Dyeing and Colorfastness in Fabrics

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This publication is one of a set written to help consumers select and care for today's clothing. Three of the publications—fibers and fabrics; information found on garment labels; and dyeing and colorfastness—aid consumers in evaluating clothing and household textiles. Those on laundry aids and laundry detergents and soaps help consumers choose effective cleaning products. The publication on professional clothing care services discusses working with a dry cleaner.

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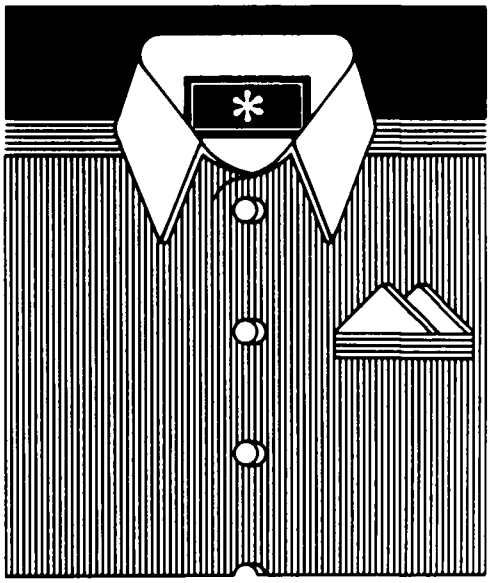
Color is an important characteristic of a textile product and is often one of the first factors considered by a consumer. Color has always been vital to textiles. Making dyes and dyeing fabrics are ancient processes, predating written history.

Natural dyes and pigments obtained from plants, animals, insects, and minerals were used as coloring agents for cloth until slightly more than a hundred years ago. The best known of the traditional dyes from plants included indigo, woad, madder, fustic, logwood, cutch, and safflower. The insects kermes and cochineal were widely used to obtain reds. Some iron oxides gave pale colors to certain fabrics, and shellfish near Tyre on the Mediterranean provided small quantities of the dyestuff called Tyrian purple used for royalty. Unfortunately, few of these natural dyes formed colorfast combinations with the fabric, even with the use of mordants, chemicals that combine with a dye to form an insoluble substance.

In 1856 an English chemist named William Perkin discovered aniline, a coal tar derivative, which dyed white silk a reddish-purple color he called mauve. His discovery led to additional research and the eventual synthesis of a wide range of chemical dyes. Today there are many hundreds of dyes and colors, in a variety of chemical categories, from which to choose. With the exception of logwood for black, natural dyes are no longer used for large-scale, commercial production but are limited to use among fiber artists. High cost, limited availability, and poor colorfastness led to the rapid decline of these dyes.

Seeing color

The visual sensation of color requires three things: the eye containing the retina where nerve cells are stimulated, an object that contains the dye or pigment and provides the color sensation, and a source of light so that the object is visible. (You can't see the color of your clothes in a completely dark closet!) The color that is visible comes from the reflected light rays. If all the light rays are reflected, the object appears white; if all the light rays are absorbed, the object appears black. Different light sources (natural, incandescent, fluorescent) may reflect the same color differently.



*** TODAY'S CLOTHING CARE**

Dyes and pigments. Dyes are defined as chemical compounds that can be attached to fabric in a more or less permanent state, and that evoke the visual sensation of a color. Dyes react differently with different fibers. The reaction of dye with the fiber can be both a chemical and a physical reaction.

Pigments also evoke color, but must be held on the fabric surface by a resin binder because there is no chemical or physical reaction with the fiber as occurs with dyes. Pigments are finely ground colored particles, similar to dust. They are not soluble and cannot penetrate the fiber surface. In addition to surface printing using binders, pigment particles can also be mixed with liquid fiber-spinning solutions to add color to manufactured fibers.

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Application of color to fabric. In order for a textile to be dyed, the dye must penetrate the fiber and either combine chemically with it or be physically locked inside the fiber structure. Certain fibers dye more readily than others. Fibers that dye easily have two characteristics: they are absorbent and they contain sites in their chemical structure to react with the dye molecules. Dye classifications that are best suited for certain fibers are described later in this publication.

Color can be applied to textile products at various stages of manufacture. However, colorfastness is primarily affected by selecting the right dyestuff to penetrate a particular fiber content, and not by the stage at which the color is applied.

Solution dyeing is the process of adding dyes or pigments to the spinning solution before the fiber is formed. This method provides excellent colorfastness since the color is locked inside the fiber structure. The disadvantage of solution dyeing is that it does not allow for quick response to changing fashion colors because dyeing must occur early in the manufacturing process. However, for difficult-to-dye fibers such as olefin, this method of color application is very important. Solution dyeing is used for some acetate and rayon drapery fabrics in which colorfastness must remain even after the fabric is exposed to light for prolonged periods.

Fiber or stock dyeing occurs when raw fiber stock which has not yet been spun into yarns is dyed in large kettles or dye vats. Frequently wool fibers are stock or fiber dyed. Yarns spun from two or more different fiber-dyed colors create a heather effect.

Yarn dyeing is a common dyeing method. It is less costly than fiber dyeing, but is more costly than piece dyeing and printing. The color is as strong on the back side of the fabric as the face side. Gingham fabric and woven plaids and stripes are constructed using dyed yarns. Some checks, stripes, and plaids may be printed designs. On these fabrics, the color on the back side of the fabric is weaker.

Piece dyeing describes the process of dyeing the entire bolt or roll of fabric in a solid color. When a fabric of blended fibers, such as cotton and polyester, is piece dyed a solid color, it is called union dyed. In union dyeing two dyes are combined in the same dyebath, with each dye suited to one of the fibers but both dyes giving the same color. Piece dyeing is less expensive than fiber or yarn dyeing, and the color decision can be made closer to fashion market usage. Dye penetration is usually excellent for piece-dyed light- and medium-weight fabrics, but for heavyweight fabrics piece dyeing may not allow thorough penetration of the yarns.

Garment dyeing is done after the garment has been cut and sewn together. Recently this coloration method has become more popular because it gives a quick response to the latest fashion colors. From the placement of a retailer's order through the manufacturing process, garment dyeing can reduce the lead time from 8—10 weeks to 2—3 weeks for a color that is selling well.

For garment dyeing, the undyed, unfinished cloth must be cut oversized to allow for normal fabric shrinkage during the final fabric preparation, dyeing, and finishing steps. Each garment must be cut from the same roll of cloth so parts will not dye differently. Labels and fasteners are carefully considered if they are sewn into the garment before the dyeing. For the garment to accept dye evenly, it should be properly prepared with the natural fiber impurities and manufacturing impurities removed. The cost of garment dyeing is expensive, but may be recovered through reduced inventories, a higher number of sales, and fewer markdowns at the end of the season.

Today garment dyeing is done on 100 percent cotton items. Industry reports predict that cotton blends and other fibers will be garment dyed, even though the procedure is more difficult for fibers other than cotton.

Overdyeing, a styling technique for denim, is achieved by using pigments or direct dyes with inherently poor colorfastness. The dyeing is followed by stone washing or stone bleaching to intentionally remove some color.

Dye classes

Dye classifications include acid, azoic, basic, chrome, direct, developed direct, disperse, reactive, sulfur, and vat dyes. The names of these dye classes generally relate to the method of dye application or the chemical composition of the dye. Within each dye class only a certain number of colors exist. Actually, most fabrics are dyed with a combination of two or three colors of the same dye class to achieve the desired hue. For this reason, selecting colored garments that match under all types of light can be difficult, as different types of light may cause the dye combination to look different.

Dye	Fibers	Colorfastness Characteristic
Acid dyes	Wool, silk, nylon, spandex, modified rayon, acrylic, polyester	Bright colors. Most have poor colorfastness to washing. Vary from poor to good in fastness to light and perspiration. Excellent fastness to dry cleaning.
Azoic dyes	Cotton primarily, also polyester.	Good to excellent fastness for washing, perspiration. Light fastness varies, poor crocking (rubbing of color onto a lighter-colored fabric).
Basic dyes	Primarily acrylic. Used on modified polyester, nylon.	Bright shades with excellent fastness to light, washing, perspiration, crocking on synthetic fibers.
Chrome dyes	Same as for acid dyes above.	Dull colors, but excellent fastness to laundering, light, and perspiration.
Direct dyes	Cellulosic fibers, cotton, linen, rayon.	Good colorfastness to light. May have poor wash fastness. Good to excellent fastness to perspiration and dry cleaning.
Developed direct dyes.	Same as direct dyes above.	Same as for direct dye, except wash fastness good to excellent.
Disperse dyes	Developed for acetate fibers, now used on most synthetic fibers.	Fume fading (to atmospheric gases), especially poor for blues and violets on acetate. Washfastness varies with fiber; poor on acetate, excellent on polyester. Fastness to perspiration, crocking, dry cleaning good to excellent.
Reactive dyes	Most cellulosics, some used on wool, silk, nylon, acrylic.	Bright shades. Good to excellent light and wash fastness. Sensitive to chlorine bleach.
Sulfur dyes	Primarily cottons.	Dull shades, no reds. Poor fastness to chlorine. Good to excellent fastness to light, washing, perspiration.
Vat dyes	Primarily cottons.	Excellent fastness to washing, chlorine bleach, light, and perspiration. May crock if not properly applied.

Consumers should consider both the store lighting and the lighting in which the outfit will be worn.

In general, each dye classification is used only on certain fibers. The dyes most often used on cellulosic fibers such as cotton, linen, ramie, and rayon include vat, reactive, direct, sulfur, and azoic dyes. The dyes used most frequently on protein fibers such as wool and silk include acid, chrome, and reactive dyes. Manufactured fibers will take basic and disperse dyes and certain acid, azoic, and reactive dyes. In addition, pigment colors may be added to the fiber solution.

Colorfastness

Colorfastness refers to the ability of a dyed fabric to retain its original color. Apparel and home furnishings are exposed to a wide variety of conditions which may affect the fastness of a color, such as laundering, dry cleaning, gas fumes, light, perspiration, and crocking.

Colorfastness within each dye classification is affected differently by each of these factors and also may vary within different colors in the same classification. Thus the consumer has no real guarantee of the degree of colorfastness unless the product is described as "colorfast." Even knowing the class of dye used on the fabric may not be helpful. Therefore, there has been no push for labeling information of the dye class used. The single exception is vat dyes, the only dye classification that is consistently colorfast to laundering. Consumers have learned to accept the term "vat dyed" as meaning a fabric with good colorfastness to washing.

When manufacturers select fabrics for a specific purpose such as curtains or draperies, they specify dyes with appropriate lightfastness. When home sewers use apparel fabrics for curtains, the fabric may not have appropriate lightfastness and may fade from exposure to sunlight.

Colorfastness problems can result from improper dye selection by the dyer; the use of inferior, less expensive dyes; use of a fabric for other than its intended purpose; combining fabrics with varying colorfastness; or incorrect care methods. For a product to retain its appearance, the consumer must follow the permanent care label instructions. If a product is unsatisfactory, the consumer should return it to the store so retailers and manufacturers are made aware of poor quality merchandise.

Some dyes, especially when used for dark or bright colors, are applied in excess to achieve the desired color. When the textile is washed, the excess dye "bleeds" and is visible in the laundry water. These items usually carry a label that reads "Wash separately or with similar colors." There is no way to prevent this anticipated loss of color. Today's dyes cannot be "set" by home methods, and the use of vinegar or salt may actually cause more loss of color.

Care labeling is required on both domestically produced and imported apparel. It is the legal responsibility of the importer or the domestic garment manufacturer to provide accurate information on garment care, and the recommended care procedure must be supported by prior product testing. Recently, problems in colorfastness and improper labeling of imported apparel have surfaced. In these cases the consumer must rely on the cooperation of the retailer from whom the product was purchased.

If a dyed fabric with poor colorfastness to laundry, e.g. red, is sewn with a light fabric, e.g. white, "migration" may occur: the red dye may stain the white fabric. If this happens, there is nothing the consumer can do to remove the stain. The problem occurred at the manufacturing level when a fabric with poor dye colorfastness was combined with white fabric. If the garment was labeled "machine washable," it was mislabeled by the manufacturer. The manufacturer is responsible not only for accurate care labeling, but for initial quality

control testing of the fabric to ascertain its colorfastness. The consumer should return the garment to the store or to the manufacturer for refund or replacement.

Retailers and manufacturers must learn to use performance specifications for colorfastness, thereby insuring that products meet high standards. Performance specifications for a wide range of apparel and home furnishings textiles have been developed by the American Society for Testing and Materials (ASTM). The American Association of Textile Chemists and Colorists (AATCC) have developed colorfastness specifications and tests. These groups are working together to provide high quality, American-made textile products in today's market.

For more information

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