Dyeing Outline

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Dyeing Overview

- Color is one of the most important factors for selecting textile products, especially where aesthetics are important.

- For user satisfaction, the color at the time of purchase, and the ability of a product to retain that color, are critical.

- Garment labels do not give consumers any indication about the ability to maintain appearance.

- Garments are often discarded due to color-related problems. To avoid this, quality assurance testing is conducted by the manufacturer to evaluate colorfastness to bleach, perspiration, salt water, washing, dry cleaning, rubbing (crocking), and light.

- Standard test methods developed by the American Association of Textile Chemists and Colorists (AATCC) and other organizations are used to evaluate colorfast properties.
- **Colorants** includes natural and synthetic dyes, and pigments.
Colorants

- **Natural dyes** come from materials found in nature. They have limited commercial value, but are popular in organic natural fiber markets, and traditional and ethnic textiles. They are popular among fiber artists. The method of collection and storage affects the color of certain natural dyes.

- **Synthetic dyes** are chemically synthesized. Most fabrics are dyed with synthetic dyes; they are less expensive than natural dyes, are available in a wide range of colors, and produce more consistent results from batch to batch.

- **Pigments**, similar to those used in paints, are fine, insoluble particles that add color. In dyeing, pigments are used for solution and product dyeing.
Wool Skeins Dyed with Natural Dyes
Yarns Dyed with Synthetic Dyes

Note: Synthetic dyes are available in a very wide variety of colors, including some very bright colors that are not available in natural dyes.
Note: This sweatshirt was pigment dyed in a product dyeing machine. To enable the insoluble pigment particles to adhere to the garment, the garment is first treated with a binder (same consistency as syrup) that coats the fabric surface. Pigment dyeing is used primarily to create garments with a "worn look." Note: Pigment dyed fabrics are technically not dyed as pigments are insoluble in water.
Dyes

- Dyes are classified by:
  - **Chemical composition** – used by manufacturers; each dye is assigned a Colour Index (CI) number based on chemical composition. Dyes are referred to by their CI number (equivalent to a generic name).
  - **Application method** – used by dyers; dyes are divided into acid, azoic, basic/cationic, direct, disperse, reactive, sulfur, or vat. Acid, azoic, basic/cationic, and direct are applied by placing textile material in a dyebath; for other dye classes fabric has to be treated either before or after dyeing to create color.

- Certain synthetic dyes from the azo group are banned in many countries including the U.S. due to health and environmental hazards. Fabrics dyed with banned dyes cannot be imported into the U.S.
Acid Dyes

- **Acid dyes** are used for wool, silk, nylon, acid dyeable acrylic, acid dyeable polyester, and spandex.

- **Acid dyes** are water-soluble dyes that were originally developed to dye wool and silk. They are the most commonly used dye class for dyeing nylon and protein fibers.

- Cellulosic fibers are not dyed with acid dyes as the acidic dyebath may weaken the fibers.

- These dyes are available in a broad range of colors that include very bright colors.

- Colorfastness properties vary considerably based on chemical structure. Thus, the suitability of the dye for the material’s end use should be considered when selecting acid dyes.

- A sub-group of acid dyes, known as mordant or metallized dyes, have a metal added to the dye molecule before, during, or after the dyeing process. The metal improves colorfastness to washing and light.
Multifiber Swatch Dyed with Acid Dye

Note: Acid dye is commonly used to dye wool, silk, and nylon fibers. Cellulosic fibers cannot be dyed with acid dyes as the acidic dyebath damages the cellulosic fibers.
Azoic Dyes

- **Azoic dyes** are used for cotton, rayon, flax, ramie, and other cellulosic fibers; there is limited use with protein and synthetic fibers.

- Azoic dyes consist of two, colorless, water-soluble components that form insoluble colored molecules in the fiber during the dyeing process.

- Azoic dyes are available in shades of red, yellow, and brown.

- Azoic is a minor dye class suitable for batik as dyeing is done at low temperatures.

- The dyed material has excellent colorfastness to light, washing, and bleach. It may exhibit poor colorfastness to crocking (rubbing) as some dye may stay on the surface and not bind with the fiber.
### Multifiber Swatch Dyed with Azoic Dye

<table>
<thead>
<tr>
<th>Acetate</th>
<th>Cotton</th>
<th>Nylon</th>
<th>Polyester</th>
<th>Acrylic</th>
<th>Silk</th>
<th>Rayon</th>
<th>Wool</th>
</tr>
</thead>
</table>

Note: Azoic is a minor dye class that is available in shades of red, yellow, and brown. Azoic are cold water dyes that are suitable for dyeing batiks made with cotton, rayon and other cellulosic fibers. Protein and certain synthetic fibers can also be dyed with azoic dyes; additional care in selection of dye and dyeing process is required. The fabric is colored by formation of dye molecule within the fabric. Therefore, hydrophobic fibers are dyed/stained in light shades.
Basic/Cationic Dyes

- **Basic dyes**, also known as cationic dyes, are used with acrylic, cationic dyeable polyester and nylon; there is limited use with protein and cellulosic fibers.

- Basic dye is one of the oldest groups of dyes that includes many of the natural dyes.

- These water-soluble dyes, with a cationic group that bonds with an anionic group in the fiber, produce brilliant colors.

- Basic/cationic dyed protein and cellulosic fibers exhibit poor colorfastness (especially with exposure to light); therefore, these fibers are not commonly dyed with basic dyes.

- Basic dyes are used primarily for acrylics, but are also used for cationic dyeable polyester and cationic dyeable nylon fabrics. The positively charged dye forms strong bonds with these fibers, resulting in excellent colorfastness to washing.

- Cationic dyes are used for gel dyeing of acrylic fibers.
<table>
<thead>
<tr>
<th>Fiber</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetate</td>
<td>Pink</td>
</tr>
<tr>
<td>Cotton</td>
<td>Pink</td>
</tr>
<tr>
<td>Nylon</td>
<td>Pink</td>
</tr>
<tr>
<td>Polyester</td>
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<td>Rayon</td>
<td>Pink</td>
</tr>
<tr>
<td>Wool</td>
<td>Pink</td>
</tr>
</tbody>
</table>

Note: Basic dyes produce very bright colors. They are used for applications such as dyeing of cut flowers where bright colors are important, but colorfastness is not important. Basic dyes are commonly used for dyeing acrylic fibers. The ability to dye acrylic with a basic dye depends on dyeing conditions as well as dye and fiber chemistry. The acrylic used in this multifiber stripe did not have the affinity for the basic dye used to dye the swatch.
Direct Dyes

- **Direct dyes** are used for cotton, rayon, flax, ramie, and other cellulosic fibers; there is limited use with protein and nylon fibers.

- Direct dyes are long, narrow-chain, water-soluble, anionic dyes.

- In the dyebath, the water-soluble dyes are, in general, absorbed by the hydrophilic fibers. The dye molecules that are trapped in the fiber have a tendency to bleed when washed as there are no chemical bonds or means to hold the dye molecules in the fiber.

- To improve the washfastness of direct dyed fabrics, after-treatments are applied to increase the size of the dye molecule and make it insoluble. The term **developed direct dye** is used for the sub-group of direct dyes which have been treated with chemicals after dyeing.

- Direct and developed direct dyes have good colorfastness to light, dry cleaning solvents, crocking, and fumes.

- Direct dyes are the least expensive group of dyes and can be easily applied to cellulosic fibers.
Multifiber Swatch Dyed with Direct Dye

Note: Direct dyes are water-soluble dyes that readily dye or color cellulosic fibers that have good absorbency. Protein and nylon fibers also have good affinity for certain direct dyes. With no aftertreatment, fabrics dyed with direct dyes have a tendency to bleed.
Disperse Dyes

- **Disperse dyes** are used for acetate, triacetate, polyester, nylon; there is limited use with acrylic and modacrylic.

- Disperse dyes are a water-insoluble group of dyes used to color manufactured fibers. They were originally developed to dye acetate because it could not be dyed using dyes available at that time.

- This group of dyes is used for a majority of the polyester, acetate, and triacetate fibers available on the market. Special fabric preparation, as well as high pressure and high temperature equipment, is often required for dyeing with this group of dyes.

- Manufactured fibers dyed with disperse dyes have excellent colorfastness to washing. They also have good to excellent colorfastness to light, bleach, crocking, dry cleaning, and perspiration.

- Acetate fibers dyed with a sub-class of disperse dyes are susceptible to fume fading, unless inhibitors are used to prevent fading. A common example is color change from blue to purple or pink shades in acetate material.
Note: The majority of the acetate, triacetate and polyester fibers are dyed with disperse dyes. Dyeing of polyester fabric typically requires special dyeing conditions such as high temperature and pressure. Nylon fibers are dyed with disperse as well as other classes of dyes.
Fume Fading of Acetate Moiré Fabric
Reactive Dyes

- **Reactive dyes** are used for cotton, rayon, flax, ramie, and other cellulosic fibers. Nylon and protein fibers require an acid dyebath.

- Reactive dyes, also known as fiber reactive dyes, color the fabrics by chemically reacting and forming strong chemical bonds with the fibers.

- This eco-friendly class of dyes is commonly used to dye cellulosic materials.

- Fiber reactive dyes have good to excellent colorfastness to light, washing, perspiration, and crocking.

- The colorfastness to chlorine is poor as the color forming substance gets oxidized.
Multifiber Swatch Dyed with Reactive Dye

Note: Unlike direct dyes, reactive dyes chemically bond with fibers. Reactive dyes are typically used for dyeing cellulosic fibers. Protein fibers can also be dyed with reactive dyes; additional care in selection of dyes and dyeing process is required for dyeing protein fibers.
Sulfur Dyes

- **Sulfur dyes** are used for cotton, flax, rayon, and other cellulosic fibers.

- Sulfur dyes are comparatively inexpensive, and are used to dye cotton and other cellulosic materials in dull shades of dark blue, brown, and black.

- Yarns for black denim are generally dyed with sulfur dyes. Yarns for dark blue denim are dyed with sulfur and indigo dyes.

- The insoluble sulfur dyes are changed to soluble forms for dyeing, and then oxidized back to the insoluble form after dyeing.

- Care is required as fibers can degrade and weaken over time if the material is not rinsed thoroughly after dyeing.

- Materials colored with sulfur dyes have good colorfastness to washing, light and perspiration. Sulfur dyes have average colorfastness to crocking and poor colorfastness to chlorine.
Note: The multifiber swatch was dyed with khaki color sulfur dye. Although protein fibers such as wool and silk have an affinity for sulfur dyes, they are not dyed with sulfur dyes because the high alkaline concentration in the dyebath damages the fibers.
Strength Loss in Black Ramie Blouse Due to Improper Dyeing with Sulfur Dyes

Magnified view

Blouse, part of the International Fabricare Institute (IFI) collection, was photographed with permission from IFI.
Vat Dyes

- **Vat dyes** are used for cotton, flax, rayon, and other cellulosic fibers.

- **Vat dyes** are water-insoluble compounds that are changed to a water-soluble (leuco) form for dyeing. Once the material has been dyed, it is exposed to air or an oxidizing agent to convert the compound back to its water-insoluble form.

- Vat dyes are available in a wide range of colors.

- Vat dyes typically have good to excellent colorfastness to washing, light, perspiration, and bleach.

- Materials that are not dyed properly may have poor colorfastness to rubbing (crocking).
Note: Vat dyes are typically used to dye cellulosic fibers. Protein fibers are not dyed with regular vat dyes because the high alkaline concentration in the dyebath damages the fibers. Protein fibers can be dyed with solubilized vat dyes that do not require an alkaline dyebath. The acetate fiber stripe is not shown in the above sample.

Dyed sample courtesy of Standard Dyes, Inc.
Pigments

- Pigment is “an insoluble, finely divided substance, such as titanium dioxide, used to deluster or color fibers, yarns, or fabrics” (Source - *Dictionary of Fiber and Textile Technology*).

- **Pigments** are used to add color to materials; however, they are not considered dyes as the insoluble particles do not react or get absorbed by the fiber.

- Pigments are commonly used for solution dyeing.

- Pigments are also used for fabric and product dyeing for garments with a “worn look.” Note: Technically, this is not considered dyeing as resin is used to glue the insoluble pigment particles to the materials. These materials have excellent colorfastness to light and bleach. Colorfastness to washing and crocking varies; it is dependent on factors such as resin/binding agent.

- Pigments are more commonly used for printing.
Pigment Dyeing – Used for dyeing garments with a “worn look”

Note: This sweatshirt was pigment dyed in a product dyeing machine. To enable the insoluble pigment particles to adhere to the garment, the garment is first treated with a binder (same consistency as syrup) that coats the fabric surface. Pigment dyeing is used primarily to create garments with a “worn look.” Note: Pigment dyed fabrics are technically not dyed as pigments are insoluble in water.
## Comparison of Colorant Usage and Colorfastness

<table>
<thead>
<tr>
<th>Colorant</th>
<th>Used for</th>
<th>Colorfastness Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acid Dyes</td>
<td>wool, silk, nylon, acid dyeable acrylic and polyester, spandex</td>
<td>• Colorfastness properties are dependent on the sub-class</td>
</tr>
<tr>
<td>Azoic Dyes</td>
<td>cotton, rayon, flax, ramie, and other cellulosic fibers; limited use with protein and synthetic fibers</td>
<td>• Excellent colorfastness to light, washing, and bleach&lt;br&gt;• May have poor colorfastness to crocking</td>
</tr>
<tr>
<td>Basic/Cationic Dyes</td>
<td>acrylic, cationic dyeable polyester and nylon; limited use with protein and cellulosic fibers</td>
<td>• Poor colorfastness to bleach&lt;br&gt;• Excellent colorfastness to washing (acrylic and cationic dyeable polyester and nylon)&lt;br&gt;• Colorfastness to light varies; acrylics dyed with newer formulations have excellent colorfastness to light&lt;br&gt;• Good colorfastness to crocking (acrylic and cationic dyeable polyester and nylon)</td>
</tr>
<tr>
<td>Direct Dyes</td>
<td>cotton, rayon, flax, ramie, and other cellulosic fibers; limited use with protein and nylon fibers</td>
<td>• Good colorfastness to light, dry cleaning, crocking&lt;br&gt;• Poor colorfastness to washing and bleach</td>
</tr>
<tr>
<td>Disperse Dyes</td>
<td>acetate, polyester, nylon; limited use with acrylic and modacrylic</td>
<td>• Excellent colorfastness to washing&lt;br&gt;• Good to excellent colorfastness to light, bleach, crocking, dry cleaning, and perspiration</td>
</tr>
<tr>
<td>Reactive Dyes</td>
<td>cotton, rayon, flax, ramie, and other cellulosic fibers; protein fibers and nylon dyed in an acidic dyebath</td>
<td>• Good to excellent colorfastness to light, washing, perspiration, and crocking&lt;br&gt;• Poor colorfastness to chlorine</td>
</tr>
<tr>
<td>Sulfur Dyes</td>
<td>cotton, flax, rayon, and other cellulosic fibers</td>
<td>• Good colorfastness to washing, light, and perspiration&lt;br&gt;• Poor colorfastness to chlorine&lt;br&gt;• Average colorfastness to crocking</td>
</tr>
<tr>
<td>Vat Dyes</td>
<td>cotton, flax, rayon, and other cellulosic fibers</td>
<td>• Good to excellent colorfastness to washing, light, perspiration, and bleach</td>
</tr>
<tr>
<td>Pigments</td>
<td>all fibers</td>
<td>• Excellent colorfastness to light and bleach&lt;br&gt;• Colorfastness to crocking and washing varies</td>
</tr>
</tbody>
</table>