Coloring Powder Compositions are Universal Dyes for Dyeing Natural and Synthetic Fibers as Well as Textile Materials based on Them

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Abstract: On the basis of comprehensive studies were designed the optimum compositions of powder colorific compositions based on salts of polyvalent metals for protein and polyamide and cellulosic fibers and fabric dyeing technology based on them. Powder colorific compositions for textiles based on protein, cellulose and polyamide fibers, due to their interaction with the fiber, help creating salt, coordination and covalent connections and creating the coloring on fibers, which has a high resistance to various physical and chemical effects. It has been established that when processing the cotton fabrics by γ-aminopropyltriethoxysilane and solutions of composition based on polyvalent metal salt, sodium nitrite and a phenol derivative in an acid medium is formed a stable chelate complex of nitrosophenol with cations of a polyvalent metal, which reacts with the modified cotton cellulose with formation a covalent bond. Dyeing of protein, polyamide and cotton fibers with colorific composition are carried out in an acidic environment at pH 3-4. At the boiling temperature reaches its equilibrium in the case of dyeing textile materials based on protein fibers for 2-3 minutes, cotton fabrics 6-7 minutes, polyamide for 35-40 minutes. The obtained colorings are characterized by high resistance to various physical and chemical factors: washing, dry cleaning, abrasion and light.

Key words: Protein fibers, polyamide fabric, cotton fabric, dyeing, colorific composition, amination, the technology of dyeing, color characteristics, mechanism of dyeing.

1. Introduction

The development of the textile industry is caused by the development of new import-substituting materials and technologies. In this respect, the development of dye compositions that encourage the formation a coloration on fiber which is light-, washing-, abrasion- and stains-proof, and dyeing technology of textile materials including synthetic, the need for which is met only by importing them from Germany, Great Britain, Russia and other countries due to the non-availability of aniline-ink industry in Uzbekistan, is present both scientific and practical interest.

The method of dyeing by synthesis on the fiber the organic dyes of low molecular weight compounds of simple structure is the most rational solution to intensification the dyeing process. This is because the molecules of the initial compounds have almost no relation to the fiber, and because of the small geometric dimensions show high diffuson coefficient values in the fibrous substrate, thereby achieving the maximum colour penetration of fibers in the minimum time of its stay in the solution.

The scientific novelty of this study consists of the following: the optimum compounds of dyeing compositions, which give steady coloring to natural and chemical fibers, have been developed. The regularities of formation of metal complexes in the structure of fibers have been studied and the mechanism of formation of metal complexes in the structure of the fiber has been researched.
In connection with the above, the goal of the research is to develop the dye compositions based on local raw materials and the technology of cotton, nylon and natural silk textile materials dyeing without application of special dyes.

2. Subject and Methods of Research

The subject of research was protein fiber, nylon fabric, cotton fabric, alkali and polyvalent metal salts, aromatic hydroxyl compounds. The study of the physicochemical properties of the fibers and material structure carried out by IR spectroscopy, spectrophotometry, chelatometry, pH analysis, X-ray diffraction, electron microscopy and other physical and chemical methods of analysis.

Protein fibers are high-molecular compounds, constructed mainly of acyclic, carboxylic and heterocyclic amino acids. There is 13% of tyrosine from the amount of amino acid at the fibroin. The presence of amino acids in the protein fibers containing aromatic rings (tyrosine, tryptophan) allows the formation of complex compounds of chelate type with polyvalent metal ions. Protein fibers consist of the remnants of -α-amino acids and, therefore, contain a large number of amino and carboxyl groups. In addition to the groups located at the ends of the polypeptide chain, the fibroin consists of a large number of residues diamino-and dicarboxylic acids. These acid residues contain inside radicals also free amino and carboxyl groups capable to a reaction of nucleophilic and electrophilic substitution. The combination of phenols with diazotised proteins may contribute to giving the color to a fiber.

On the other hand, amines as well as carbonyls have the property of forming coordination bonds. With polyvalent metal cations such as iron, nickel, cobalt, copper, having their own chromophoric properties, they form colored complexes. By the action of nitric acid on the protein fibers, all amino groups are changing. Moreover, there is a possibility of a transition part of the amino groups in the azo group and further interaction with metal cations with complexes formation. The presence of hydroxyl or amino groups in the n-position to the azo group promotes the formation of stable complex compounds.

In articles [1, 2] has been informed about the development of dye compositions based on derivatives of phenol, which can color the protein fibers. Dyeing compositions include phenol derivatives, salts of polyvalent metals, sodium nitrite. Sodium nitrite in the dye composition contributes diazotization of amino groups and the transition of phenols in nitrosophenol forming colored complex compounds with transition metal cations.

The possibility of dyeing protein fibers by the solutions of copper, iron, cobalt and nickel salts has been studied. The results showed that the treatment of protein fibers by aqueous solutions of Cu²⁺, Co²⁺, Ni²⁺, Fe³⁺ metal salts, they become dull colors that can easily remove from the fiber during the subsequent washing. Processing of protein fibers by Cu²⁺, Co²⁺, Ni²⁺, Fe³⁺ salt solutions in the presence of sodium nitrite contributed to the getting a bright and stable colors. Under the action of sodium nitrite on protein fibers in acid medium, all amino groups of fiber are changing. Not exclude the possibility of a transition of some amino groups in the azo group and further interaction with transition metal cations with formation of complex compounds.

Getting the metal complexes in the polymer matrix of protein fibers initiate in a known manner the formation of complex compounds of polyvalent metal cations with phenol derivatives. Protein fibers were treated at the boiling point for 2-3 min in a solution containing a water-soluble polyvalent metal salt, phenol and sodium nitrite. The molecules of these compounds are virtually no affinities to the fiber and because of the small geometric dimensions show high diffusion coefficients in the fibrous substrate. Equally important is the fact of the presence of the amino and carboxyl groups in fiber capable of forming complex
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compounds or associate fiber with the formed complex by strong, covalent bonds [3].

Dyeing the protein fibers by dye composition is carried out in an acidic medium at pH = 3-4. The dyeing reaches equilibrium within 2-3 min at boiling temperature (Fig. 1).

The input of metal complexes based on cations of copper, iron, nickel, cobalt to the protein fibers contributes to the intense colors of fiber, resistant against various physical and chemical factors: the wet treatments, to organic solvents, to light and abrasion.

Table 1 shows the color tones of natural and synthetic fibers, dyed by dyeing powder compositions based on resorcinol.

Based on the conducted studies, it was concluded that the developed dye composition can be applied to any dyeing fibers in the presence of the primary amino groups in polymer substrate. Polyamide fibers as well as the protein fibers contain as functional one the amino and carboxyl groups, adsorption of dye compositions components molecules is carried out by undergoing the salt formation reactions between these functional groups, and accordingly with anions and cations of dye compositions. The presence of ending primary amino groups in the polyamide fiber allows the direct synthesis of colored compounds in the fiber by diazotization of primary amines with their transformation into a diazonium salt capable to interact with phenols, aromatic amines and some other compounds with free o-and p-positions with formation azo dyes in conjunction of arilazogroup to a carbon atom. The presence of the hydroxyl group in o-position to the azo group leads to the formation of chelate bond, which contributes to stable complexes. This conclusion was confirmed by dyeing of polyamide fibers by dye compositions.

By the conducted research it have been evidenced that during the treatment of polyamide fiber by composition “sodium nitrite-a polyvalent metal salt” they are not colored. The polyamide fibers practically not colored in the same treatment process by the compositions “sodium nitrite-phenol derivatives”. The processing of polyamide fibers by compositions “sodium nitrite-a polyvalent metal salt-phenol derivatives” gives the variety of intense colors of fiber. The color tone of obtaining colors depends both on the nature of the input cation and the organic component (Table 2).

Table 1  The color tones obtained on different fibers with powdered dye compositions.

<table>
<thead>
<tr>
<th>Input polyvalent metals cations</th>
<th>Fiber nature</th>
<th>Color tone of obtained coloration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe$^{3+}$</td>
<td>Natural silk</td>
<td>From green to black</td>
</tr>
<tr>
<td></td>
<td>Cotton</td>
<td>Green</td>
</tr>
<tr>
<td></td>
<td>Nylon</td>
<td>From green to black</td>
</tr>
<tr>
<td>Co$^{2+}$</td>
<td>Natural silk</td>
<td>From orange to burgundy</td>
</tr>
<tr>
<td></td>
<td>Cotton</td>
<td>Orange</td>
</tr>
<tr>
<td></td>
<td>Nylon</td>
<td>From orange to burgundy</td>
</tr>
<tr>
<td>Cu$^{2+}$</td>
<td>Natural silk</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td>Cotton</td>
<td>Brown</td>
</tr>
<tr>
<td></td>
<td>Nylon</td>
<td>Brown</td>
</tr>
<tr>
<td>Ni$^{2+}$</td>
<td>Natural silk</td>
<td>From mustard to brown</td>
</tr>
<tr>
<td></td>
<td>Cotton</td>
<td>mustard</td>
</tr>
<tr>
<td></td>
<td>Nylon</td>
<td>From mustard to brown</td>
</tr>
</tbody>
</table>

Table 2  The color characteristics of dyed polyamide fiber by powder dye compositions.

<table>
<thead>
<tr>
<th>Organic component</th>
<th>Input salt</th>
<th>Resorcinol</th>
<th>Pyrocatechol</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\lambda$, nm</td>
<td>P, %</td>
<td>Color tone</td>
</tr>
<tr>
<td>Fe$_2$(SO$_4$)$_3$</td>
<td>535</td>
<td>53</td>
<td>Green</td>
</tr>
<tr>
<td>CuSO$_4$</td>
<td>598</td>
<td>44</td>
<td>Brown</td>
</tr>
<tr>
<td>NiCl$_2$</td>
<td>582,5</td>
<td>40</td>
<td>Coffee</td>
</tr>
<tr>
<td>CoCl$_2$</td>
<td>603</td>
<td>63</td>
<td>Orange R</td>
</tr>
</tbody>
</table>

$\lambda$-wave length, P-saturation.
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The effective method for studying the processes of complex formation and chemical interaction of polymers with different compounds is the method of spectrophotometry. The solutions of source PA fiber and fiber colored by dye composition in the range of 300-1,100 nm have been studied.

From the absorption spectrum of the PA fiber can be found that the source PA fiber in the studied range has no typical absorption band. It is known that the amino groups can form complexes with polyvalent metal cations, but nevertheless they are not stable, which is confirmed by the obtained data. The PA fiber dyed by compositions-phenol derivatives, salts of polyvalent metals, sodium acetate does not colored. In dyeing PA fiber by compositions - phenolic derivative, polyvalent metal salt, nitrite and sodium acetate the nylon fiber gets various colors.

In the IR spectra of colored PA fibers (Fig. 2) the absorption band of stretching vibrations $\tilde{\nu}$ (NH) shifted to a lower frequency area, indicating the formation of a coordination bond of $M\rightarrow N$ type. In all probability, the presence of $M\rightarrow N$ bonds causes the appearance of weak absorption bands with peaks at 550-530 cm$^{-1}$ due to the stretching vibrations $\tilde{\nu}$ (MN). The absorption band of the carbonyl group (1,650 cm$^{-1}$) also shifts to a lower frequency area, which indicates the formation of the coordination bond of the M-O carbonyl group.

The absorption band at 1,550 cm$^{-1}$ can be attributed to the stretching vibrations of the aromatic azo-group, which appears once again with the absorption band at 1,040 cm$^{-1}$. The presence of the nitroso groups in a colored polyamide fiber is occurring with its typical absorption band at 1,350 and 1,400 cm$^{-1}$.

The formation of colored complex compounds in polymer substrate has been found by spectrophotometric studies of solutions of polyamide and protein fibers. The even distribution of complexes (nano) particles in the fiber volume has been determined by X-ray diffraction and electron microscopy.

One of the shortcomings of nylon fibers is low lightfastness. It has been found that the input of the compositions into the fiber contributes to its light stability.

The chemical structure of polymers has a significant effect on the fixation of the input compounds because the functional groups of building blocks, the end groups of the macromolecules and other elements of the main valences circuit and side groups are potential active centers, on which the physical and chemical adsorption of the compounds can occur.

One of the end groups of polyamide macromolecules is an amino group that makes possible to apply the developed dye composition for dyeing it. Due to the dense packing of the structural elements, the rate of dyeing of polyamide textile materials is lower than the other studied fibers. Dyeing of polyamide fibers at the boiling temperature reaches its equilibrium after 35-40 minutes (Fig. 1).

The possibility of using the developed dye compositions for dyeing cellulose textile materials has been studied. [4] Effective way to modify cellulosic materials with obtaining highly substituted aminated cellulose is the introduction of amino groups by reacting cellulose with alkoxysilanes. We used $\gamma$-aminopropyltriethoxysilane that makes possible to obtain aminated cotton fabric with a degree of
substitution $\gamma$ equal to 16.5.

To study the mechanism of interaction of cotton fiber cellulose with $\gamma$-aminopropyltriethoxysilane it has been taken IR spectra of the initial and aminated cotton fabric (Fig. 3)

The main IR absorption bands of OH groups of cellulose located in 3,650-3,100 cm$^{-1}$ (valence vibrations) and 1,500-600 cm$^{-1}$ (deformation vibrations). Lack of absorption in a spectrum of cotton cellulose on 3,650 cm$^{-1}$ indicates that there are no free hydroxyl groups in solid cellulose, the groups are linked by hydrogen bonds. Modification of cotton fabric by $\gamma$-aminopropyltriethoxysilane (Fig. 3) contributes to the increase of intensity of the absorption band at 3,500-3,300 cm$^{-1}$ and 1,640 cm$^{-1}$, which is a testament to the amination of cotton fabric, because the absorption band of the primary amino group is located within the 3,300-2,500 cm$^{-1}$ (valence vibrations) and 1,640-1,535 cm$^{-1}$ (deformation vibrations) [5].

The modification of cotton fabric by $\gamma$-aminopropyltriethoxysilane is also can be identified by an absorption band at 2,962 cm$^{-1}$, responsible for CH$_2$ (deformation vibrations), appeared again at 1,380 cm$^{-1}$ (CH$_2$ valence vibrations). In the absorption spectrum of the aminated cotton fabric the absorption band appears at 1,000 cm$^{-1}$, responsible for the siloxane groups Si-O (valence vibrations) and the absorption band at 850-820 cm$^{-1}$, responsible for the group Si-C (valence vibrations).

The mechanism of interaction of cotton cellulose with $\gamma$-aminopropyltriethoxysilane occurs according to the following reaction:

$$
\text{C}_6\text{H}_4\text{O}_3(\text{OH})_2 + \text{C}_2\text{H}_5\text{Si}-(\text{CH}_2)_3\text{NH}_2 \rightarrow \text{C}_6\text{H}_4\text{O}_3(\text{OH})_2 - \text{Si}-(\text{CH}_2)_3\text{NH}_2 + \text{C}_2\text{H}_5\text{OH}
$$

In accordance with the reaction, the cotton cellulose is reacted with $\gamma$-aminopropyltriethoxysilane with the formation of covalent bonds. This is evidenced by data on the results of washing the aminated cotton fabric: cotton cellulose degree of substitution does not change even when washing the aminated cotton at the boiling temperature.

Carried out researches have shown that the metal complexes in the structure of the cotton fibers are formed only in the presence of aromatic hydroxyl compound in composition formulation. It is known that under the action of nitrous acid the phenols easily nitrosated with the formation of nitrosophenols. O-nitrosophenols with polyvalent metal cations forming brightly colored chelate compound. Under the action of nitrous acid (sodium nitrite in an acidic environment) on resorcinol is formed 2.4 dinitrosoresorcinol. Having a hydroxyl group in the o-position to the nitroso group contributes to the formation of chelate bonds and hence ensures a high strength of colored complex of 2.4 dinitrosoresorcinol with polyvalent metal cations:

When the aminated cotton fabric treated with a solution of composition comprising a polyvalent metal salt, the aromatic hydroxyl compound and sodium nitrite in the presence of an acid the primary amino groups under the action of nitrous acid (sodium nitrite in acidic medium) are transformed into the diazonium salt.

$$
\text{C}_6\text{H}_4\text{O}_3(\text{OH})_2 - \text{Si}-(\text{CH}_2)_3\text{NH}_2 + \text{HONO} \rightarrow \text{C}_6\text{H}_4\text{O}_3(\text{OH})_2 - \text{Si}-(\text{CH}_2)_3\text{N}^+ + \text{H}_2\text{O} + \text{C}_2\text{H}_5\text{OH}
$$
Diazotized cotton cellulose easily interacts with the aromatic phenol. Usually at aromatic substitution, the attacking diazonium group is electrophilic and becomes in a position with a higher content of electrons. In phenol and its derivatives, these are $o$-and $n$-positions and more favorable of them is $o$-position. The resulting dyed metal complex due to free $n$-position of the benzene nucleus, binds to the cellulose fiber by strong covalent bond.

To determine coordination centers of polyvalent metal ions to the functional groups of the modified cellulose was withdrawn IR spectra of cotton fabric containing complexes of copper, cobalt or iron (Fig. 4).

Dyeing of cellulose materials was carried out in an acidic medium at pH = 4.3 at the boiling point. The dyeing of cotton jersey reaches its equilibrium value during 6-7 minutes. However, the amount of evenly adsorbed dye in the case of cotton fiber dyeing is higher, as evidenced by the intensity of the colors obtained. Apparently, the formation of colored complex compounds in the structure of the fiber happens not only intramolecularly but also intermolecularly; and the small distance between the structural elements of the cotton fiber contribute to the formation of more intermolecular colored structures.

One of the shortcomings of the cellulose fibers is the low elasticity, low shape stability. Modification of cellulose fibers by silanes followed by input of developed compositions increase the elasticity; improve the physical and mechanical properties.

3. Research Results and Their Discussion

When comparing the spectra of the initial, modified by $\gamma$-aminopropyltriethoxysilane and containing complexes based on polyvalent metals cotton fabrics is seen that in the IR spectra of cotton fabric containing metal complexes a shift of the absorption band 1,630 cm$^{-1}$ relating to the amino group of aminated cotton fabric up to 1,600 cm$^{-1}$ is observed. The shift of the absorption band in a low frequency area indicates the formation of a coordination bond $\text{Me-N}$ [6]. The formation of coordination bond confirms the appearance of a new peak in the region 550-560 cm$^{-1}$ in the cotton fabric spectrum containing complexes, and that peak is responsible for the valence vibration of $\text{Me-N}$. The spectrum of the cotton fabric containing metal complexes also has an absorption band at 1,000 cm$^{-1}$, responsible for the siloxane groups $\text{Si-O}$ (valence vibrations) and the absorption band at 850-820 cm$^{-1}$, responsible for the group $\text{Si-C}$ (valence vibrations).

The data obtained allow us to conclude the occurring coordination via the nitrogen atoms of nitroso groups.

Availability of aromatic azo group in the cellulose complexes is confirmed by absorption band at 1,550 cm$^{-1}$ that again appears as an absorption band at 1,046-1,060 cm$^{-1}$. 
To determine the complex formulation it has been determined the amount of metal and nitrogen cations in cotton fabric dyed by metal complexes. Determination of cations was conducted by spectrometric titration of salt solutions by 0.01 M solution of Trilon B (sodium salt of ethylenediaminetetraacetic acid) in the presence of ammonia buffer solution. When Trilon B interacts with metal cations almost exclusively the complexes of formulation 1:1 are obtained. With an excess of Trilon B highly charged cations such as Fe$^{3+}$ also forms complexes of 1:2, but their stability compared with the stability of 1:1 complexes are small.

The number of amino groups in the aminated cotton fabrics is equal to 3.2 g-atom/g$\times 10^{-3}$. When nitriding the aminated cellulose the number of nitrogen atoms is doubles and becomes 6.4 g-atom/g$\times 10^{-3}$. The rest number of nitrogen accounts for dinitrosoresorcinol (Table 3).

From the data obtained it is clear that the metal complexes of dinitrosoresorcinol with the cations of Fe$^{3+}$, Ni$^{2+}$, Co$^{3+}$ has a composition of 3:1, i.e. one metal atom per three molecules of dinitrosoresorcinol. Table 3  The content of metal and nitrogen cations in cotton fabrics containing metal complexes.

<table>
<thead>
<tr>
<th>Metal nature</th>
<th>The metal content on the fabric, Me$_{\text{g-atom./g} \times 10^{-3}}$</th>
<th>The nitrogen content on the fabric, N$_{\text{g-atom./g} \times 10^{-3}}$</th>
<th>The number of dinitrosoresorcinol molecules per metal atom</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe</td>
<td>1.1</td>
<td>12.7</td>
<td>11.5</td>
</tr>
<tr>
<td>Co</td>
<td>1.0</td>
<td>11.2</td>
<td>11.2</td>
</tr>
<tr>
<td>Ni</td>
<td>0.9</td>
<td>11.0</td>
<td>11.4</td>
</tr>
<tr>
<td>Cu</td>
<td>1.4</td>
<td>11.4</td>
<td>7.6</td>
</tr>
</tbody>
</table>

Metal complexes of dinitrosoresorcinol with Cu$^{2+}$ have a composition of 2:1, i.e. one metal atom per two molecules of dinitrosoresorcinol. Analysis of the obtained IR spectra of cotton fabrics containing metal complexes leads to the conclusion that Fe$^{3+}$, Ni$^{2+}$, Co$^{3+}$, Cu$^{2+}$ forms one chelate bond and one salt bond with dinitrosoresorcinol that confirms the literary data.

Polyvalent metals (iron, cobalt, and nickel, copper) cations with phenols form colored complex compounds. The carried out modifications contribute to the dyeing of polymeric substrate. Due to the fact that the compositions based on phenols, metal salts have small geometric dimensions and have no affinity to fibers, a high rate of dyeing, and dyeing ability by the same composition of the different nature of the fibers has been established. Dyeing at boiling temperature reaches its equilibrium in the case of dyeing the textile materials based on protein fibers for 2-3 minutes, cotton fabrics 6-7 minutes, polyamide for 35-40 minutes (Fig. 1).

The high permanence of the obtained colors to different physical and chemical factors has been determined (Table 4).

The mechanism of color formation on various fibers by means of dye compositions has been studied by IR spectroscopy. Based on the obtained data has been suggested the following mechanism for the dyeing of textile materials based on the different nature of the fibers: by the action of sodium nitrite in acid medium the phenol derivatives transfers to dinitrosophenols.

Table 4  Color permanence of different fibers, dyed by powder dye compositions.

<table>
<thead>
<tr>
<th>No.</th>
<th>Material type</th>
<th>Input salt</th>
<th>Color tone</th>
<th>Color permanence, points</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>To light</td>
</tr>
<tr>
<td>1</td>
<td>Natural silk jersey Nylon</td>
<td>Ni$^{2+}$</td>
<td>Dark brown</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Natural silk jersey Nylon</td>
<td>Cu$^{2+}$</td>
<td>brown</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Natural silk jersey Nylon</td>
<td>Fe$^{3+}$</td>
<td>green</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Natural silk jersey Nylon</td>
<td>Co$^{2+}$</td>
<td>orange</td>
<td>5</td>
</tr>
</tbody>
</table>
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that with polyvalent metal cations form colored complexes interacting with diazotized groups of different fibers. Consequently, the structural elements of fibers are part of the resulting colored structures that explains the high strength properties of obtained colors to the different physical and chemical impacts.

The high permanence of the obtained colors to light, in contrast to the colors of azoic dyes is explained by the presence of polyvalent metal cations in the dye composition.

4. Conclusion

On the basis of comprehensive studies the optimum compositions of powder dye compositions based on salts of polyvalent metals for protein, polyamide and cellulose fibers and fabric dyeing technology based on them have been developed.

The dyeing of protein, polyamide and cotton fibers with dye composition is carried out in an acidic environment at pH 3-4. At the boiling temperature, they reach equilibrium in the case of dyeing textile materials based on protein fibers for 2-3 minutes, cotton fabrics 6-7 minutes, polyamide for 35-40 minutes.

The dye compositions for textile materials based on protein, cellulose and polyamide fibers, due to their interaction with the fiber contribute to the formation of salt, covalent and coordination bonds and the formation of the color on fibers with high resistance to the various physical and chemical factors: washing, dry cleaning, abrasion and light.

Thus, the carried out study showed that the protein, polyamide and cellulose fibers can be colored by powdered dye composition.

References: