PRINTERS AND PRINTS

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PRINTERS

Q.: Do pigment inks clog a printer more frequently than dye inks?
A.: Not really, although the nature of the inks may suggest that. The dye-based inks are a solution of a dye, usually in water containing some additives. The main purpose of the additives is to control viscosity, wetting of the paper and drying of the print. The inks are intrinsically stable unless the ink is allowed to dry.

The pigment-based inks are dispersions of very fine solid particles in water containing some additives. The pigment particles are coated with a dispersant which adheres to the surface of the pigment, reduces the attraction between particles, makes the surface compatible with water and improves the optical properties of the ink. The pigment dispersions are sensitive to extreme temperatures, mechanical shear, and other variables. The condition of a pigment-based ink depends therefore how the cartridge has been stored. The pigment particles may settle. The ink cartridge should be shaken before unwrapping and installing to redistribute the pigment. If the cartridges are left a long time in the printer, some of the pigment particles will settle and cause the print to be lighter. If the pigment particles in one cartridge settle faster than in another, a color shift will occur.

The particles in a pigment-based ink are so small that they pass easily through the jets of the printer, unless the ink dries out and the particles stick together. In actual use, properly prepared pigment-based inks do not clog the printer jets more frequently than the dye-based inks.
More information on pigment dispersions is available in my book “Dispersions”, (1999).

Q.: Which printer should I buy?
A.: I assume that you have enough space for a tabloid (13” wide print) size printer. The Epson and Canon printers use different techniques for the deposition of ink (jet or bubble) but this is not a main feature distinguishing printers. The main difference between printers is the ink they are using: a dye-based ink or a pigment based ink. Sublimation printers, which deposit the dye vapor, can make a letter size or smaller print.

The first decision in the printer selection process is to choose a dye-based ink printer or a pigment-based ink printer.

The print quality no longer favors dye-based inks. Although the old pigment prints were dull and exhibited metamerism (illumination dependent color change), the new pigment-based inks have been greatly improved. I have compared prints made with dyebased and pigment-based inks. Both inks make beautiful prints. An exact comparison of inks is complicated by other variables, such as the ink system, the printer hardware, the printer profile, and the paper. In my opinion, the print quality is not a valid reason for preferring either the dye-based or pigment-based inks.

The unquestionable advantage of the pigment-based inks is the durability of the print. Pigment prints are more lightfast than prints made with dye-based inks. The resistance to fading is frequently expressed with the number of years the prints are supposed to last. Prints made with dye-based inks are claimed to last 35 years, and the prints made with pigment inks 71 or up to 200 years! These numbers used by reputable print manufacturers and photographic magazines have no scientific basis. The accelerated fading tests can only indicate that under the test conditions the pigment prints are more fade resistant than the dye prints. To express this result with an exact number of years is a meaningless speculation. Although pigment prints are certainly more resistant to fading, the light fastness of prints made with dye-based inks on a suitable paper is considerable. The prints I have made with dye-based inks on Epson Premium Glossy or ColorLife Photo paper have not faded noticeably in three years. Undoubtedly, the light fastness of dye-based inks is adequate for photographic exhibitions and print contests. The cost of the ink is an important factor. Although it is difficult to measure which printer uses more ink, the pigment-based inks are more expensive.

The cost of the ink can be reduced by returning the cartridge for a refund. (The Staples stationary store in Wilmington offers a $ 3.00 credit per cartridge).

The speed of printing is important, especially for professional use. New printers are much faster then the models they have replaced but a speed and a print quality do not go hand in hand. The Canon i-9900 can make a 13x19 print in less than two minutes. The Epson R2400 needs over four minutes for a 13x19 print but the print quality is superior. The productivity of the printer depends on the paper feed as well. A loading tray that can hold at least 50 sheets is essential for printing hundreds of postcards.

Most of the new printers can print CD and DVD labels

If you find it difficult to decide which printer to buy, the print manufacturers can make the decision for you. All new Epson prosumer or professional quality printers use pigment based ink. It seems that the venerable Epson 1280 printer will not be replaced by a newer dye-based ink printer. Canon is joining Epson with the new PIXMA Pro 9500 pigment printer, although Canon continues with dye-based printers: The new PIXMA Pro 9000 printer with the eight dye ChromaLife 100 system, and the i-9900 printer with the eight color ChromaPlus dye system.

Q.: How do the pigment ink systems differ?
A.: Epson has now two sets of pigment-based inks: the Ultrachrome K3 ink system has CcMmYK colors with three blacks, are used in Stylus Photo R2400, 4800, 7800, and the 9800 printers (13, 17, 24, or 36 inches wide). The letter size Stylus Photo R800 and the 13” wide R1800 printers have seven UltraChrome High-Gloss colors: the usual cyan, magenta, yellow plus a red, blue and two blacks. The ink set contains a gloss optimizer for glossy paper as well. The droplet size is very small (1.5 picoliters vs.2.0) but a 20x loupe is needed to see the difference on a print.

The new inks with two or especially with three inks are superior for black-and white prints. The Epson Stylus 2400 printer has nine cartridges but only eight cartridges are loaded at a time in the printer. The Photo Black and Mate Black can be swapped to fit the media. The Canon pigment-ink printer PIXMA Pro 9500 has ten ink cartridges, including a gray, black, and matte black. Unlike the Epson K3 system, all three Canon black cartridges are in the printer. The printer is new and tests are pending.

Q.: I have the Photoshop CS2. How can I get a custom color profile for my printer and the paper?
A.: The color profiles supplied with the printer software are quite good, although not perfect. Custom made profiles cost between $25 and $50. They can be ordered from www.datamediastore.com for $25. If you have an Epson printer, you can order the profile from www.Epson.com. Select USA>Drivers & Support > Printers > Drivers & Downloads. Select your printer from the list and select the ICC Printer Profile for your operating system. Download the profile for the paper you are using and install it.

PRINTS

Q.: You have stated that prints from a digital SLR camera are sharper than prints originating from a film camera but film has a more information. Is this statement contradictory?
A.: Not necessarily. At the beginning of the digital revolution, it was believed that a print made with a digital camera could not be as sharp as a print made by scanning a slide. As we know now, prints from a digital camera can appear sharper. Although film has more information, even after scanning, than a digitally captured image, the grain of film limits the apparent sharpness of the print. Images from a good

digital camera are virtually noiseless, even at the ISO 400 setting.

The unexpected sharpness of digital prints is a result of digital manipulation as well. Sharpening of the image does not increase the resolution but creates an optical illusion of greater sharpness. If more pixels are needed for a larger print, the file size can be increased by upsampling. Software, such as PhotoZoom and Genuine Fractals, is available to increase the file size by interpolation and digital wizardry. Photography is intertwined with graphic imaging.

Sharpness is not the only important factor determining the quality of the print. Although the digital prints are sharp, they do not have quite the tonality of the print originating from film. Film has more information for a smooth reproduction of color than a digitally captured image. For this reason, film is still the preferred medium for certain applications. The proven archival stability is another asset of film.

Q: Digital prints have been reported to last over hundred years. How do the people who make such claims know the lifetime of prints?

A.: They really don't know it. The reported numbers are guesses and have no scientific basis whatsoever. I do not know how these numbers were derived because I have not seen a rational explanation.

The prediction of the print stability needs several pieces of information: the results of a reliable accelerated light fastness test, the knowledge how color fades with time, the acceptable limit of fading, and the validity of the laboratory test results when applied to actual real life conditions.

The fading of prints is a relatively slow process. It may take months to see a noticeable difference in the color of the print. Therefore, an accelerated exposure test is used to measure fading. The light fastness of dyes on paper or textiles is evaluated by covering the half of the sample with black paper and exposing the assembly to light. The light source is usually xenon arc in an apparatus designed for light fastness tests. The conditions (illumination, moisture, and temperature) are carefully controlled. The intensity of light is calibrated instrumentally or by using a dyed standard. The illumination is filtered to simulate daylight. The samples are exposed to the standard light source and the time noted when the first noticeable color change can be seen. Alternatively, the time of the exposure is varied and the color change is measured instrumentally for each time interval. The fading of the dyed species is sometimes plotted against time and the curve is used to describe light fastness.

All dyes used for making color prints do not have the same light fastness, some colors may degrade sooner than others. Consequently, the light fastness of all dyes or pigments used for printing must be tested.

The accelerated test can be used to compare the light fastness of dyes or pigments. The test report may state that under the test conditions the sample A is more lightfast than sample B. Another way to evaluate the light fastness is to report, as an example, that sample A had the light fastness of 20 hours and the sample B of 10 hours. The change of color can be expressed also in delta E values for a given exposure time.

If the test is used to determine the useful life time of the print the complexity of the test increases enormously. The maximum acceptable color change must be defined. A reasonable limit may be the extent of fading that eliminates detail or changes noticeably the color balance of the print.

The really complicated part of the life time estimation is the understanding how the print fades. To predict how long a print will last, we must know the kinetics of fading, that is, the rate at which the degradation occurs. In other words, we must know how the color of a print changes with time and express the change with numbers. In order to extrapolate the color change over a long period of time, we must assume that these numbers will be constant. Radioactive decay can be predicted with a great accuracy because the environment, heat, moisture, and the surrounding matrix have no effect on the rate of decay. Fading of dyes and pigments is quite different. Fading of dyes in solution, such as a photochemical fading or chemical bleaching, is relatively simple kinetically. The fading of dyes on fibers, as my own research has shown, is a complex process affected by several variables. Even under controlled conditions when time is the only variable, fading of dyes does not obey a simple kinetic order. Numerous research papers, including my own, have attempted to find an equation which would relate the fading of a dyed textile linearly to exposure time. This has been successful only in a limited number of cases. Usually the plot of color against the exposure time is a curve. This is the situation for dyes on paper as well. To use a curve to predict fading by extrapolation is a risky procedure.

If the prediction of fading under test conditions is not difficult enough, it is even more difficult to decide how the laboratory test relates to real life conditions. It may be assumed that the light fastness of the prints will have in real life the same stability rank as in the test. This may not be true, however, because the fading curves may cross each other.

This state of uncertainty is complicated further when trying to express the lifetime of a print with the number of years. It appears reasonable to compare the light fastness of the print to a known standard. Properly stored reversal color (Cibachrome) prints are the most lightfast of the color print media and may serve as a suitable reference. If an accelerated laboratory test shows a digital print to be more lightfast than a silver based color print, then the temptation is to use this information to predict the life time of the digital print. To use the silver based color print as the reference has its limitations, however. The light fastness of a silver based print is highly variable and depends on the paper, processing, as well as the storage conditions. Some photographs printed from a negative have faded within a year, some have lasted decades. The color of prints does not change only when exposed to light but during dark storage as well. The simple truth is that the longevity of digital prints is not known.

The light fastness of digital prints was inadequate at the beginning but has been greatly improved. Digital ink prints, especially the pigment prints, seem to be now as light fast as the silver based color prints. Time will tell how long digital prints will last. To predict the stability of digital prints with a number of years does not make sense, because the stability of silver based color prints has not been described with such numbers either.

COLOR OF PRINTS

Q.: What is color accuracy, e.g. “Extremely high (Avg. Delta E = 8.65)” and how is it measured?
A.: Color accuracy is measured by the ICC (International Color Consortium) test procedure. A standard color chart (T-8 test target) is photographed or scanned and the resulting image is compared to the original standard. The colors of the image and the original standard are measured and the color difference is expressed by the L*a*b* chromaticity coordinates as a Delta E value. I would not characterize a Delta E 8.65 value as “extremely high color accuracy”. This color difference is quite visible.

Q.: What is the difference between color ranges (gamut) for cameras, scanners, and printers?
A.: Each film, digital camera, scanner, monitor, or printer has its own range of color, the color gamut. The color sensitivity, consequently the gamut, of CCD sensors in scanners and cameras varies. The color systems RGB, sRGB, and CMYK have each a different gamut as well. A gamut of a printer may be slightly wider than that of the monitor, meaning that some colors the printer can print may not be visible on the monitor. Kodak has therefore designed the PhotoProRGB wide gamut color space.

Because the gamut of each device can vary, it is not possible to rank the cameras, scanners and printers in the order of their gamut range. As a rough approximation, a transparency film has the widest gamut, which is narrower after scanning, but wider than the gamut of digital cameras and inkjet printers.

Q.: Is black a color?
A: This is a frequently asked question. Colors are created by absorption of light. Black is a color because a black surface absorbs light. A black-and-white print is called a monochrome print, not a zerochrome or

antichrome print.

Black is a very important color. No textile dye line is complete without a black dye.

Q.: If black is a color, is not white a color as well?
A.: An ideal white surface does not absorb light and reflects all of the illuminating light. By a theoretical definition, a white surface is free from color. In real life, white surfaces absorb some of the illuminating light and the word "white" is commonly used to describe a real white or a nearly white item. A white photo paper reflects only about 93% of the light, depending on the quality of paper. Some photographic papers are ivory colored but the prints are considered to be black-and-white. A white dye does not exist and a fabric is made white by bleaching to remove the colored substances. White pigments, such as titanium dioxide, reflect light and are used to cover the off-white appearance of a surface.

Q.: Why is the definition of a monochrome print so controversial?
A.: A black-and white print when toned to sepia, blue or any other shade, is converted to a color print having one color. The black-and-white prints, before or after toning, are therefore called monochrome prints. This definition was complicated by photographers who toned only a part of the black-and-white print. Now the print had two colors: the original black and the color of the toned area. PSA decided that the partially toned prints are still monochrome prints and allowed a black-and-white print to have a tone color in addition to black. This inexact definition of a monochrome print has been interpreted by some photographers that a monochrome prints may have two colors. PSA has revised the definition of a monochrome print but allows the use of the old two-color definition by international exhibitions and the controversy continues.

Q.: When is a color print a monochrome print?
A.: The word monochrome means "one color", hence a monochrome print has only one color. In order to decide that a color print is a monochrome print we have to understand the meaning of the word "color". Colors are created by absorption of light at certain wavelengths in the visible spectrum. If light is absorbed completely, the surface is black. Black &white prints are called monochrome prints, their only color is black. A black&white print painted with a color is no longer a monochrome print, because it has now two colors – the black areas and the color of the paint. However, when a black&white print is toned, it remains a monochrome print because the black color is replaced, not complemented, by another color.

The definition of a monochrome print hinges then on the definition of color. A color can be described by its lightness, chroma and hue. Color systems have been designed to express colors with numbers. The L*a*b* color system is the easiest to explain. As an approximation, the L*a*b* color system can be visualized as a stack of disks, like a stack of CD disks. The lightness of the disks decreases gradually from the white disk (L = 100) at the top to the black disk (L = 0) at the bottom. Now visualize that each disk is a color wheel. When moving along the edge of the disk, the hue changes from yellow (+b), to red (+a), blue (-b), green (-a), and back to yellow. The intensity of the color, called chroma, decreases along the radius from the edge to the center. (The chroma is sometimes equated with saturation but for photographers saturation has a different meaning). The lightness of the colors decreases from top to the bottom of the stack. The colors on the top white disk are extremely bright. In real life the colors are duller and are described by colors on the lower disks with a gray component.

A color print meets the monochrome definition when its colored areas have the same hue. The intensity (chroma) of the color may change but not the hue.

Colors have been defined by other color systems as well. Printing and design industries use the notation developed by the American artist Munsell. Each color is presented by a color chip with letters and numbers. Several more sophisticated color systems have been developed, the CIE color space and its modifications are most often used.

Q.: I have used a Sony DSC 150 and a Canon EOS 300D SLR camera for photographing violet flowers and found that half of them turned out bluish. I have read on the Internet that the violet color falls outside of the RGB gamut, unless the color is a mixture of blue and red. Digital cameras cannot record a pure violet color. Is this a good explanation of the color problem?
A.: The violet color is difficult to reproduce digitally. It does not matter whether the violet is a single "pure" color or a composite of red and blue. A color is defined by its wavelength. If a certain wavelength cannot be reproduced digitally, it does not matter whether the wavelength originates from one color or from a mixture of colors.

Most of the natural colors are mixtures. The Russian botanist Tswett invented chromatography by separating the color components of a leaf. However, a camera is not a chromatograph. It does not separate the individual colors of a color mixture. The camera sees the composite spectra of light reflected by the colored object and captures the colors falling on a light sensitive plane. The film or the digital sensor separates the colors into three colors, like our eye. The dyesites sensitive to red, green, or blue are on the sensor arranged in the Bayer pattern to simulate the color perception of the eye.

The tricolor theory states that every color can be created by mixing various amounts of red, green, and blue (RGB). To define a color by numerical coordinates various color systems have been designed, none of them being perfect. Not all colors located in the color space of a color diagram can be reproduced photographically. Only a limited area, the color gamut, of the color map contains colors available for color reproduction. The gamut of the colors depends on the device (monitor, printer), the sensor (or film) and the color mode. The default mode of most digital cameras is the sRGB, designed to record colors that most monitors can display correctly. The RGB color mode has a wider gamut than that of the sRGB and is a better choice for images intended for editing and printing. A very wide color space, the Ektra Space or Pro Photo, contains almost every color captured on film.

A color, which falls outside of the color gamut, cannot be reproduced accurately on a print. A violet color of a flower may be an example of this limitation. If the color of a violet flower is not within the gamut of the monitor, the true color cannot be restored by manipulating the red and blue colors in the Photoshop.

The many variables involved make it obvious that the reproduction of color is a complicated task. Although digital photography cannot equal the rich color display of a projected color slide, digitally acquired images can produce very pleasing prints.

How important is the exact color reproduction? It is certainly essential when photographing paintings and recording the nature. However, nature photographers have preferred the saturated colors of Velvia film to the neutral colors of the Astia film. An accurate reproduction of color is important for colors that people can remember, such as skin tone and the color of the sky.