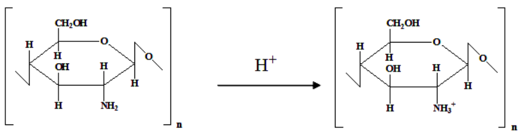
UDK 677.047.41.027.423.5

UTILIZATION OF CHITOSAN FOR DYEING TEXTILE MATERIALS OF DIFFERENT NATURE USING ACTIVE DYES

I.I. MANYUKOVA, V.V. SAFONOV

(The Moscow State Textile University named after A.N. Kosygin)

Chitosan is the most well known soluble chitin derivative – product of chitin's deacylation [1]. Chitosan (basic form) is water-insoluble, but is good soluble in diluted solutions of some acids [2], [3], as a result of obtaining a positive charge (salt form):



Presence of ionogen amino groups in chitosan determines many properties of it, including consumer ones. Diversity of unique consumer properties of chitosan ensures its wide utilization. There are more than 100 fields of chitosan's application, preparations and medical compositions on the basis of it. Natural polymer chitosan can be used in finishing manufacture to improve the quality of textile materials as indelible finishing, which helps to improve dyeing of fabrics subject to give finish [4…11].

It has been established in this paper that treatment in chitosan solution prior to dyeing with reactive dyes results in increase of intensity of dyeing of cotton, linen, woolen and blended fabric (wool/polyacrylonitrile and wool/kapron). This is illustrated in Fig. 1. Uniform bright dying can be reached on blended fabrics using one class of dyes.

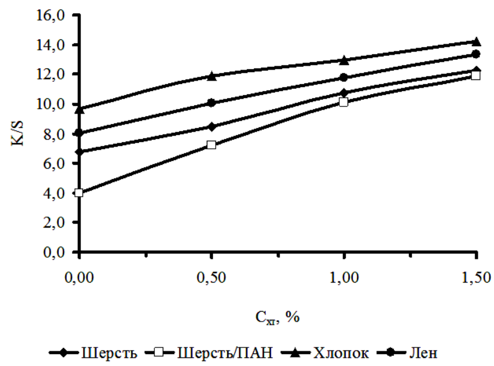


Fig. 1. Dependence of colour intensity of fabrics from chitosan concentration

The conducted tests testify that chitosan treatment enables to increase resistance to different physical and chemical effects when dyeing with reactive dyes is carried out. The obtained results are given in Table 1.

Table 1. Resistance of dyed textile materials

Testing methods	Cotton and linen fabrics		Woolen and blended wool/polyacrylonitrile fabrics	
	without chitosan treatment	with chitosan treatment	without chitosan treatment	with chitosan treatment
Washing fastness				
40°C	5/5/5	5/5/5	4/4/4	5/4/5
90°C	5/4/5	5/4/5	-	-
Resistance to distilled water	5/5/5	5/5/5	5/4/4	5/4/5
Sweat resistance	5/4/5	5/5/5	4/4/4	5/4/4
Resistance to rubbing				
dry	5/4/4	5/5/5	5/4/5	5/4/5
wet	4/4/4	5/4/4	4/4/3	4/4/4

Increase of intensity and dyeing fastness of textile materials may be attributed to the fact that chitosan forms on textile fabrics a stabile film which changes the essence of colouring textile materials. Investigation of chitosan's film structure by means of X-ray structural analysis revealed that chitosan - regenerated as films in salt form - has a structure which is typical for amorphous substances (Fig. 2). Basic form of chitosan has a more ordered structure.

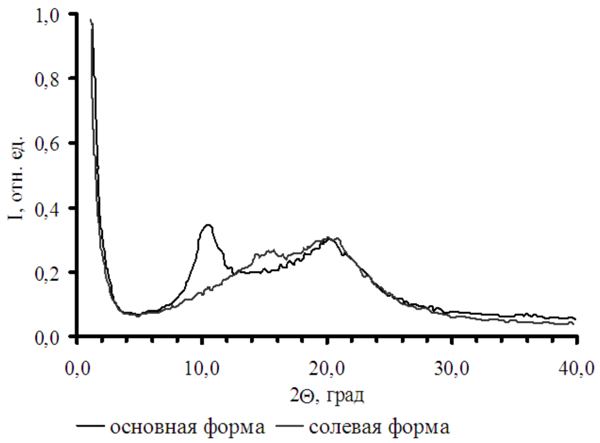


Fig. 2. X-rays of chitosan films

Amorphous film of chitosan is able to adsorb dyes from solutions quicker; and high degree of film's swelling allows to adsorb bigger quantity of dyes. It was found that film of chitosan has a high degree of swelling, both in water, as well in the medium of water steam. Swelling kinetics of chitosan films is given in Fig. 3.

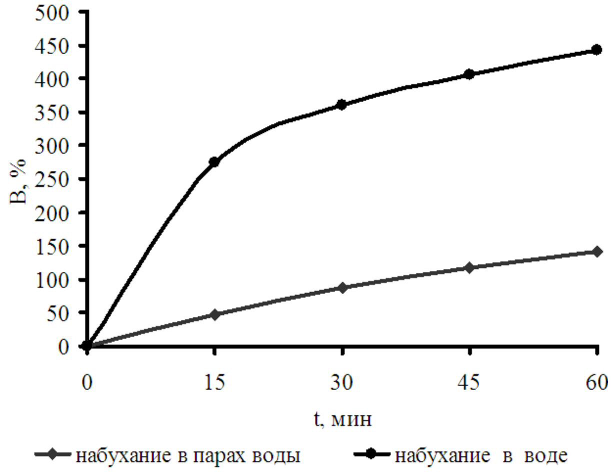


Fig. 3. Kinetics of swelling of chitosan films

By means of infrared spectroscopy, bonds of chitosan with dye and fiber have been determined. The study of IR spectra of chitosan-treated cellulose films revealed that main interactions proceed in the range of oscillations 3600…3100 cm^{-1}, which are typical for oscillations of hydroxyl groups. No frequency drifts or redistribution of band intensity has been found within the range 1800…1300 cm^{-1}. From the aforesaid it follows that chitosan is fixed on the surface of cellulose fiber by force of adhesion and molecular interactions.

Investigation of strength value of adhesion bond of chitosan film with the fiber, as well as effect of thermal processing on the strength of adhesion bond, revealed that temperature increase of thermal processing results in deterioration of adhesion bond between chitosan film and fiber. Optimal temperature range for processing is 60…80°C.

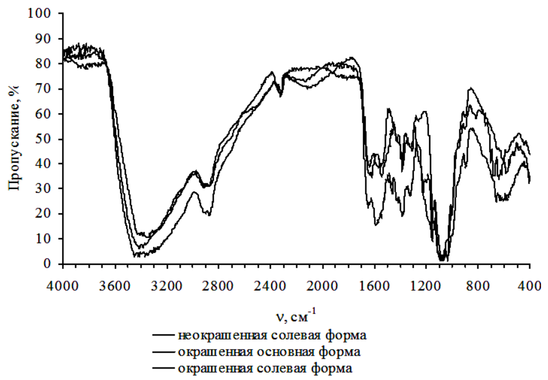


Fig. 4. IR-spectra of dyed and undyed chitosan films

Analysis of IR spectra (Figure 4) of films dyed in salt and basic forms revealed that when dyeing chitosan film in salt form with reactive dye, it forms covalent, hydrogen and ionic bonds. Dyeing of basic form of chitosan results in formation of covalent and hydrogen bonds. Consequently, it is advisable to carry out dyeing of the salt form of chitosan.

It has been established in this paper that chitosan treatment results in change of properties of textile materials. As a result of treatment, positive charge of chitosan leads to change of electrokinetic potential of fibers: surface charge of cellulose fibers in water medium changes from the negative to positive charge, thus improving approach of dye anions to fiber; in protein fibers positive charge increases. Effect of chitosan on electrokinetic potential of fibers of different nature is illustrated in Fig. 5.

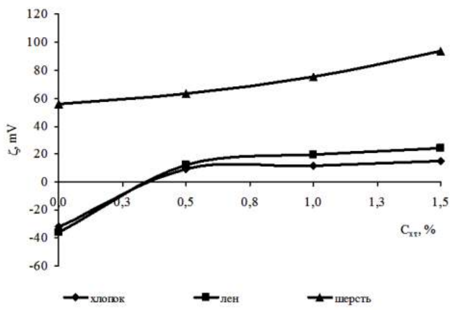


Fig. 5. Impact of chitosan treatment on electrokinetic potential of fibers of different nature

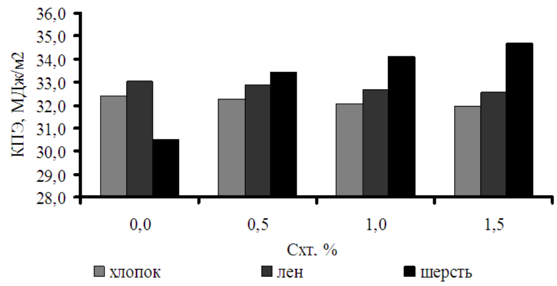


Fig. 6. Impact of chitosan treatment on indices of critical surface energy of fibers of different nature

In addition, change of surface energy with increase of chitosan concentration in protein fibers is observed (Fig. 6), which results in improvement of capillary properties. Impact of chitosan concentration on change of critical surface energy of cellulose fibers is less marked.

It has been established in the paper that finishing of fibers with chitosan solutions results in deterioration of air permeability and resistance to abrasion, rupture and repeated folding. In Table 2 physical-mechanical indices of textile materials during treatment with different chitosan concentrates are given.

T a b l e 2. Physical-mechanical indices of textile materials during treatment with different chitosan concentrates

Raw material mixture of fabric	C_{XT}, % In finishing mixture	Breaking load, N		Resistance to repeated folding, cycles		Resistance to abrasion by cotton system, cycles
		warp	weft	warp	weft	
Cotton	0,0	264	178	1521	1382	2663
	0,5	298	247	2830	2303	3109
	1,5	332	238	3570	3338	3589
Linen	0,0	364	366	1174	1052	1586
	0,5	438	460	1910	1620	2101
	1,5	609	623	2430	2220	2568
Wool	0,0	258	386	8214	8474	2345
	0,5	285	410	9750	10300	2954
	1,5	324	440	11563	258	3267
Wool/ polyacrylonitrile	0,0	284	301	7247	7512	2860
	0,5	346	342	8653	8970	3202
	1,5	214	363	10442	10752	3689

The data presented in Table 2 indicate that increase of chitosan concentration in finishing mixture leads to improvement of physical-mechanical properties of all fibers under consideration.

C O N C L U S I O N

1. Chitosan treatment of textile materials made of fibers of different nature results in improvement of quality of finished products due to increase of intensity and colour fastness of textile materials.

2. Chitosan treatment of textile materials made of natural and synthetic fibers leads to increase of their physical-mechanical indices, which improves utilization properties of textile materials.

B I B L I O G R A P H Y

1. *Gorbacheva I.N., Ovchinnikov Y.K., Halbreich L.S., and others*// High-molecular compounds, Series A, 1988, V.30 #12, p. 2512.

2. *Shin Younsook, Yoo Dong* // J. Appl. Polym. Sci. – 1998, v. 67. №9, p. 1515…1521.

3. *Erra P., Molina R., Jocic D., Julia M.R., Tascon J.M.D.* // Text. Res. J. – 1999, v. 69, № 11, p. 811…815.

4. *Julia M.R., Pasual E., Erra P.* //J. Soc. Dyers .and Color. – 2000, v. 166. № 2, p. 62….67.

5. *Halbreich L.S.* "Chitin and chitosan: structure, property, utilization". – 2001, p. 1470…1487.

6. *Vikhoreva G.A.* // Khimicheskaya technologiya. – # 2, 2002, p. 43…44.

7. *Sadov F.I., Markova G.B.* Production of chitosan and its utilization/ Under the editorship of F.I. Sadov // Scientific and research work. – V. 13, p. 70…74.

8. *Klochkova I.I., Safonov V.V.* Magazine "Textile Industry". Scientific almanac". # 1, January – February 2005, p. 44…47.

9. *Klochkova I.I., Safonov V.V.* Scientific-production magazine" "Herald of Dimitrovgrad Institute of Technology, Management and Design of RAS, Dimitrovgrad, January – March 2006, p. 44…47.

10. *Klochkova I.I., Safonov V.V.* Magazine "Proceedings of higher institutions". Technologiya textilnoy promyshlennosti". – October 2006, # 4, p. 50…54.

11. *Vakhitova N.A.* Doctoral dissertation – MSTU named after A.N. Kosygin. – Moscow, 2005.

Recommended by the department of chemical technology of fibrous materials. Received 05.06.09.