полиэфирные волокна и коллаген находятся в высокоэластичном состоянии, видимо, фиксация красителя на полиэфирных волокнах происходит в результате их совместного плавления.

Морфология поверхности образцов тканей до и после крашения с металлокомплексом коллаген: Cr^{3+} исследована с помощью сканирующего электронного микроскопа SEM EVO MA 10, Zeiss (Германия).

Судя по изображениям, краситель не нарушает структуру полотен, не образует отдельную фазу, сорбируется в микропоры волокон. Даже при значительном увеличении на поверхности полиэфирных и хлопко-полиэфирных волокон не заметно наличие посторонних примесей, в том числе красителя. Это объясняется тем, что после крашения и термофиксации при 130–140 °С краситель сорбируется на поверхность волокна, диффундируется в свободные поры и во время охлаждении поры волокон сужаются, а краситель остается внутри волокна и ткань равномерно окрашивается. После крашения и термофиксации мокрые обработки проводятся при температурах не выше 95–100 °С, и краситель остается в порах волокна. На изображениях хлопковой ткани после крашения комплексом, заметно наличие примесей и красителя на поверхности волокон. Это подтверждает то, что краситель в меньшей степени абсорбируется в волокна хлопковой ткани, остается на поверхности волокон. При этом структура всех окрашенных образцов сохраняются.

Устойчивость окраски к стиркам проводилась по ГОСТ 9733.4-83 и оценивалась по ГОСТ 9733.0-83 «Материалы текстильные». Результаты для всех трех видов ткани, окрашенных при pH = 7: 5/5/5.

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SIZING AND DESIZING OF COTTON YARNS BASED ON GRAFT COPOLYMERS OF COLLAGEN WITH ACRYLIC MONOMERS

Ibodulloyev B. SH., Basic doctoral student, Rafikov A. S., professor, Djalilov Sh.S., assistant professor

Tashkent Institute of Textile and Light Industry, Tashkent, Republic of Uzbekistan

Abstract. *The conditions for graft copolymerization of collagen hydrolyzate, isolated with a dilute alkali solution from cattle skin waste, with monomers – acrylic and methacrylic acids are given. The synthesized copolymers are used for sizing cotton yarn before weaving. The process of desizing cotton yarns were carried out by biochemical method.*

Keywords: graft copolymerization, collagen, monomer, sizing and desizing.

The preparation of cotton yarn for weaving is a technological link between the production of yarn and the production of fabric, therefore it plays a significant role in achieving high quality textile materials in the modern weaving industry on highly automated looms. Aqueous solutions of starch, cellulose derivatives, proteins, polyvinyl alcohol (PVA), polyacrylamide (PAD), polyacrylic acid (PAA), polymethacrylic acid (PMAA) are reagents for sizing cotton yarn [1, 2, 3]. At most textile enterprises of the Republic of Uzbekistan, inexpensive starch is used as a sizing agent. Starch-based solutions do not meet many modern requirements. Including: low solution stability, low strength, stiffness and brittleness of the film, the difficulty of desizing fabrics. Collagen is an excellent sizing agent, and a collagen-containing solution of raw animal skin waste has been successfully used for sizing cotton yarn [4]. The general lack of protein substances, i.e. the rigidity

and brittleness of their film on the surface of materials affects one of the main properties of cotton yarn: the relative elongation of the threads under tension decreases. The solution to the problem is seen in the use of modified proteins to obtain a sizing composition, including collagen graft copolymers. The purpose of this study is the synthesis of graft copolymers of collagen with (meth)acrylic acid the preparation of a sizing solution based on new sizing reagents for cotton yarn.

Synthesis of graft copolymers was carried out in a three-necked flask equipped with a stirrer, a reflux condenser, and a capillary for blowing nitrogen gas. The calculated amount of a 10 % solution of collagen, monomer, initiator was loaded into a flask, the flask was placed in a water thermostat. The synthesis was carried out by stirring the solution in an atmosphere of gaseous nitrogen, at a mass ratio of collagen : monomer = 1:1, at a temperature of 60 °C for 6 hours.

The sizing process of cotton yarn was carried out on a GA392 single thread sizing machine (China). The speed of yarn passage is 20 ± 1 m/min, the temperature of the sizing solution is 45 ± 2°C, the drying temperature is 60 ± 2 °C. Desizing of the yarn was carried out by the traditional method in a soap-soda solution at a temperature of 90–95 °C, as well as by a biochemical method in a 0.2 % protease solution at a temperature of 30 ± 1°C and pH = 6 ± 0.1 for 1 hour. The pH of the medium was controlled using a buffer solution consisting of a mixture of potassium dihydroorthophosphate (KH_2PO_4) and sodium hydrogen orthophosphate (Na_2HPO_4). Then the yarn was washed and dried at a temperature of 50 °C to constant weight.

Potassium persulfate is an oxidation-reduction initiator, which initially dissociates into ions and forms an ion-radical and a free radical when interacting with water molecules. As a result of exposure of collagen with nitrogen hydrogen, these particles create active centers of grafting in the protein macromolecule. The formation of active centers in the interaction of collagen macromolecules with PP:

$$S_2O_8^{2-} \rightarrow 2SO_4^{-\bullet} \qquad SO_4^{-\bullet} + H_2O \rightarrow HSO_4^- + OH^\bullet$$

$$R_1 - NH - CO - R_2 + SO_4^{-\bullet} \,/\, OH^\bullet \rightarrow R_1 - N^\bullet - CO - R_2 + HSO_4^- \,/\, H_2O$$

The initiation and growth reactions of grafted polymer chains:

$$R_1 - N^\bullet - CO - R_2 + CH_2 = CH(X) \rightarrow (R_1)(R_2CO)N - CH_2 - C^\bullet H(X)$$

$$(R_1)(R_2CO)N - CH_2 - C^\bullet H(X) + nCH_2 = CH(X)$$
$$\rightarrow (R_1)(R_2CO)N - [CH_2 - CH(X)]_{n-1} - CH_2 - C^\bullet H(X)$$

As can be seen from the above reaction, initiating radicals are generated in the collagen molecule, and these active centers serve to graft acrylic monomers. The growth of grafted chains occurs according to the radical mechanism. It showed high copolymerization efficiency in polymerization reactions with collagen and acrylic monomers.

Graft copolymers of collagen with acrylic and methacrylic acids were used for sizing cotton yarn. Studies have been carried out to clarify the nature of the interaction of cotton cellulose with copolymers. The detected changes clearly indicate the formation of new intermolecular hydrogen bonds between the macromolecules of cellulose and collagen graft copolymers (Figure 1).

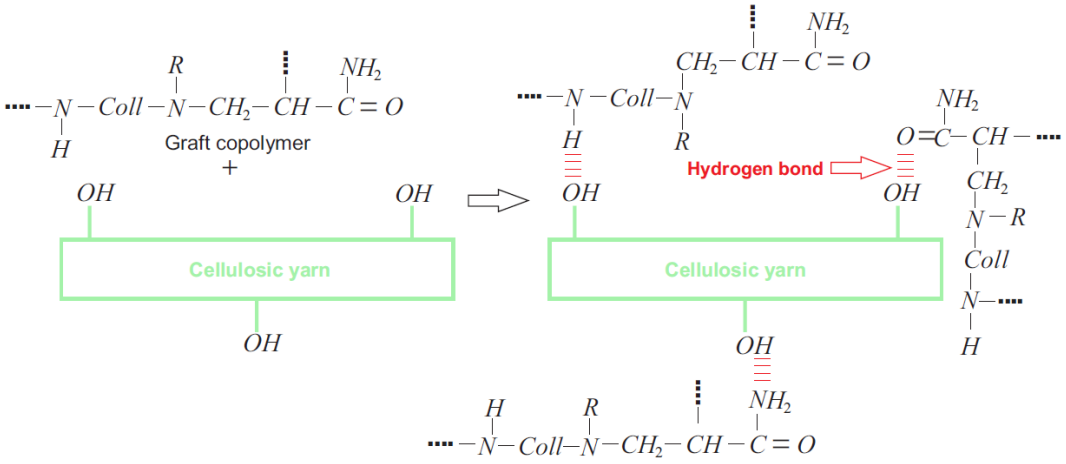

Figure 1 – Scheme of the formation of intermolecular hydrogen bonds between cellulose and collagen graft copolymers

The surface morphology of the yarns can be observed in Figure 2, which shows enlarged images using a digital optical microscope and SEM. the fibers of the raw yarn are friable, individual fibers protrude from the common bundle. These individual fibers, clinging to the mechanisms of looms, cause thread breakage, deteriorating the quality of the weaving process. On the surface of the sized threads, a layer of sizing agent is very clearly visible. The sizing is sticky and has a certain viscosity, covers the surface of the yarn and partially penetrates deep into the thread.

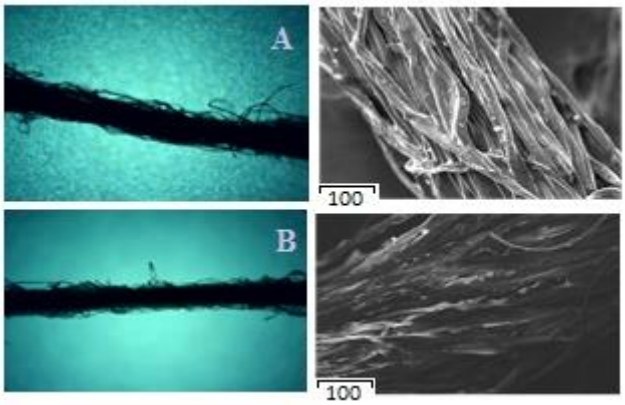

Figure 2 – Morphology of the surface sizing cotton yarns. A – sized with graft copolymer with acrylic acid, B – sized with graft copolymer with methacrylic acid

The physical-mechanical properties of the sized yarn are the main indicator of the suitability and effectiveness of the sizing agent. Sizing of cotton yarn with a starch solution, and especially with solutions of collagen graft copolymers, leads to an increase in the strength of the threads. The degree of desizing was checked by changing the linear density and capillarity of the yarns with a linear density of 30 tex after each process.

Table1 – Change in the capillarity of yarn (mm) with a linear density of 30 tex in the processes of sizing and desizing

Linear density of the original yarn	The linear density of the yarn after sizing with a solution of graft copolymers of collagen with monomers		The linear density of the yarn after sizing from collagen copolymers with monomers	
	AA	MAA	AA	MAA
30	36	38	Desizing in soapy soda solution	
			32	33
			Desizing in a protease solution	
			29	29

Graft copolymers of collagen with acrylic monomers contain hydrophilic functional groups, so they do not reduce the capillarity of yarns. In the process of desizing, especially in a protease solution, after removal of the sizing agent, the porosity of the threads increases. The polymer layer with acrylic and methacrylic acids have good affinity for cotton fiber, forms a smoother and more elastic layer without external damage.

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