STUDY OF INFLUENCE OF THE PREPARATION METHOD ON THE LIGHT FASTNESS OF COTTON KNITTED FABRIC

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Abstract: *The main goal of this research is to study the effect of preparation methods (boiling, bleaching, combined boiling and bleaching principle, developed preparation principle) on the quality of cotton knitted fabric, sorption capacity in relation to reactive dyes and light fastness of colour. The quality of the preparation was evaluated in terms of capillarity, degree of removal of waxy substances, whiteness, breaking load and sorption of reactive dyes using traditional methods. The light fastness of the obtained colours was evaluated after exposure of Light Fastness Tester (Mercury-Tungsten Lamp) RF 1201 BS («REFOND») with a PCE-TCR 200 colorimeter. It has been established that high indices of light fastness of colours obtained on cotton knitted fabric with reactive dyes are ensured by the developed preparation principle.*

Keywords: *light fastness, cotton knitted fabric, reactive dyes, preparation, dyeing.*

1 INTRODUCTION

Light fastness of colour is an important indicator of quality for textile materials intended for sportswear, T-shirts and clothes for children. Preparation of textile materials is an important stage, since the efficiency of dyeing processes and final finishing, and hence the quality of the textile material as a whole, depends on its implementation [1, 2].

Since the range of fabrics for summer clothing is widely represented by cotton knitwear, the study of the effect of its preparation on the light fastness of colors is an actual task.

The process of cotton knitwear preparation is the most technologically complex, energy-consuming and labor-intensive stage of finishing works. Therefore, technologically and scientifically-based exclusion of some operations is relevant when producing high quality cotton knitted fabrics with low cost.

It is known [3, 4] that the preparation includes a set of processes that ensure the removal of natural impurities (mainly waxy substances) and substances deposited on the fabric during their manufacture (oiling agents) from grey knitted fabric in order to give high capillarity and whiteness. In the course of preparation, the following aggressive factors influence on textile materials:

1) alkaline boiling solution at high temperature, which is the cause of the destruction of cellulosic material under the influence of atmospheric oxygen;
2) peroxide compounds used in bleaching and leading to a decrease in the strength and degree of polymerization of cellulose.

The milder conditions will be during the preparation of textile materials, the more will be preserved strength and natural properties of cellulose, and clothing will have a higher quality [5-7]. There is no direct relationship between high indices of light fastness and other indicators of the resistance of colors to physical and chemical effects (washing, dry and wet crocking). However, it can be argued that, in general, the quality of color depends on the rate of diffusion and sorption of the dye, which are determined by the physicochemical properties of the fiber [8].

It is known [6, 7] that on a fabric that has been maximally cleared of natural and technological contaminations, it is possible to get pure and bright colors that are resistant to washing, dry and wet crocking. But it should be noted that the effect of the degree of preparation on resistance of obtained colours to the action of light was not investigated on cotton knitted fabric with different degrees.

2 THE GOAL OF THE STUDY

The goal of present work was to study the influence of the preparation method of cotton knitted fabric on its quality, sorption ability in relation to reactive dyes and on the stability of colours to the action of light.

3 MATERIALS AND METHODS

Study of influence of the preparation method on the light fastness of colors was carried out on grey cotton rib knitted fabric 1×1 with surface weight 150 g/sm^2. Preparation of grey knitted fabric was carried out under the conditions given in Table 1.

The textile auxiliaries used are Ultravalon TC, Albafluid CD, Albaflow FFC-01, Clarite by Huntsman NMG and Oxipav A1214C.50 by LLC Research and Production Association NII PAV.

The combined preparation principle of knitted fabric and composition of surfactants were developed in previous works [9, 10]. The surfactant composition contains in a certain ratio Ultravon TC as a wetting agent, Albafluid CD as an anticrease agent, Albaflow FFC-01 as a defoamer and Oxipav A1214.50 as a detergent.

The capillarity of fabric was determined by the height of potassium dichromate solution (5 g/l) on a 30 cm long strip of fabric after 30 and 60 min.

Whiteness was evaluated using a PCE-TCR 200 colorimeter.

The degree of wax removal was measured using a gravimetric method by determining the samples mass before and after extraction of knitted fabric with petroleum ether for 6 h.

The breaking strength was determined using the tearing machine RT-250K by breaking small strips.

Dyeing cotton knitted fabric was carried out using reactive bifunctional dyes Bezaktiv Cosmos S-C: Rot, Blue and Gold (Bezema) by exhaust dyeing method with the 1/50 solution rate. The dye solution contained 1% dye and dyeing auxiliaries (30 g/l NaCl + 15 g/l Na_2CO_3). The dyeing was done for 60 min in 60°C, and afterwards overflow cold, hot washing, boiling soaping and cold rinsing procedures are applied.

The light fastness of samples was evaluated after exposure of Light Fastness Tester (Mercury-Tungsten Lamp) RF 1201 BS (REFOND) with a PCE-TCR 200 colorimeter.

Colour measurements were averaged for each sample. Total colour difference (*dE*) was measured on the dyed cotton knitted fabrics samples after light exposure. Colour difference was calculated according to CIE 1976 L*a*b* equation (1):

$$dE = [(dL)^2 + (da)^2 + (db)^2]^{½} \quad (1)$$

where *dL* – difference in lightness-darkness,

da – difference in redness-greeness

db – difference in yellowness-blueness.

Table 1 Cotton fabric preparation conditions

Preparation method	Preparation conditions
Boiling	TF-129B (washing agent) – 2 g/l Albafluid CD (anticrease agent) – 0.8 g/l Soda ash – 1.5 g/l Treatment at 80°C for 20 min. Washing in hot water, drying
Bleaching	Ultravalon TC (wetting agent) – 1.1 g/l Albafluid CD (anticrease agent) – 0.8 g/l Albaflow FFC-01 (defoamer) – 0.5 g/l Clarite (hydrogen peroxide stabilizer) – 0.4 g/l Hydrogen peroxide 60% w/w – 1.5 g/l Sodium hydroxide – 1.5 g/l Treatment at 98°C for 20 min Washing in hot water, neutralization, washing in hot water, drying
Base principle	***Boiling:*** TF-129B (washing agent) – 2 g/l Albafluid CD (anticrease agent) – 0.8 g/l Soda ash – 1.5 g/l Treatment at 80°C for 20 min Washing in hot water. ***Bleaching:*** Ultravalon TC (wetting agent) – 1.1 g/l Albafluid CD (anticrease agent) – 0.8 g/l Albaflow FFC-01 (defoamer) – 0.5 g/l Clarite (hydrogen peroxide stabilizer) – 0.4 g/l Hydrogen peroxide 60% w/w – 1.5 g/l Sodium hydroxide – 1.5 g/l Treatment at 98°C for 20 min Washing in hot water, neutralization, washing in hot water, drying
Developed principle	Treatment in solution: Surfactant composition – 1.5 g/l Hydrogen peroxide 60% w/w – 1.5 g/l Sodium hydroxide – 1.5 g/l Treatment at 80°C for 20 min Washing in hot water, neutralization, washing in hot water, drying

4 RESULTS AND DISCUSSION

The degree of preparation was evaluated by the value of capillarity (Figure 1), whiteness (Figure 2), degree of waxes removal (Figure 3) and strength (Figure 4) of the prepared textile material.

Grey cotton knitted fabric has no capillarity. The minimum capillarity that a textile material must have after preparation is 100 mm; well-prepared fabrics are characterized by capillarity in the range of 150-170 mm. The results of determining the effect of preparation method on capillarity are shown in Figure 1.

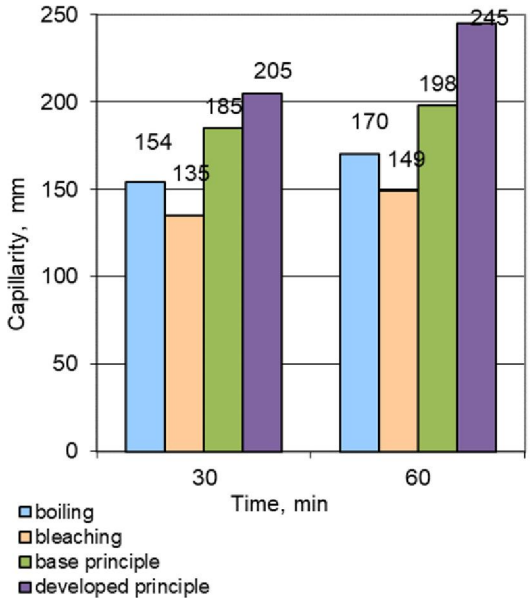


Figure 1 The influence of preparation method of cotton knitted fabric on the capillarity index value

The results show that the studied preparation methods provide indexes of the capillarity of cotton knitted fabric at the level of 135-205 mm in 30 min and 149-245 mm in 60 min. It should be noted that the lowest capillarity is characteristic of the sample after bleaching and the highest capillarity is characteristic of the sample prepared according to the developed principle.

The obtained results (Figure 2) showed that individually alkaline boiling and bleaching provide a slight increase in whiteness compared with the preparation by combined methods according to the base and developed principles.

The diagram in Figure 3 illustrates the obtained data on the degree of wax removal from knit samples depending on the preparation method. The data indicate that a grey sample contains most waxes. After preparation according to the studied methods the content of wax-like substances decreases. Moreover, when preparing according to the base principle, there is less wax on the knitted fabric than after alkaline boiling. The least amount of waxes contains a sample prepared according to the developed principle.

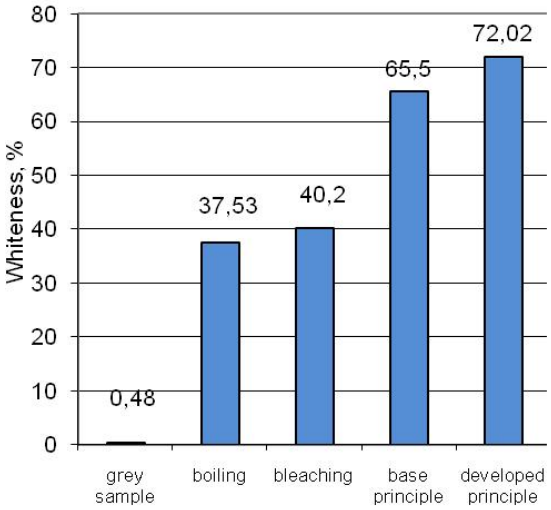


Figure 2 The influence of the preparation method of cotton knitted fabric on the value of whiteness index

The data presented in Figure 3 correlate with the results of the determination of capillarity and show that no more than ≈58% of initial waxes are removed during knitted fabric preparation according to individual principles and to the combined base principle. This fact explains the low indexes of knitted fabric capillarity according to these methods of preparation.

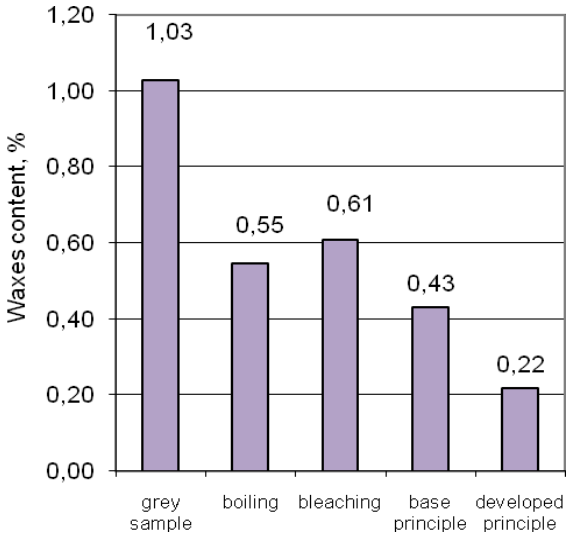


Figure 3 The influence of the preparation method of cotton knitted fabric on the waxes content

It is established (Figure 4) that the bleached sample and the sample prepared according to the base principle have the lowest strength. The knitted fabric prepared according to the developed principle is the least damaged.

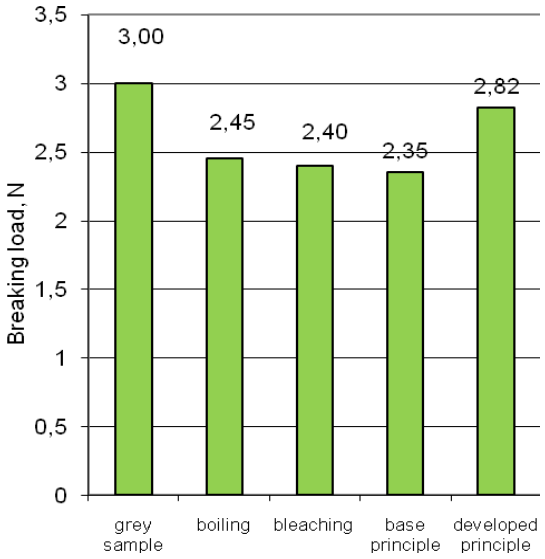


Figure 4 The influence of the preparation method of cotton knitted fabric on the index of breaking load

Grey cotton knitted fabric does not have capillarity due to the presence of natural fatty and waxy substances and knitting oil. Available waxy substances are arranged on the fiber in such a way that their hydrophobic groups are directed away from the surface of the fiber, as a result of which textile materials are not wetted with water, becoming hydrophobic.

Removal of cotton waxes and oils applied to the threads prior to the knitting process and some amount of water-soluble cellulose impurities during the boiling process increases the capillarity of the knitted material. However, during the boiling, cotton colouring matters are not removed, which leads to a slight increase in the whiteness of the knitted material and, as a result, to obtain less bright colors.

The bleaching solution is not able to penetrate deep into the fibers during bleaching due to the presence of hydrophobic substances on the surface of the textile material. The conditions of the bleaching process (pH of the medium, temperature) are such that in the first stage waxes and oils are removed. At this time, hydrogen peroxide, intended for the oxidation of coloured cotton impurities, decomposes unproductively. Thus, neither high capillarity nor whiteness can be achieved during whitening. In addition, the high temperature of the bleaching process at 98°C and the presence of hydrogen peroxide cause significant damage to the textile material.

The combined preparation method by the base principle includes sequential operations of boiling and bleaching, as a result of which the knitted fabric acquires high indexes of capillarity and whiteness. However, the preparation by the base principle occurs at elevated temperatures, which leads to a decrease in the strength of the textile material.

The developed preparation principle of cotton knitted fabric through the use of highly effective surfactant composition allows combining operations of boiling and bleaching as well as carry out the process at a reduced temperature of 80°C [9, 10]. The result is a textile material with a high degree of removal of waxy substances, high indexes of capillarity, whiteness and a low loss of strength. In addition, this technology of preparation due to the use of low temperatures is energy saving, more economical and environmentally friendly.

Next, we studied the effect of the preparation method on the degree of fixation of reactive dyes on the knitted fabric (Figure 5), on the fading kinetics of colours on cotton knitted fabric (Figure 6) and the light fastness of the colours obtained (Table 2).

The results (Figure 5) show that among the studied preparation methods, only the developed principle provides high fixation indexes of reactive dyes. Obviously, this is due to a more complete removal of wax-like substances and oil from knitted fabric during its preparation, and, therefore, high capillarity and high sorption properties of the textile material. The sorption surface of the fiber is determined by systems of submicroscopic pores and capillaries as well as existing cavities and cracks. In the process of preparation, the structure of the fibrous material changes, the surface is freed from impurities, pores open and microcracks appear. The internal stress decreases, causing unevenness of properties, ensuring the penetration of chemical reagents into the fiber. As a result, the dyes penetrate deeper into the fiber and the degree of fixation of the reactive dyes on cotton knitted fabric is increased.

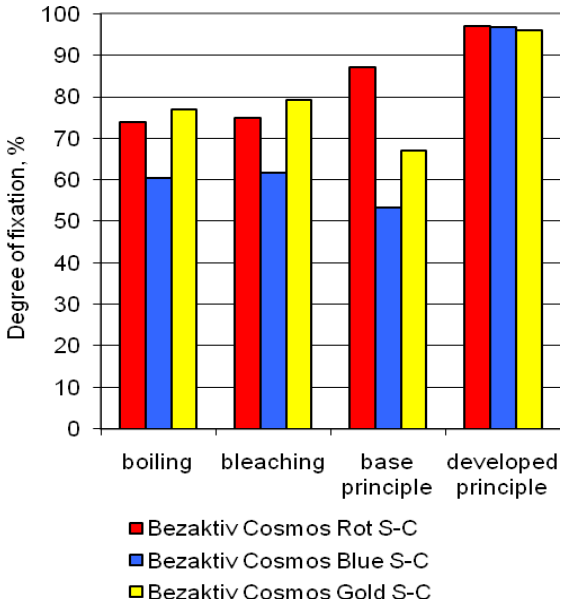
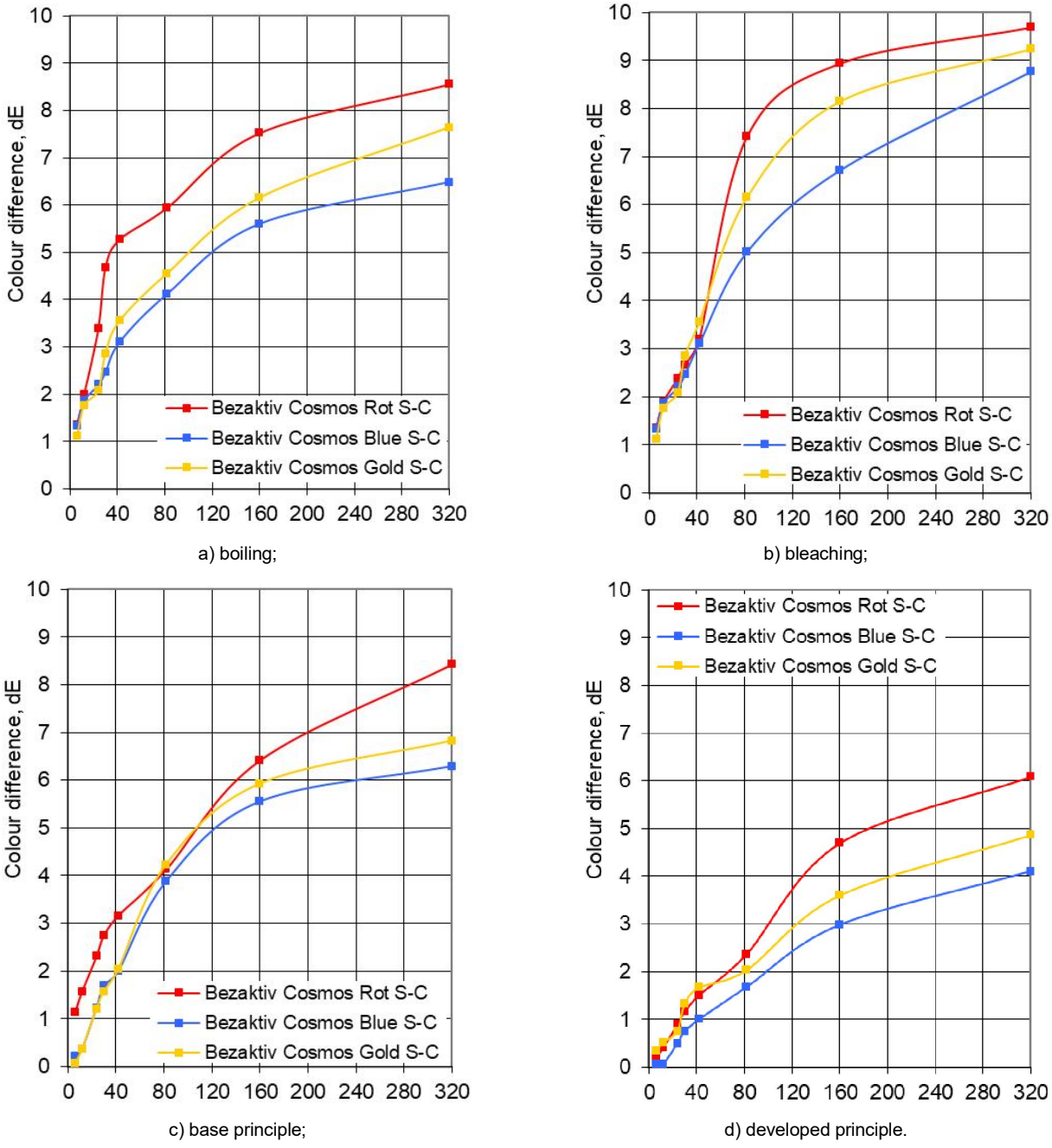


Figure 5 The influence of the preparation method of cotton knitted fabric on the degree of fixation of reactive dyes

Table 2 The influence of the preparation method of cotton knitted fabric on the light fastness of colours of reactive dyes

Dye	Light fastness			
	Boiling	***Bleaching***	***Base principle***	***Developed principle***
Bezaktiv Cosmos Rot S-C	2	2	3	4-5
Bezaktiv Cosmos Blue S-C	2-3	2	4	5-6
Bezaktiv Cosmos Gold S-C	2	3	4	5

The obtained data testify to low indices of light resistance of the colors of the samples prepared by the methods of boiling and bleaching and according to the base principle. The light fastness of the colors of knitted fabric, prepared according to the base mode, is somewhat higher than that of samples subjected to alkaline boiling and bleaching. The reason for this may be the incomplete removal of waxes and, as a result, low capillarity indexes, which leads to non-dyeing of the textile material and a decrease in the resistance indexes of the obtained colours to the action of light. The colours of knitted fabric, prepared according to the developed principle, are characterized by high index of light fastness.



a) boiling; b) bleaching;

c) base principle; d) developed principle.

Figure 6 The influence of the preparation method of cotton knitted fabric on the fading kinetics of colours of reactive dyes

5 CONCLUSIONS

It has been established that the developed preparation principle of cotton knitted fabric contributes to the maximum removal of wax-like and colouring matters from a textile material, and as a result, increased capillarity and whiteness. In this case the strength of knitted fabric is reduced slightly. This is facilitated by the application of the previously developed highly effective surfactant composition, which allows to combine the operations of boiling and bleaching and to carry out the preparation process at a reduced temperature of 80°C.

As a result of preparation according to the developed principle the knitted fabric obtains high sorption properties in relation to reactive dyes and the resulting colours are characterized by high resistance to the action of light.

6 REFERENCES

1. Abdel-Halim E.S., Al-Deyab S.S.: Low temperature bleaching of cotton cellulose using peracetic acid, Carbohydrate Polymers 86(2), 2011, pp. 988-994, DOI:10.1016/j.carbpol.2011.05.051
2. Fei X., Yao J., Du J., et al.: Analysis of factors affecting the performance of activated peroxide systems on bleaching of cotton fabric, Cellulose 22(2), 2015, pp. 1379-1388, DOI:10.1007/s10570-015-0550-1
3. Shao J., Huang Y., Wang Z., Liu J.: Cold pad-batch bleaching of cotton fabrics with a TAED/H_2O_2 activating system, Coloration Technology 126(2), 2010, pp. 103-108, DOI:10.1111/j.1478-4408.2010.00234-x
4. Tzanov T., Calafell M., Guebitz G. M., Cavaco-Paulo A.: Bio-preparation of cotton fabrics, Enzyme and Microbial Technology 29(6-7), 2001, pp. 357-362, DOI:10.1016/s0141-0229(01)00388-x
5. Hartzell M.M., Hsieh Y.-L.: Enzymatic scouring to improve cotton fabric wettability, Textile Research Journal 68(4), 1998, pp. 233-241, DOI:10.1177/004051759806800401
6. Prabaharan M., Rao J.V.: Study on ozone bleaching of cotton fabric - process optimisation, dyeing and finishing properties, Coloration Technology 117(2), 2001, pp. 98-103, DOI:10.1111/j.1478-4408.2001.tb00342.x
7. Hashem M., El-Bisi M., Sharaf S., Refaie R.: Pre-cationization of cotton fabrics: An effective alternative tool for activation of hydrogen peroxide bleaching process, Carbohydrate Polymers 79(3), 2010, pp. 533-540, DOI:10.1016/j.carbpol.2009.08.038
8. Ali S., Khatri Z., Khatri A., Tanwari A.: Integrated desizing-bleaching-reactive dyeing process for cotton towel using glucose oxidase enzyme, Journal of Cleaner Production 66, 2014, pp. 562-567, DOI:10.1016/j.jclepro.2013.11.035
9. Skalozubova N., Kunik A., Semeshko O., et al.: Designing a composition formulation of surface active substances for the pretreatment of knitted fabric, Eastern-European Journal of Enterprise Technologies 4(6(82)), 2016, pp. 29-36, DOI:10.15587/1729-4061.2016.75027
10. Semeshko O., Asaulyuk T., Saribyekova Yu.: Optimization of preparation technology of a cotton knitted fabric by the method of mathematical planning, Proceedigns of 2nd International Conference "EastWest Chemistry Conference", 2018, pp. 301-302