Dyeing of a Blended Fabric with a Continuous Method with Active and Dispersive Dye

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Abstract: In the article the possibilities of obtaining intense and uniformly colored dyes for blending blended fabrics on the basis of cotton and polyester fibers of various proportions with the use of a combination of active and disperse dyes and studies. The color indices of the samples stained according to the proposed technology are given.

Keywords: cotton, polyester fiber, active dye, disperse dye, blended material, thickener, caustic alkali, calcined soda, salt.

Introduction
In the world, research work is underway aimed at developing new scientific and technical solutions and resource-saving technologies, as well as introducing the latest equipment for the chemical finishing of mixed textile materials. In this regard, special attention is paid to expanding the range of finished products by creating energy-saving technologies for bleaching, dyeing and printing mixed fabrics containing natural and chemical fibers with high color and physical and mechanical properties [1].

Theoretical Studies
It is known that polyester fibers are obtained as a result of the polycondensation reaction of terephthalic acid or its dimethyl ether and ethylene glycol [2]. But depending on the reaction conditions, the reagents used, the fiber spinning conditions, the produced polyester fibers in different countries use different names such as Dacron (USA), Teteron (Japan), Trevir and Lanon (Germany), Tergal (France), Tesil and Svitlen (Czech Republic), Elana (Poland), Lavsan (Russia) [3]. Also, in order to reduce the static electricity, increase hygroscopicity, improve dyeability, make the fiber fireproof or slow combustible, and also to eliminate other disadvantages, polyethylene terephthalate is modified, i.e. upon receipt of the polymer, along with the main monomer, another monomer is added in an amount of 5-10% (with respect to the main monomer). Depending on their properties and quantity, the resulting copolyester changes its properties [4, 5].

The scientific literature has a wealth of information on the finishing of cotton/polyester blended fabrics due to the high volume and high quality of this blend. According to the prevailing notions, if the second component is added in an amount of up to 15% in a mixture of cotton and chemical fibers to impart low wrinkling and improve the appearance of the product, then it is considered to be made from 100% natural fibers.

Recently, the manufacture of products from a mixture of fibers has been an effective way to use...
industrial waste [6].

Fabrics made from the same fibers in different blend ratios can be used in a variety of applications. Meanwhile, the definition of the type of processing of textile materials depends on the field of application. For example, if fabrics made from polyester, polypropylene and jute fibers in a ratio of 20:30:50 are used for the manufacture of dense clothing fabrics, then at a ratio of 25:25:50 they are used for the manufacture of tablecloths, lining and furniture fabrics [7]. To avoid the risk of permanent creases during finishing due to slight deformation of the chemical fibers in the mixture, finishing of such fabrics requires the use of equipment on which processing is carried out only in the expanded state.

The object of our research was fabric samples made of cotton and polyester fibers in various ratios: cotton (Namangan-77) and polyester (molded in JV Reprocessing Uz LLC from polyethylene terephthalate granules produced in South Korea) fibers. The quality indicators of the material after dyeing are determined by the following characteristics: color intensity, uniformity, purity, wash and friction strength.

**Analysis of the results.** The use of a combination of dyes when dyeing materials made of mixed fibers makes it possible to obtain an intense and uniform color. When carrying out the dyeing process with various classes of dyes, it is necessary to take into account their compatibility in solution. In this case, both dyes must retain their coloring properties in the selected dyeing mode (temperature, pH), form strong bonds with the fibers, and maximally transfer from the coloring solution to the fibers. When using a combination of dyes, one- or two-stage dyeing methods can be used. In the one-stage dyeing method, the dyes of both classes are in the same dye solution, in the two-stage dyeing method, the fibers are dyed respectively, first in a dye solution of one class, then in a dye solution of another class. In addition, the presence of a dye and excipients in the composition of one or two solutions also determines the one- or two-stage dyeing process.

Continuous dyeing methods are usually used to increase the intensity of technological processes and to obtain cost-effective colors with the same color indicators of products in one batch.

Dyeing of a mixed fabric of cotton and polyester fibers in a continuous one-stage method is carried out as follows: Samples are impregnated at room temperature with a solution containing active and dispersed dyes, urea, an alkaline agent and manutex. Then the samples are dried, heat treated, washed successively with cold, warm and hot water. In order to remove non-fiber-fixed dyes from the fibrous substrate, the penultimate washing process is carried out in a surfactant solution. Then washed with hot and cold water, dried samples. Table 1 shows the results of dyeing samples by the two-bath continuous method with the composition given in [8].

<table>
<thead>
<tr>
<th>Cotton Samples/PE, %</th>
<th>Color indicators of samples</th>
<th>Strength, score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intensity, %</td>
<td>Equivalence, %</td>
</tr>
<tr>
<td>75/25</td>
<td>11</td>
<td>1,7</td>
</tr>
<tr>
<td>57/43</td>
<td>7</td>
<td>1,2</td>
</tr>
<tr>
<td>44/56</td>
<td>6,5</td>
<td>1,4</td>
</tr>
</tbody>
</table>

According to the data in the table, the uneven coloration of the samples is visible, in addition, a decrease in the color intensity is observed with an increase in the amount of polyester fibers in the mixture. Perhaps the reason for the formation of uneven colors is the presence of caustic alkali in the composition of the dye bath used as an alkaline agent. Apparently, under the action of alkali and urea in a solution, the sorption on the surface of the fabric of products of the interaction of a dispersed dye with a chlorotriazine active dye containing hydroxyl and amino groups led to the formation of an uneven color of cotton fibers. In addition, the sorption of a disperse dye into cotton fiber in a strongly alkaline environment leads to the formation of a dull tone on the surface of the fabric. The drying mode of the fabric impregnated with the dye...
solution also led to a decrease in the intensity of the stains of the samples. This is especially observed on samples containing 56 and 43% polyester fiber. When drying a damp fabric immediately at a high temperature, due to the migration of a dispersed dye, the color intensity of the polyester component decreases. Manutex concentrations can be increased to reduce dye migration, but it is considered problematic to control the interaction of the two classes of dyes in an alkaline environment. The dyeing process can be carried out in a slightly alkaline environment, but this reduces the amount of binding dye, which leads to a decrease in color fastness to washing. Thus, different requirements for dyes and the composition of the dye bath, as well as the difficulty of selecting compatible types of dyes of different classes, obliges the use of a two-stage dyeing method.

In connection with these, the technology of a continuous two-stage method of dyeing mixed fabrics based on cotton and polyester fibers of various ratios with a mixture of active and disperse dyes has been studied. In this case, the active and disperse dyes are in one solution, the alkaline agent is in the second solution. Thus, in an alkaline medium, a decrease in the degree of hydrolysis of active dyes and the interaction of dyes of various classes is achieved. It is known that active dyes covalently bind to cellulose fibers, forming strong colors. But their hydrolysis at high temperature in an alkaline medium leads to a decrease in the fixed part of the dye, i.e. the hydrolyzed part of the dye is only sorbed into the fiber (not fixed), which leads to a decrease in the color strength of the dye.

A suspension of a disperse dye with a dispersant and a thickener was prepared, the suspension was added to a solution of the active dye in a wetting agent. Mixed fabric samples were impregnated with this solution, heated to 600°C. Then the samples were pressed (65-70%) and dried. The dried tissue samples were put through the process of thermostable at a temperature of 180-200°C for 1 minute.

Thermally insulated samples were impregnated at room temperature with a solution containing caustic alkali, soda ash and table salt. The samples were pressed (80%) and steamed for 10-20 minutes, then washed with cold and hot water. To remove the sorbed (not bound) active dye, the samples were treated in a detergent solution with a concentration of 1–2 g/L, then washed with hot water and dried. The color indices of the experimentally stained samples are shown in Table 2.

**Table 2. Color indicators of samples of mixed fabric dyed by thermosol method**

<table>
<thead>
<tr>
<th>Cotton Samples/PE, %</th>
<th>Color indicators</th>
<th>Strength, score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intensity, %</td>
<td>Equivalence, %</td>
</tr>
<tr>
<td>75/25</td>
<td>14</td>
<td>0.7</td>
</tr>
<tr>
<td>57/43</td>
<td>10</td>
<td>0.9</td>
</tr>
<tr>
<td>44/56</td>
<td>11</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Note: Thickener concentration – 35 g/l,
Dispersant concentration – 3 g/l.

A sharp increase in color intensity is associated with the formation of a whole film on the surface of the fabric. Coating the surface structure with a film negatively affects the air conduction of tissues. From the data in the table it can be seen that although in all three samples the uniformity of colors is good, the intensity of the colors is low.

The alginate thickener in the dye solution serves to prevent the migration of the disperse dye at high temperature. It follows from this that it is possible to increase the color intensity by increasing the concentration of the thickener in the solution (Fig. 1.).
The formation of a covalent bond of the dye with cotton fiber and the reaction of its hydrolysis is favored by an alkaline environment. The hydrolyzed dye has an affinity for cellulose, can dye the fiber, but is not able to form chemical covalent bonds with it, and therefore sharply reduces the strength of the colors obtained by using active dyes. In this regard, the main task in dyeing with active dyes is to create conditions for the chemical fixation of the dye on the fiber while minimizing the hydrolysis process, which also helps to reduce the color intensity. The influence of the concentration of the alkaline agent on the color intensity is shown in fig. 2. [8].

Electrolytes increase the rate of dye transfer from solution to fiber. The main parameter on which economic indicators and consumer properties depend is the intensity of colors. In the presence of electrolytes, due to the rapid and more complete depletion of the dye solution, the colors are more intense, and the waste water less polluted. The mechanism of the intensifying action of electrolytes is manifested in the following: cellulose fibers, when immersed in a dye solution, acquire an excess negative charge. Since the particles of active dyes are also negatively charged, they are repelled from the fiber during the dyeing process. Positively charged electrolyte cations neutralize the negative charge of the fiber and dye and facilitate the process of dye sorption by the fiber. At the same time, the presence of an electrolyte can cause enhanced aggregation of the dye, which in turn will lead to a decrease in the color intensity. As can be seen from fig. 3, in the
two-stage dyeing method, no dye aggregation is observed: at an electrolyte concentration of 125 g/l, an equilibrium is formed in the system.

![Color intensity vs. electrolyte concentration graph](image)

1-75/25; 2-44/56; 3-57/43

**Fig. 3. Influence of electrolyte concentration on the color intensity of cotton/PE fabric, (%)**

Disperse dyes are distinguished by their small molecular size, simple chemical structure, and low molar mass; therefore, their particles at high dyeing temperatures are able to penetrate into the pores of thermoplastic fibers, forming “solid solutions”.

<table>
<thead>
<tr>
<th>Cotton/PE samples, %</th>
<th>Color Intensity, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dispersant concentration, g/l</td>
</tr>
<tr>
<td></td>
<td>3</td>
</tr>
<tr>
<td>75/25</td>
<td>41</td>
</tr>
<tr>
<td>57/43</td>
<td>35</td>
</tr>
<tr>
<td>44/56</td>
<td>30</td>
</tr>
</tbody>
</table>

With an increase in the concentration of the dispersant, the color intensity of the samples of blended fabrics also increases, which is especially noticeable in the sample containing the largest amount of polyester fiber (Table 3).

Based on the obtained results, the paper proposes a technology for coloring a mixed fabric based on cotton and polyester fibers of various ratios in a continuous two-stage method with a composition that includes a mixture of active and disperse dyes [9].

**Conclusion**

In contrast to the one-stage method, the proposed two-stage heat-setting-steam method achieves intense, uniform and wet-resistant colors on both components (Fig. 4).

![Diagram of dyeing process](image)

**Fig. 4. Technology of dyeing in a continuous two-stage method of mixed fabrics**
References


