Chapter 11

Dyeing and Printing

Summary

• How do dying and printing affect textiles?
• How are they different from one another?
• What processes and materials are used?
• How do these processes and materials affect the environment?

Color

• Goal: Produce appealing, level, fast color on product at reasonable price with good performance and minimal environmental impact.
• History and background.
• Complex area: Difficult to get color on fabric in uniform appearance (level) that will not fade, bleed, or alter appearance.

Colorants

• Pigment
  – Insoluble inorganic compound glued or bonded onto fiber surface; no affinity for fiber
  – Colors must be cured
  – White and colored pigments

Ingredients in Pigment Paste

• Opacifiers: Produce good covering power; variety of lusters.
• Thickeners: Prevents migration of paste.
• Thinners: Keeps paste semi-fluid.
• Antibleeding agents: Eliminates halo effect.
• Pigments: Colored compound.
• Softeners: Maintain soft hand of fabric.
• Easier to match colors with pigments than with dyes.

Dye

• Organic compound that is water or other carrier-soluble; has affinity for fiber (forms some kind of bond with fiber).
• Fiber specific: Fibers differ in chemical composition and restrict dyes that can be used.
• High color strength
• Fastness varies with dye and dye class.
• Components
  • Chromophore: colored part of molecule
  • Auxochrome: alters color and provides bonding and solubility sites
Dye Classifications

• **Acid (anionic):** Wool, silk, nylon; some rayon, acrylic, and polyester; bright colors, poor wet fastness and may have poor light fastness.
• **Azoic:** Cotton; some polyester; bright shades; good fastness to light and water; poor crocking; water insoluble; solubility cycle dye.
• **Cationic (basic):** Acrylic, wool; some polyester and nylon; good fastness on synthetics, but poor on natural fibers; bright colors.

Developed direct [direct dye + metal (mordant)]:
• Cellulosic fibers; good light fastness, fair wash fastness; duller colors.

• **Direct:** Cellulosic fibers; similar to above, but brighter colors; large, planar molecules; moderate wet fastness; most commercially important class at present.
• **Disperse:** Synthetics; good fastness; may fume fade; needs special equipment.

Dye Classifications

• **Fluorescent:** Most fibers; dye absorbs energy at one wavelength and reemits at another wavelength; whitens yellowed fabric; used in finishing and home laundry.
• **Mordant dyes [acid dye + metal (mordant)]:** Wool, silk, nylon; some rayon, acrylic, and polyester; duller colors; excellent fastness.
• **Natural dyes:** Minor dye class; renewable and sustainable; from plant, animal, and mineral sources; applied to some apparel and furnishings; limited colors and availability.

• **Reactive:** Natural fibers; bright, pure colors; good to excellent fastness.
• **Sulfur:** Cotton; insoluble in water; solubility cycle dye; difficult process; dull colors; good fastness; may tender fabric; used for bottom weight goods.
• **Vat:** Cotton; insoluble in water; solubility cycle dye; difficult process; dull colors; good fastness; incomplete color range; used for bottom weight goods.

Stages of Dyeing

• **Fiber stage**
  – **Mass pigmentation (solution dyeing, producer colored, spun or dope dyed):** Add colored pigments to spinning solution; color integral part of fiber.
  – **Gel dyeing:** Color incorporated before fiber coagulates.

• **Stock dyeing:** Dyed before yarn processing; heather effect
• **Top dyeing:** Top is dyed; difficult to distinguish between top and stock dyeing
Stages of Dyeing

• **Yarn stage**
  - Dye in yarn stage
  - Stripes, plaids, or structural design fabrics
  - More expensive than piece dyeing; solid colors usually piece or product dyed (not yarn or fiber dyed)

• **Piece or fabric stage**
  - Dyed in fabric stage: generally produces solid color

• **Product or garment stage**
  - Color added, product cut and sewn
  - Found in socks, hosiery, tee shirts, jackets, slacks, towels, etc.
  - Problems with leveling, difference in components, poor penetration, dimensional changes; requires well prepared gray goods

Yarn Dyeing

• More likely to see stripe parallel to warp yarns in woven fabric (easier to dress loom) or parallel to course in knit fabric. Change color at yarn feed for circular or flat bed knits.
  - Skein dyeing
  - Package dyeing
  - Beam dyeing

Stages of Dyeing

• **Cross dyeing**: Fibers of different dye receptivity (modification or generic class) for different colors (red: cotton; blue: wool).

• **Union dyeing**: Fibers of different dye receptivity (modification or generic class) for uniform color (cotton/polyester blend).

Stages of Dyeing

• **Batch or exhaust dyeing**: Textile circulated through dyebath.
  - Beck, reel, or winch dyeing: continuously immerse fabric in dyebath
  - Jig dyeing: large runs of fabric passed through dyebath several times
  - Pad dyeing: in bath in open width; dye forced into fabric (30-300 yd/min)

Methods of Dyeing
Methods of Dyeing

- **Package dyeing**: Dyebath forced through textile; usually yarns, but some fiber and fabric.

Combination Dyeing

- Textile and dyebath are circulated.
  - **Jet dyeing**: similar to beck dyeing; used for delicate fabrics; 215-870 yd/min
    - **Paddle machine, rotary drum, or tumbler**: product dyeing; abrasive & chemical washes
    - **Continuous machine or range**: large lots of goods; one or two bath processes for union and cross dyeing; Thermosol process

Printing

- **Localized application of color to fabric’s surface**.
  - **Direct print**: Color applied directly to desired location.
    - **Block**: hand process; carved wood block pressed in dye paste, stamped onto fabric; different block for each color
  - **Wet print**: Paste made of dyes, not pigments.
  - **Dry print**: Paste made of pigments, uses adhesive (change fabric hand).
  - **Foam print**: Uses less water and energy.
Direct Roller Print

- Roller etched with design; picks up paste and presses it onto fabric as fabric passes between rollers; different roller for each color up to 16 colors; duplex print: printed on both sides of fabric.

Roller Printing

Types of Printing

- **Direct print**: applying dye or pigment directly onto white or previously dyed cloth
  - Blotch printing: both the background color and the design are printed on the fabric

Warp Print

- Warp yarns printed before weaving; hazy pattern.

Resist Print

- **Screen print**: screens etched with design; control location of color; one screen/color
  - Hand screen print
  - Flat screen: flat; slower; shorter yardages
  - Rotary screen: cylinder screen; faster; most common method to print yardage
Types of Printing

- **Discharge print**: Piece dyed fabric with color removed by printing with bleach paste.
  - Requires dark ground.
  - Discharged areas may be tender with poor aging resistance.
  - Trace of dark ground may be visible on technical back in printed area.

**Discharge Print**

- **Direct Print**: Piece dyed or paste may be blocked from passing through certain areas during printing.

- **Resist Print**
  - **Batik**: Hot wax on fabric; piece dyed; wax removed; price related to quality & colors present.
  - **Tie-dyed**: Yarn or fabric wrapped to prevent dye penetration during piece dyeing. Thread removed after dyeing.
  - **Ikat**: Yarn tied to prevent dye penetration; dyed, woven; single or double ikat.

**Resist Print**

- **Stencil print**: Precursor of screen print; paper or metal pattern; brush or spray color on
Burn-out Printing

- Chemicals destroy certain fibers in a mixed fiber fabric to create a pattern

Other Printing Methods

- **Digital (ink jet) print:** Color applied using ink jet printer; carpets and textile samples.
- **Heat transfer print:** Design printed on paper with disperse sublimable dyes (with heat, dye evaporates); fabric and design on paper are placed in close contact, heated, and dye transfers.
- **Electrostatic print:** Powdered dye heat-fixed to fabric surface; dye location controlled by screens.

Other Printing Methods

- **Differential print:** Screen print on carpet with fibers of different dye affinity (cross dye).
- **Foil print:** Special adhesive applied to fabric; fabric dyed and partially cured; foil transferred by heat transfer press; bonds only where adhesive has been applied.
- **Hand painting:** Silk painting

Developments

- **Metamorphic color systems with heat sensitivity**
- **Metal as dye**
- **Microliquid crystals in surface coating:** change color with temperature
- **Dye and print combinations**
- **Shift to shorter runs**
- **Computer applications:** experiment with design; minimize seconds & environmental impact; stricter color control; decrease dead time; increased efficiency
- **Softer binders for pigment prints**
Color Problems

• Colorfastness: related to chemistry of fibers, dyes, and pigments; penetration, and fixation
  – Bleeding: loss of color in water or other solutions; may color other fabrics present
  – Crocking: color transfer to another fabric from rubbing together
  – Migration: color movement to adjacent areas or fabrics
  – Fading: color loss due to perspiration, gas fumes, sunlight, etc.; dyes degraded

Color Problems

• Tendering: Fabric strength loss due to reaction of dye and fiber, caused by heat, light, atmospheric contamination, etc.
• Frosting: Colored portion of fabric lost by abrasion due to poor dye penetration.
• Out-of-register: Print color overlaps or misses desired areas.

Color Problems

• Off-grain: Fabric printed off-grain; print disappears off fabric edge when cut on grain.
• Production matching problems: assessed with colorimeter or human eye
  – Side-to-side: Color does not match from selvage to selvage.
  – Side-to-center: Color does not match from selvage to center.
  – End-to-end, ending, or tailing: Color does not match between ends of roll/bolt.

Environmental Impact

• Water contamination: Chemicals with high BOD and COD (biological and chemical oxygen demand); color, salt, heavy metals.
• Alternatives to colored textiles: Naturally colored fibers or use of natural dyes.
• Supercritical carbon dioxide or liquid carbon dioxide as alternatives to traditional water-based systems.

Summary

• Dying uses dye. Printing uses pigment.
  – Pigment sits on top of the fiber and attaches through a “glue”, while dye permeates the fiber molecules and bonds to them.
  – Dyes are fiber bound; the dye only works with certain types of fibers; pigment is not fiber-specific, but alters the surface of the fabric when the pigment is applied.
  – Dye can warp in the fiber stage until a stage, fabric may be washed the pigment to cut and made. The later in the stage the garment is died, the less colorfast. They have to hold the dye in. However, the manufacturer is able to adjust the color fastness to consumer demands.
• Printing can be applied through direct printing (applying the design directly) or resist printing (masking off the design in one way or another)
  – Direct printing includes: serigraph printing, discharge printing, removing color, one color, block print (partially), tie-dye, Bonding or using the type of printing before cutting, direct and then cut
  – Other printing methods include: digital printing, electrostatic printing, heat transfer printing, hot stamping, and hand printing.

Summary

• Colorfastness refers to how well the color holds to the fabric. If the dye or pigment is colorfast, it holds well. If it is not very colorfast, it comes off by one of the means listed below:
  – Problems with color fastness include: bleeding (color transferring to other fabrics in the wash), crocking (color transferring by rubbing), migration (color transferring to adjacent areas – like red thread bleeding onto white fabric over time), and fading (color loss by time, sunlight, or other natural offensives)
• Other dying and printing issues that arise include: tendering (weakening of the fiber due to the chemical process of dying or printing), frosting (poor dye penetration in certain areas), off-register prints (not matching up), and prints that are off-grain from the fabric.
• The process of dying uses a large amount of water that can become contaminated. This can be partially reclaimed and recycled or solutions can be used as carriers for the dye. However, the biggest impact from textiles on the environment occurs after it reaches the consumer.