TECHNICAL BULLETIN

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ISP 1001

COLORFASTNESS OF COTTON TEXTILES

This report is sponsored by the Importer Support Program and written to address the technical needs of product sourcers.

INTRODUCTION

Today's consumer is more sophisticated than ever. They are conscious not only of style and comfort, but also of care and durability. They demand a quality product. Market studies show that consumers make many purchase choices based on color. Therefore, a fabric's ability to retain its original color is one of the most important properties of a textile product.

The colorfastness or color retention of cotton textiles is influenced by a number of variables that occur both pre-consumer and post-consumer. This report summarizes how variations in raw materials, chemicals, manufacturing processes and consumer practices all have an effect on the performance characteristics of a fabric. Manufacturers must understand how the many variables affect colorfastness to achieve the ultimate goal of consumer satisfaction.

COLORFASTNESS AND TEST METHODS

Colorfastness is defined by the American Association of Textile Chemists and Colorists as "the resistance of a material to change in any of its color characteristics, to transfer its colorant(s) to adjacent materials, or both, as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage, or use of the material." In other words, it is a fabric's ability to retain its color throughout its intended life cycle. There are many types of colorfastness properties that must be considered to provide the consumer with an acceptable product. The American Association of Textile Chemists and Colorists has over thirty test methods that evaluate different colorfastness properties. These include, but are not limited to wash, light, crock, dry cleaning, perspiration, abrasion and heat. The type of product being manufactured determines which types of colorfastness are important and therefore which test methods are relevant. For example, upholstery fabrics must have excellent lightfastness and crockfastness properties, whereas washfastness is important for clothing fabrics. Manufacturers must know a fabric's intended end use in order to make processing decisions that will produce a product of acceptable performance.

TEXTILE MANUFACTURING PROCESSES AFFECTING COLORFASTNESS

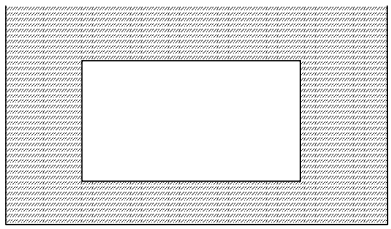
Preparation

Many aspects in the textile manufacturing process of taking a loom state fabric to a finished product have an effect on the colorfastness properties. Preparation is the first stage of textile wet processing. Cotton fibers are approximately 95% cellulose. The non-cellulosic portion consists of natural products such as waxes, sugars, metals, and man-made products such as processing aids, grease, plastic, and rubber. To achieve optimum dyeing and finishing conditions, it is important that these impurities are thoroughly removed with minimal damage to the cotton fiber.

Dye Selection

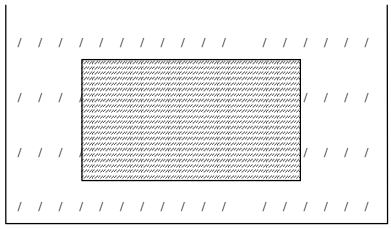
Dyeing is the crucial step in determining the colorfastness performance of a fabric. The American Association of Textile Chemists and Colorists define a dye as "a colorant applied to or formed in a substrate, via the molecularly dispersed state, which exhibits some degree of permanence." Dyeing is accomplished by immersing the textile in a dye bath, applying heat and chemicals to drive the dye onto the textile, and then rinsing the substrate to remove the surface dye. These principles are illustrated below.

1. Immerse textile in dyebath



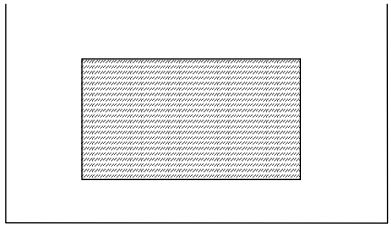
- All dye is in bath

2. Apply heat, time chemicals to drive dye onto textile



- Most of the dye now on textile, hopefully

3. Rinse to remove surface dye



- Unfixed dye removed

Different dye classes are used for each fiber type. The table below shows which dyes can be used for which fibers.

Dye Classes Available for Different Fibers

Fiber	Dyestuffs
Cotton & manmade cellulosics	Direct, Vat, Sulfur, Naphthol, Reactive, Pigment
Polyester	Disperse, Basic
Nylon	Disperse, Acid, Premetallized
Acetate	Disperse
Wool & Silk	Acid, Premetallized
Acrylic	Disperse, Basic

Dye selection must be based on desired performance criteria, manufacturing restrictions and the costs a market can bear for each end product. Every dye has unique colorfastness properties. Some dyes are known for their excellent washfastness characteristics and others are known for their lightfastness properties. The structure of the dye, the amount of dye, its method of bonding to the fabric and dyeing procedures all contribute to a dye's performance characteristics. Dye combinations in a specific formulation must also be evaluated for their effect on colorfastness. Heavy shades often have reduced fastness properties. When high concentrations of dye are required, proper rinsing and washing off procedures are essential. However, due to entrapped dye particles within the cellulose structure, some unbound dye molecules can still remain and contribute to color loss and dye transfer.

DYES FOR COTTON

Dyes can be categorized based on the mechanism by which they become fixed to a fiber. Dyes used for cotton fibers can be categorized into the surface bonding, adhesion, or covalent bonding mechanisms.

Pigments are sometimes used to color cotton fabrics, however they are not considered dyes. They are completely insoluble in water and have no affinity for cotton fibers. Some type of resin, adhesive, or bonding agent must be used to fix them to the cotton fiber. Typically, they exhibit good colorfastness to light and poor colorfastness to washing.

Direct dyes are water soluble and categorized into the surface bonding type dye because they are absorbed by the cellulose. There is no chemical reaction, but rather a chemical attraction. The affinity is a result of hydrogen bonding of the dye molecule to the hydroxyl groups in the cellulose. After the dyestuff is dissolved in the water, a salt is added to control the absorption rate of the dye into the fiber. Direct dyes are fairly inexpensive and available in a wide range of shades. Typically, they exhibit good lightfastness and poor washfastness. However, by applying a fixing agent after dyeing the washfastness can be improved dramatically.

Vat, sulfur, and naphthol dyes are fine suspensions of water insoluble pigments, which adhere to the cotton fiber by undergoing an intermediate chemical state in which they become water-soluble and have an affinity for the fiber. Typically, vat dyes exhibit very good colorfastness properties. Sulfur dyes are used to achieve a low cost deep black. They exhibit fair colorfastness properties, although the lighter shades tend to have poor lightfastness. Naphthol dyes are available in brilliant colors at low cost, but application requirements limit their use. They exhibit good lightfastness and washfastness, but poor crockfastness.

Reactive dyes attach to the cellulose fiber by forming a strong covalent (molecular) chemical bond. These dyes were developed in the 1950's as an economical process for achieving acceptable colorfastness in cellulosic fibers. Bright shades and excellent washfastness properties are the trademark of reactive dyes. One concern regarding reactive dyes is their susceptibility to damage from chlorine. Another is that lighter shades tend to have reduced lightfastness properties.

The following table summarizes the fastness properties of the dye categories or classes available for dyeing cotton fabrics. Keep in mind that these are generalizations. Every dye is unique and some dyes within a particular class may behave differently.

Fastness Characteristics of Dyes for Cotton

Dye Class	Wash	Light	Crock	Perspiration	Chlorine
Pigment	Poor to Good	Good to Excellent	Poor to Good	Good	Good to Excellent
Direct	Poor to Good	Moderate to Good	Poor to Good	Poor to Good	Poor to Moderate
Vat	Good to Excellent	Good to Excellent	Fair to Good	Good	Good to Excellent
Sulfur	Good	Poor to Good	Poor to Good	Good	Poor to Moderate
Naphthol	Good to Excellent	Moderate to Good	Fair to good	Fair to Good	Moderate
Reactive	Good to Excellent	Moderate to Good	Fair to Good	Poor to Good	Poor to Good

Finishing

Finishing is the final stage of textile wet processing. Different types of finishes can be utilized depending on the desired performance characteristics of the end product. Resin and enzyme treatments are common finishing techniques that can influence the colorfastness of textile fabrics. Crosslinking resins are used to improve the durable press or wrinkle resistance of a fabric. Generally, resin treated fabrics demonstrate improved color retention to laundering. However, this increase in color retention comes at the expense of reduced physical properties of the fabric. Silicone softeners incorporated into the resin finish bath may further improve color

retention for some fabrics. Softeners and resins play a key role in reducing surface abrasion and therefore improved overall wash performance. Cellulase enzymes are used to remove surface fibers that can create a fuzzy appearance on the surface of a fabric. Generally, enzyme treated fabrics show improved ability to maintain their original color and appearance after multiple home launderings. The degree of improvement from any of these finishing techniques is highly dependent on the individual dyes used in a particular formulation to achieve a given shade.

CONSUMER PRACTICES

Manufacturers can follow every recommendation and precaution to produce a fabric with optimum performance characteristics. However, colorfastness properties are also influenced by consumer practices. These include laundry detergent selection and wash procedures. Therefore, when evaluating colorfastness properties of a product it is important to use the appropriate test method that accurately reflects the consumer laundry practices. Due to higher energy costs consumers are laundering clothes at lower temperatures. For this reason detergent with "color safe" or activated peroxy bleaching agents, which improve cleaning efficacy at lower wash temperatures, are one of the fastest growing segments of the home laundry market. Some fabrics may fade a little when home laundered with standard detergent, but fabrics laundered with detergents containing activated bleach can show significant losses in color strength as determined by the sensitivity of the dye to those detergents. Another type of detergent available to consumers is those containing enzymes, which remove surface cellulosic fibers from the fabric. Many times the loss or apparent loss of color can be attributed to surface changes in the fabric caused by abrasion during laundering. Detergents containing enzymes generally reduce the color change associated with home laundering by decreasing the fuzziness of a fabric's surface. Wash procedures also influence a fabric's ability to retain its color. Consumer practices such as washing clothes inverted, reducing the wash load size, adding softener to the final rinse and reducing the tumble dry time minimize color loss.

CONCLUSIONS

The colorfastness of cotton textiles can be a complicated subject. Fiber quality, yarn formation, fabric construction, textile wet processes and consumer practices can all have an influence on the performance characteristics of a fabric. Of these variables, the choices made during textile wet processing have the most significant effect on the colorfastness properties. Dye selection is of the utmost importance. Consumer practices such as detergent selection and laundering techniques also play a major role in the color retention of a fabric. Customer satisfaction should improve as manufacturers gain experience and knowledge in understanding and controlling the many aspects that influence colorfastness.

Importer Support Program

The Cotton Board and Cotton Incorporated are funded by U.S. upland cotton growers and importers of cotton and cotton products (this includes raw cotton, piece goods, and finished apparel). A percentage of the importer funds are devoted for importer specific programs organized under the Importer Support Program. Examples of projects funded from this fund include training schools, educational programs, focus groups, economic meetings, and research initiatives.

Selected technical issues have been identified by importer members as relevant to their business. This report is a condensed, less technical report of those issues intended to provide the reader with basic, yet useful information on the topic.

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