

Effects of Post-Processing Treatments on the Image Stability of Color Prints



For many years, Kodak has been investigating the factors that affect the image stability of color photographic materials. We have emphasized the important influence of proper processing on the dye stability of our color print materials. At the same time, we have examined the effects of several common post-processing treatments on the image stability of prints made on KODAK Papers, including KODAK PROFESSIONAL and KODAK Edge and ROYAL Generation Papers. Treatments include the following:

- Lacquering
- Laminating
- Texturing
- Retouching
- Mounting (including face mounting)
- Emulsion cleaning

“Dye stability” refers specifically to the stability of the dyes that form the photographic image, and is an important component of overall image stability, which also includes staining and physical changes.

You’ll obtain the highest level of image stability in a print made on KODAK Paper by processing it in a properly controlled process and drying it thoroughly immediately after processing. The photographic process and the paper are designed to provide the highest level of image stability that is possible with today’s color photographic technology.

Most post-processing treatments will not affect the dye stability of prints on KODAK Papers. A few treatments that afford physical protection to prints—e.g., laminating—may yield some benefit. Others may actually reduce image stability. The effects of post-processing treatments on image stability vary widely with the type of treatment, and depend on the manner in which the treatment is applied.

TESTING POST-PROCESSING TREATMENTS

The only way to determine conclusively the effect of a post-processing treatment on image stability is to test that treatment. However, that may not be as simple as it sounds.

Many post-processing treatments are currently in use, and new ones are constantly appearing. The manufacturers of the products used in these treatments regularly introduce new materials and reformulate the existing ones. Individual photographers and finishing labs experiment with treatments and materials, including household products such as lacquers and bleaching agents. Therefore, a recent test of a product could be meaningless if the formula has changed and a lab isn’t aware of the change. Testing a particular treatment can be quite complex and time-consuming if it includes chemical analysis of the components of a formulation, as well as tests of the light- and dark-keeping properties of treated prints.

For all these reasons, it’s impossible to test every combination of products and post-processing treatments for color prints. However, we have tested the major types of post-processing treatments. The following sections describe the results of these tests.

LACQUERING

Lacquering prints is a routine procedure in many professional applications and can serve a number of purposes:

- enhancing the appearance of a print
- protecting a print from scratches and soil
- facilitating print retouching

Aqueous lacquers are applied with rollers or are brushed on prints as they travel on a conveyor belt. Some print finishers still use sprays that they apply with propellant-containing spray cans or spray guns powered by dry compressed air.



Caution

Lacquer prints in a well-ventilated, non-explosive atmosphere. Always wear a protective face mask, and follow the safety precautions provided by the lacquer manufacturer.

Although print lacquering provides some benefits, certain lacquer ingredients can accelerate fading and staining of color prints. All lacquers contain a polymer that remains as a very thin coating after the other components have evaporated. Cellulose derivatives and acrylates (i.e., acrylic resins) are common polymers used in lacquers. (Although it is now quite uncommon as a component, you should avoid lacquers that contain cellulose nitrate, which turns yellow with aging.) Some lacquers also contain plasticizers—most commonly phthalate esters—which usually have no effect on image stability. Matte lacquers contain a suspended inorganic material called a matting agent that roughs up the surface to give a different look and/or facilitates retouching applications. Lacquer ingredients and constituents are listed in the following table.

Lacquer Ingredient	Common Constituent
Polymer	Cellulose derivative or acrylic
Solvent	Organic liquid or water
Plasticizer	Phthalate esters
Matting agent	Suspended inorganic solid

Although the organic solvent lacquers are not as popular as they once were, be aware of the type of solvent in a lacquer. Small organic molecules used in solvents can penetrate the emulsion layers and move emulsion components into layers in which they were not intended, especially if the print was not completely dry when the lacquer was applied. See the table under “Blue Print.”

The only material that should remain on a print after conventional lacquering is the thin coating of polymer (and the matting agent in the case of a matte lacquer). This thin polymer layer is not an effective barrier to water or air. Ultraviolet absorbers contained in a lacquer are not very effective in protecting prints, because the polymer layer is so thin.

Adverse Effects of Lacquering

Without testing every lacquer formulation, it’s difficult to say whether or not a particular lacquer will have adverse effects on image stability. Here are some of the physical signs of harmful effects that certain lacquer ingredients have on image stability.

Note: The table following “Yellow Print” summarizes this information.

Blue Print—This phenomenon indicates a drastic reduction in the stability of the yellow dye to light. It is most pronounced when a print has been lacquered in a very humid environment or was not thoroughly dried before lacquering. Some solvents used in lacquers can penetrate moist gelatin and move certain components from one emulsion layer to another. It is better to choose a lacquer that contains solvents that are *not* capable of penetrating moist gelatin.

Solvents Capable of Penetrating Moist Gelatin	
Class of Solvent	Example
Alcohols	Butanol (butyl alcohol), isopropyl alcohol
Esters	Ethyl acetate
Ketones	Methyl isobutyl ketone
Carbitols	Butoxyethanol (butyl Carbitol)

Cyan Spots—Cyan Spots are closely related to the “blue print” effect. Lacquer solvents that penetrate moist gelatin also cause them, but, in this case, the solvents cause crystallization of the ultraviolet absorber in the paper emulsion. This allows for back scattering of the light and a resulting cyan appearance. Changes in paper formulations have made our current products much less susceptible than earlier papers to the formation of cyan spots.

Red Print—This is another effect related to solvent penetration. In this case, the solvent penetrates only into the top image-forming emulsion layer, which contains the cyan dye. It then promotes a thermal reaction between the cyan dye and other components of the cyan layer. Again, the best prevention is to avoid solvents that can penetrate moist gelatin.

Avoid applying strong pressure to any area of a lacquered print. Pressure will accentuate fading of the cyan dye by moving layer components around and bringing them into contact with the dye.

Yellow Print—Organic solvents that are capable of producing peroxides, such as ethers and ketones, can cause the formation of yellow colorants in the magenta emulsion layer. These yellow colorants result from the degradation of unused magenta dye couplers. Recent products such as KODAK EKTACOLOR EDGE 7 and EDGE 8 Papers, as well as KODAK PROFESSIONAL SUPRA III, SUPRA ENDURA, PORTRA III, PORTRA ENDURA, ULTRA III and ULTRA ENDURA Papers have a much-reduced susceptibility to this staining. The yellow-print effect is most common when prints are kept in a confined space—e.g., in closed photo albums or behind glass in frames—where neither the solvents nor the resulting peroxides formed can evaporate completely.

Staining or Fading Caused by Lacquer Ingredients		
Appearance	Cause	Recommendation
Blue print	Reduced stability of the yellow dye layer from incomplete drying before lacquering, or from lacquering the print in humid conditions	Don't use lacquers with these solvents: water, butanol or isopropyl alcohol, ethyl acetate, methyl isobutyl ketone, or butoxyethanol.
Cyan spots	Crystallization of UV absorber in the paper emulsion	
Red print	Reaction between the cyan dye and other components of the cyan layer	Avoid using lacquers with the solvents listed above; don't apply pressure to prints after lacquering.
Yellow print	Degradation of unused magenta dye couplers, especially evident in prints kept in confined spaces	Avoid lacquers with the solvents listed above; allow prints to air before framing or storing them.

You can avoid all the effects described above by using a lacquer formulated with solvents that don't penetrate moist gelatin or produce peroxides. Hydrocarbons meet these requirements but are being replaced by aqueous lacquers which can swell the gelatin but often do not have the ability to move emulsion components around from layer to layer.

Shellac and polyurethane varnish are not really lacquers, but some people use them for print coating. Shellac is a natural resin dissolved in alcohol; it shouldn't affect image stability when applied to a thoroughly dried print. However, we have not tested shellac for its effects on image stability, and the shellac itself could absorb moisture and eventually turn yellow or become sticky (or both). Testing shows that polyurethane varnish will not affect print dyes but, like shellac, it can turn yellow with age.

Removing lacquer from a print requires a solvent that can dissolve the polymer coating. Using an inappropriate solvent can lead to accelerated dye fading. Denatured alcohol and acetone are good choices. Hexane and toluene sometimes work; however, they are highly flammable and require careful handling. Before you remove a lacquer, be sure that the print is dry and that the atmosphere isn't humid (less than 50% RH).

Guidelines for Lacquering

When lacquering prints, follow these guidelines for the best chance of preserving print image stability:

- Dry prints thoroughly before lacquering. If you don't lacquer the print soon after processing and drying, the gelatin emulsion can absorb moisture from humid air. If you don't know the moisture content of a print, re-dry it in a heated dry-mounting press or with a hair dryer. Then allow the print to cool to room temperature before applying the lacquer.
- Use lacquers with solvents based on hydrocarbons or aqueous lacquers.
- Apply multiple light coats of lacquer rather than a single thick coating.
- Lacquer prints in a dust-free, well-ventilated environment where the relative humidity is 50 percent or lower.
- To prevent sticking, don't allow a lacquered print to come into contact with the glass in a frame. If you use a lacquer that contains peroxide-forming solvents, don't place the print in a tightly sealed enclosure.

LAMINATING

Laminating is a variation on lacquering. Instead of applying a very thin polymer layer that is readily removable, laminating involves applying a much thicker layer to the surface of the print by means of thermosetting or a pressure-sensitive or contact adhesive. The laminate may contain UV absorbers, plasticizers, and matting agents. It may be glossy or textured.

Laminates provide excellent protection against fungus and bacterial attack, moisture, dirt, and harmful gases in the air. However, the permeability of laminates varies considerably.

In encapsulating, the edges of the laminate extend beyond the boundaries of the print. These edges stick together to form a sealed envelope around the print, minimizing the penetration of air into the paper from the edges.

Because a laminate is nearly as thick as the print itself, it can incorporate a significant amount of UV absorber to limit the portion of color dye fading attributed to UV exposure. However, for a couple of reasons, the laminate should not be so thick that it totally prevents air penetration. First, the size and weight of the laminated print could become unwieldy. Second, totally preventing air penetration with conventional color papers can adversely affect the rate of cyan dye fading.

Our experience with testing of laminated prints is mostly for shorter-lived commercial and ID badge applications where light stability is important. However, limited tests on laminated prints indicate that these prints are reasonably dark stable if air penetration is not totally eliminated and the laminate does not thermally yellow or thermally delaminate with time.

The choice of laminate *adhesive* can also affect the image stability of a print. Avoid silicone adhesives that release acetic acid upon curing. This released acid can adversely affect cyan and yellow dye stability. One technique that is becoming popular is so-called face mounting, where the emulsion is adhered to a sheet of acrylic plastic. We advise caution with this technique both because the adhesives must be tested for this application and because face mounting significantly reduces air permeation to the emulsion.

TEXTURING

Print texturing can involve the use of rollers or plates, textured laminates, lacquers, and canvas mounting. We have observed degradation in image stability after texturing. If archival quality is desired, texturing is not recommended.

Improper use of pressure rollers or plates is the primary cause of print degradation from texturing. If the texturing is too deep, the pressure can crack the emulsion layers, sometimes causing flaking of pieces from one or more emulsion layers. Flaking can produce colored spots on the print. For example, if the cyan layer flakes off, red spots can appear on the print. Texture prints to the minimum depth that produces the required effect—in no case deeply enough to crack the emulsion layers.

If you use texturing lacquers, observe the precautions outlined under “Lacquering.” Before using a texture spray or

brush coating, apply one or two coats of an acceptable lacquer spray.

Texturing with canvas mounting has no adverse effect on image stability *except* when combined with excessive pressure or use of improper adhesives, laminating techniques, or lacquer coatings.

RETOUCHING

An “ideal” retouching dye for prints intended for viewing or graphic reproduction would have these characteristics:

- The light-absorption characteristics of the retouching dyes would exactly match those of the dyes in the print.
- The retouching dyes and print dyes would have the same light- and dark-keeping properties and identical responses to other post-processing techniques.

These ideal characteristics haven’t been achieved. Therefore, some retouched areas of a print will gradually become more distinct and visible as a print ages or is subjected to light.

Kodak manufactures two forms of retouching dyes for color prints:

- KODAK Retouching Colors (CAT No. 189 0888)—a set of nine colors and a dye remover, each in cake form in a small jar (also available individually)
- KODAK Liquid Retouching Color Set (CAT No. 190 1743)—a set of nine liquid colors in small bottles (also available individually)

Both types of retouching dyes are water-soluble, organic dyes related chemically to the dyes used to make dye transfer prints. Their dark- and light-keeping properties are similar to those of dye transfer dyes—very stable in the dark, with light stability comparable to that of the dyes in KODAK Papers. When used according to instructions, KODAK Retouching Dyes will not adversely affect the image stability of prints made on KODAK Papers.

Both forms of KODAK Retouching Dyes are designed to be absorbed into the gelatin of KODAK Papers. If you use both types on a single print, always apply the liquid dyes and allow the print to dry thoroughly before applying any dry dye. Use KODAK Retouching Colors (dry dyes) *in the dry mode only*. If you need to remove dry dye, remove it with the dye remover, *before* you set the dyes by lightly steaming the print. Dry the print thoroughly before doing any additional post-processing treatment.

The dry retouching dyes are designed for use *only* in the dry mode. Diluting them seriously reduces the dark stability of the image dyes in the print. If the dry dyes come in contact with water, they will no longer perform acceptably because of changes in their chemical composition. Discard them.

At this time, the only solvent available for the safe removal of liquid retouching dyes or dry dyes after they’ve been set by steaming is 5-percent *clear* ammonia solution. (White or cloudy ammonia solutions contain other agents that may be harmful to prints.) If you treat an area of a print

with 5-percent ammonia solution, wash the area with distilled or tap water after treatment.

Other commonly used retouching materials include colored pencils, pastels, oils, and air-brush colors. We suggest applying one or two coats of an acceptable lacquer spray (i.e., a spray that is retouchable) before using any of these opaque retouching media. Because such a wide variety of materials is available, the effects of these materials on dye stability haven't been widely tested. However, as with lacquers, oil paints that contain peroxide-forming solvents or solvents that penetrate moist gelatin can have an adverse effect on image stability.

MOUNTING

Print mounting involves such varied procedures that making specific recommendations is difficult. Print-mounting materials include almost every type of solid support known. Common examples are plastics, metals, woods, ceramics, and cloth.

Mounting falls into two broad classes:

- archival or conservation mounting for long-term preservation
- decorative or utility mounting for short-term display

A few mounting support materials are definitely inert with respect to image stability. These include clean glass and acid-free archival mounting board. Metals, textiles, woods, and plastics may or may not affect image stability. While some plastics, such as polyethylene, polystyrene, and polyesters (including MYLAR and ESTAR Base) should be

inert, other materials require testing. ISO 14523:1999, *Photography—Processed Photographic Materials—Photographic Activity Test for Enclosure Materials*, describes a test for enclosures, adhesives, mounting boards and other materials that will be used in close proximity to processed prints.

Another standards committee, ANSI IT9-2, Print subcommittee of IT9, is studying post-processing concerns and will be making recommendations in the next few years.

There are a wide variety of mounting adhesives and techniques. We have not tested all the available adhesives and techniques, and some may have adverse effects on image stability. If you use mounting techniques that involve heat for adhesion, keep the temperature to a minimum and subject prints to heat for as short a time as possible to avoid altering the emulsion structure. Adhesives that involve water could cause small areas of the image to turn color (pink) where excessive moisture affected the print.

In general, we have found that prints mounted on a canvas are less stable over time than untreated images. We do not recommend canvas mounting for applications that require archival quality.

EMULSION CLEANING

Archival photographic emulsion cleaners are available commercially. They are intended for removing non-water-based stains, markings, and debris from silver-based photographic emulsions. Limited testing of some of these products has not shown adverse effects on image stability; however, Kodak cannot guarantee the effects of these products on print longevity. It is best to follow the manufacturer's recommendations for use.

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MORE INFORMATION

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