenburg-imaging.com). Join discussion groups such as the ones on Yahoo! Groups, Google, and LinkedIn. The new technology is challenging the traditional ideas about photography. One needs to adjust expectations.
- Select long-lasting colorants. For example, pigment-based inks are more stable than dye-based inks but tend to have a smaller color range. Currently, companies are improving the dye-based inks permanence and the color range of the pigment-based inks.
- Select archival paper such as 100% cotton rag. For coated papers, it is recommended that the paper bases used should be acid-free, buffered, lignin-free and optical brightener-free.
- Match media and paper correctly to get the optimum permanence (see information from Wilhelm's and Aardenburg Imaging's test results along with manufacturers websites for product information). Permanence tests are specific to a particular type of ink and dye on a specific paper/substrate. Substituting materials will not yield the same results. Third party inks, even though less expensive may not provide the same value. If print quality and durability are a concern, it is best to use the brand-name inks.
- After printing, keep prints away from light or display behind glass, which decreases airflow, fading from gasses and some UV exposure problems.
- Cold storage (near 32°F) of these materials is recommended like with other traditional color materials. This may especially be important during this transitional period given the short life expectancy and lack of information on digital images. (Wagner March 2004)
- If cold storage is not possible, store prints in a dark, dry and cool place. Keep humidity fluctuations to a minimum. The conditions should be 68°F (20°C) or lower with 30–40% RH.
- Store prints flat using archival materials that have met the requirements of the International Organization for Standardization (ISO 18902), specifically the Photographic Activity Test (ISO Standard 18916). Place prints in individual enclosures. Don't use paper clips, rubber bands or pressure-sensitive tape.
- Keep prints away from oxidizing materials such as household chemicals.

Currently, there are no standards for color images made from digitized files.[5] The suggestions above are based on the current environmental and storage conditions for traditional photographic media.

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NOTES

1. For more information about printing technologies see chapter 3 in Harald Johnson's Mastering Digital Printing.
2. In 2000, an Orange Shift problem resulted with the Epson Premium Glossy and Luster Photo microporous papers. Shortly after printing on these papers, sometimes even after 24 hours, a severe color shift occurred, and sometimes shifting the image to a bright orange. Even though coatings provide better image quality they also allow gasses to more easily permeate the paper. Epson has since reformulated the papers.
3. See https://www.nps.gov/nr/publications/bulletins/photopolicy/index.htm for more information.
4. Cold storage (near 32°F) of these materials may be another option since it is highly recommended method for other traditional color materials. See Henry Wilhelm's The Care and Permanence of Color Photographs for more information on cold storage.
5. "However, research within ASTM International Subcommittee D01.57 is active, and that in our January meeting we hope to continue the development of a standard specification. We already have a test method that will

work, with some adjustments and numerous round-robin verifications; we have a major manufacturer of printers and inks that has agreed to send a technical representative; and we have artists who use the printed digital media for art: all essential players in any effort to write a consensus standard." (Gottsegen: August 2006)

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