# TECHNICAL BULLETIN

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**TRI 4006**

# SELECTION OF COLOR SYSTEMS FOR FLAME RESISTANT COTTON FABRICS

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# INTRODUCTION

A major class of flame retardant chemicals used to impart durable flame resistance to cotton fabrics is based on organophosphorus derivatives with strong reducing power. To confer flame resistance to fabric, the nature of the treatment requires substantial add-on (up to 20% by weight) of an insoluble white polymer, thus further resulting in shade depth alteration. Because of the number and complexity of coloring systems employed, handling of the attendant problems of finishing colored cotton fabric has remained largely an empirical science based on trial and error. This brief summarizes our experience and provides guidelines for screening treatments to such fabrics to predict the expected shade loss and alterations and to screen dye baths, therefore minimizing adverse effects.

## A. <u>Chemistry</u>

The general chemical scheme for application of the phosphonium salt flame retardants is presented in equation 1.

(1)

$$R_4P^{\oplus}\ X^{\ominus} \xrightarrow{base} \underset{\text{(reducing agent)}}{R_3P:} \xrightarrow{NH_3} \underset{\text{polymer}}{\left[R_3\overset{\oplus}{P} - CH_2 - N\right]} \xrightarrow{[O]} \underset{\text{polymer}}{\left[R_2 - \overset{O}{\overset{\|}{P}} - CH_2N\right]}$$

Chemically, most shade changes probably result from reaction of the strong reducing agent $R_3P$ with dye, as illustrated in equation 2.

(2)

$$\text{Dye}\ [ox] + R_3P: \longrightarrow \text{Dye}\ [red] + R_3P=0$$

## B. <u>Observed Effects on Dye Classes</u>

If the reduced form of the dye can be reversibly oxidized with hydrogen peroxide ($H_2O_2$) in the course of fixing the flame retardant polymer, the original shade may be recovered. Such is the case with certain sulfur dyes. In many cases, however, this is not applicable. Significant changes in the lightfastness of dyed fabrics probably result from the flame retardant acting as a sensitizer or energy transfer agent.

Our experience suggests the following expected trends of observed effects. Because of the add-on requirements to achieve flame resistance, some colors weaken and/or change hue; this is most pronounced with dark shades, e.g., navy, black. The effect can usually be minimized by using only the amount of flame retardant necessary to meet the char length and durability requirements. Shade changes follow the trends in the following table:

| Dye Class | Effect |
|---|---|
| Vats | Minimal shade change; a few exceptions |
| Sulfurs | Shade changes; recovered generally on oxidation; must compensate for lost flame retardant |
| Pigments* | Little effect |
| Napthols | Minimal shade change; some exceptions |
| Reactives | Most change shade; few exceptions such as yellows |
| Directs | Most change shade |
| Lightfastness properties should be measured on a case-to-case basis since the effect is difficult to predict. Laboratory trials can be run to screen dyestuff combinations. | |
| *Pigments are normally applied after the flame retardant. | |

**C. <u>Laboratory Procedure for Determining Effect on Shade</u>**
To determine the effect on dye shade for a specific fabric, the following procedure is recommended. Apply a bath constituted as:

| | **Percent** |
|---|---|
| Phosphonium Precondensate | 45 |
| Sodium Acetate[1] | 2 |
| Wetter | 0.2 |
| Water | to 100% |

Apply to a sample of fabric approximately 12" x 12" by padding and squeezing. Dry the fabric at 225° F according to the following weight related guidelines:

| **Fabric Weight** | **Time (sec.)** |
|---|---|
| 3 - 7 $oz/yd^2$ | 45 |
| 8 - 11 $oz/yd^2$ | 60 |
| > 12 $oz/yd^2$ | 90 |

Following drying, the fabric is suspended freely in a chamber of sufficient size to provide at least one inch free space in all dimensions around the fabric. The chamber should be capable of having ammonia gas introduced and exhausted. (**Caution:** Chamber should be placed in a laboratory hood or be otherwise well ventilated.) The fabric sample is exposed to ammonia gas at a modest flow rate for a period of one minute in this chamber.

[1] If recommended by chemical supplier.

Following ammoniation, the fabric is immersed in a solution of $H_2O_2$ in 1 liter of water. The quantity of $H_2O_2$ (real) used is 5% based on the weight of the treated fabric. The fabric is washed thoroughly in warm water and dried.

Shade evaluation of the treated fabric can be handled by visual inspection[2]. Alternatively, instrumental methods may be employed to evaluate both loss of strength and change of color. Samples of the treated fabric can be evaluated for lightfastness and compared with the untreated fabric by using AATCC Method 16E-1987.

## D. Procedure for Correcting Shade or Fastness Deficiencies

Because of the numerous dyestuffs employed to formulate commercial colors on fabrics, the correction of such deficiencies remains an empirical science. When a problem color is found in the screening procedure of the previous section, we recommend reformulating the shade using different dyestuffs, e.g., substitute vats for reactives. By describing the reducing capacity of the flame retardant to the dye manufacturer, the manufacturer may be able to recommend alternative candidate colors to employ. For multi-dye mixture shades, change of one component may significantly improve shade and lightfastness properties.

In some cases, shade alteration is more subtle in that slight hue shifts occur, e.g., redder, greener, etc. We have found that, in such instances, the shift direction caused by the flame retardant chemical is predictable and reproducible so that in combination colors, it can be compensated for by altering the component proportions. For example, if a light blue dye combination shifts to a red cast on finishing, color compensation in the original mix may result in the finished fabric meeting a specified shade standard. Effects on lightfastness properties are handled in exactly the same empirical fashion.

[2] Using AATCC Evaluation Procedure 1 (Gray Scale for Color Change).

# RESEARCH AND TECHNICAL SERVICES

Cotton Incorporated is a research and promotion company representing cotton worldwide. Through research and technical services, our company has the capability to develop, evaluate, and then commercialize the latest technology to benefit cotton.

- Agricultural research leads to improved agronomic practices, pest control, and fiber variants with properties required by the most modern textile processes and consumer preferences. Ginning development provides efficient and effective machines for preservation of fiber characteristics. Cottonseed value is enhanced with biotechnology research to improve nutritional qualities and expand the animal food market.

- Research in fiber quality leads to improved fiber testing methodology and seasonal fiber analyses to bring better value both to growers and then mill customers.

- Computerized fiber management techniques result from in-depth fiber processing research.

- Product Development and Implementation operates programs leading to the commercialization of new finishes and improved energy and water conserving dyeing and finishing systems. New cotton fabrics are engineered -- wovens, circular knits, warp knits, and nonwovens -- that meet today's standards for performance.

- Technology Implementation provides comprehensive and customized professional assistance to the cotton industry and its customers -- textile mills and manufacturers.

- A fiber-to-yarn pilot spinning center allows full exploration of alternative methods of producing yarn for various products from cotton with specific fiber profiles.

- The Company operates its own dyeing and finishing laboratory, knitting laboratory, and a laboratory for physical testing of yarn, fabric, and fiber properties including High Volume Instrument testing capable of measuring micronaire, staple length, strength, uniformity, color, and trash content.

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