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Research Article

STUDY OF THE PHYSICO-CHEMICAL PROPERTIES OF A POLYMER COMPOSITION

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ABSTRACT

The article analyzes the problems of using thickening polymer compositions in the textile industry for stuffing cotton fabric with active dyes. Particular attention is paid to the determination of the structural and mechanical properties of thickening polymer systems. The physico-mechanical and color properties of printed fabrics printed with active dyes are determined. And also the influence of various factors on the physicochemical properties of polymer systems based on starch, Na-CMC and sericin was studied and the optimal compositions of the components that make up the thickeners were determined.

KEYWORDS

Polymer compositions, dye, fabric, serecin, component, viscosity.

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INTRODUCTION

Despite significant achievements in the field of refining cotton fiber fabrics, progress in this area is far from being exhausted. Therefore, the development of effective water-soluble compositions based on local raw materials, suitable both for yarn sizing and as a thickener in the process of printing fabrics, is a very urgent task.

The viscosity of thickeners is one of the main characteristics of the system, since it should be within the optimal value, which ensures the formation of a protective film with dyes on the surface of the fabric, which gives it strength and complete transfer of the dye to the fabric [1].

The viscosity of the studied systems was measured at certain shear rate gradients, namely, at a magnification of 8000 times, i.e. from $4 \cdot 10^{-1}$ to $3{,}122 \cdot 10^{3}\ s^{-1}$. The conditional structure index (PS) was calculated using the formula

$$PS\ con. = (\eta_1/\eta_2) - 1 ,$$

where η_1 is the viscosity at $\acute{\varepsilon} = 0.4\ s^{-1}$, η_2 is the viscosity at $\acute{\varepsilon} = 3.122 \cdot 10^{3}\ s^{-1}$

. PScond values for the studied compositions are presented in Table 1.

As follows from the data obtained, the compositions included in the first group are characterized by significantly lower values of PScond (no more than 100) compared with the thickeners of the second group, for which PScond is 200-300 or more. Therefore, we can conclude that the first group of compositions is characterized by a relatively lower loss of viscosity in the process of mechanical destruction. This should provide more stability when dealing with thickeners on the press. Obviously, the Newtonian nature of the flow of such a thickening makes it of high quality. Therefore, it must be assumed that Na-CMC in the composition of the polymer composition is more effective than other thickeners.

Table 1

Conditional indicators of the structure of the polymer composition

Compositions	Concentration, %	Viscosity at ε = 0.4 s-1, ή1	Viscosity at ε = 3,122 · 103 s –1, ή2	Index of structure, PSusl
Na-CMC	9	183,8	2,47	72,85
Alginate sodium	8,0	219,4	6,56	32,70
Starch	7,05	29,9	8,74	3,83
Starch	12	1114,0	3,17	353,7
Manutex	2,5	441,4	1,83	247,6
Half print	14	366,4	1,78	226,9
Imprint	16	872,4	3,86	214,7

Table 2 shows the data on the heat of activation of the viscous flow of solutions of the polymer composition and Na-CMC, as well as the approximate

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values of the relaxation time for these systems. It can be seen (Table 2) that the value of ΔHvis for Na-CMC solution is almost 2-2.5 times greater than for the composition. For the latter, it is equal to 4-5 kcal/mol and expresses the heat of activation due to the formation of less strong fluctuation networks.

The obtained experimental data allow us to conclude that the less pronounced anomaly in the viscosity of the composition based on the carbon chain polymer of the hydrolyzed acrylic emulsion is due to weaker intermolecular interaction, smaller segment size, and greater chain flexibility compared to the Na-CMC polar heterochain polymer. As a consequence of this, the composition of starch, sericin and Na-CMC is characterized by lower values of ΔHbind, relaxation time and the lowest value of the structure index PScond = 3.83.

Table 2
Change in the Heat of Activation of Viscous Flow and Relaxation Time of Na-CMC Solutions and Polymer Composition

Composition composition	Temperature, T, K	Temperature, 1/T • 103,TO	Lgή to lg P=2,00	Heat of activation (ΔNyaz), kcal / mol	Relaxation time th (s)
Na-CMC	293	3,413	2,2490	9,7	3,2
	313	3,195	1,7360		
	333	3,003	1,4120		
HAE starch	293	3,413	1,5430	6,4	$2{,}6 \cdot 10^{-2}$
	313	3,195	1,4620		
	333	3,003	1,2440		
Starch PAA	293	3,413	1,4870	6,9	$2{,}8 \cdot 10^{-2}$
	313	3,195	1,3210		
	333	3,003	1,1160		
Starch HAE + PAA	293	3,413	1,5630	5,3	$2{,}3 \cdot 10^{-2}$
	313	3,195	1,4920		
	333	3,003	1,3111		
HAE + PAA + Na-CMC starch	293	3,413	1,6420	4,7	$1{,}9 \cdot 10^{-2}$
	313	3,195	1,5170		
	333	3,003	1,3840		

Studies have shown that when studying the dependence of the yield strength (Pm) of a water-soluble polymer composition, very positive results are obtained for thickeners based on a mixture of sericin, starch and Na-CMC. These data are presented in Figures 1, 2. A smooth course and the absence of minima on the curves of the dependence of Pm on the composition of the composition are visible, which

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indicates good compatibility of thickeners, regardless of both their ratios in the mixture (cr.1), and additives and printing ink components (cr.2). The presence of good compatibility is also confirmed by the high stability of the obtained mixtures [2].

The research results indicate that, according to the nature of the rheological curves, starch paste without sericin and PAA can be attributed to elastic-brittle or elastic-brittle solid-like systems, for the description of the structural and mechanical properties of which such characteristics as the modulus of elasticity and viscosity of the elastic effect are used [3].

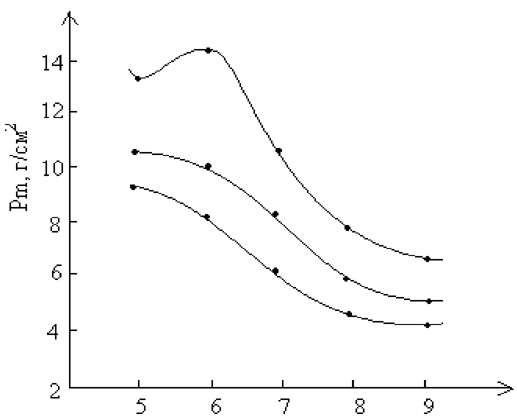

Fig. 3.8. The dependence of the yield strength of the composition on the concentration of HAE and thickening based on: 1 - starch + CMC + HAE; 2 - starch - PAA + HAE; 3 - starch - PAA + CMC + HAE

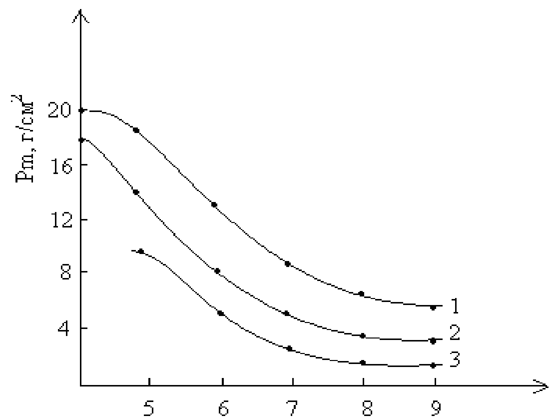

Fig. 3.9. The dependence of the plastic strength Pm of the internal structure of the polymer composition on the concentration of HAE and thickeners based on: 1 - starch + CMC + HAE; 2 - starch + PAA + HAE; 3 - starch + PAA + CMC + HAE

It follows from the flow curves of 6% starch pastes and polymer composition that when CMC and sericin are introduced into the composition, the elastic-viscous solid-like system of 6% starch paste is transformed into an elastic-plastic system [4]. In addition, it was noted that the higher the content of CMC and sericin in the system, the more pronounced the plastic properties of the system are [5].

From the data obtained (table 3.) shows that the viscosity of the resulting composition with the same concentration of starch is relatively high. If at 293K the viscosity of a 4% starch solution reaches 14.516 Pa.s, then the viscosity of the same solution with the addition of Na-CMC and sericin with a concentration of 3.0 and 0.3%, respectively, relative to the weight of starch will be 24.721 Pa.s. The viscosity of the solution is 41.064 Pa.s if the concentration of non-starch is brought to 6%. The viscosity of the system rises to 62.787 Pa.s if the starch is modified with Na-CMC and sericin (the concentration of modifiers is 3.0 and 0.3% of the starch weight, respectively), in In this case, the viscosity of the system will be 1.5 times higher than the initial one [6]. Based on this, it can be said that the functional groups of the initial components interact due to van der Waals forces, which indicates the modification of starch hydroxyl groups [7]. It should also be emphasized that the addition of modifiers to the system not only increases its viscosity, but also leads to an increase in the degree of thixotropic reduction, which subsequently reduces the yield strength of the thickener. If the starch concentration reaches 5.0% then the degree of thixotropic reduction is 84.2% and the yield strength is 39.14 g/cm2, at the same starch concentration, if modified, then the values will change as follows 97.6% and 34. 23 g/cm2, respectively.

Important factors that determine the technological properties of the thickener and its quality are the chemical nature, structure, and complex of chemical properties of the ingredients of thickening systems. In addition, the thickener must have high elasticity, have sufficient viscosity at a low concentration of thickening components and high wetting ability of the fibrous material, be stable during storage and use, and also have good biodegradability in washing and finishing [8].

Table 3

Change in the rheological properties of the developed composition depending on the concentration of starch, CMC and sericin

The concentration of starch in the thickener, %	The concentration of modifiers,% by weight of starch		η, Pa·c (T=293K)	The degree of thixo-tropic restoration,%	Yield strength, Pm, g/sm^2	The degree of starch depletion,%
	Na-CMC	Sericin				
4	-	-	14.516	80,4	41,36	-
5	-	-	23.543	84,2	39,14	-
6	-	-	41.064	93,3	25,40	-
4	2,0	-	16.730	83,7	40,23	63,0
	3,0	-	18.145	86,4	37,14	67,5
	4,0	-	21.283	95,2	33,26	72,3
	-	0,1	15.264	82,3	40,78	56,4
	-	0,2	17.846	85,1	38,19	58,6
	-	0,3	18.935	94,4	35,27	64,0
	3,0	0,3	24.721	96,7	30,41	75,7
5	2,0	-	26.434	86,8	38,76	60,4
	3,0	-	28.743	88,7	35,28	62,3
	4,0	-	32.672	96,1	31,08	64,7

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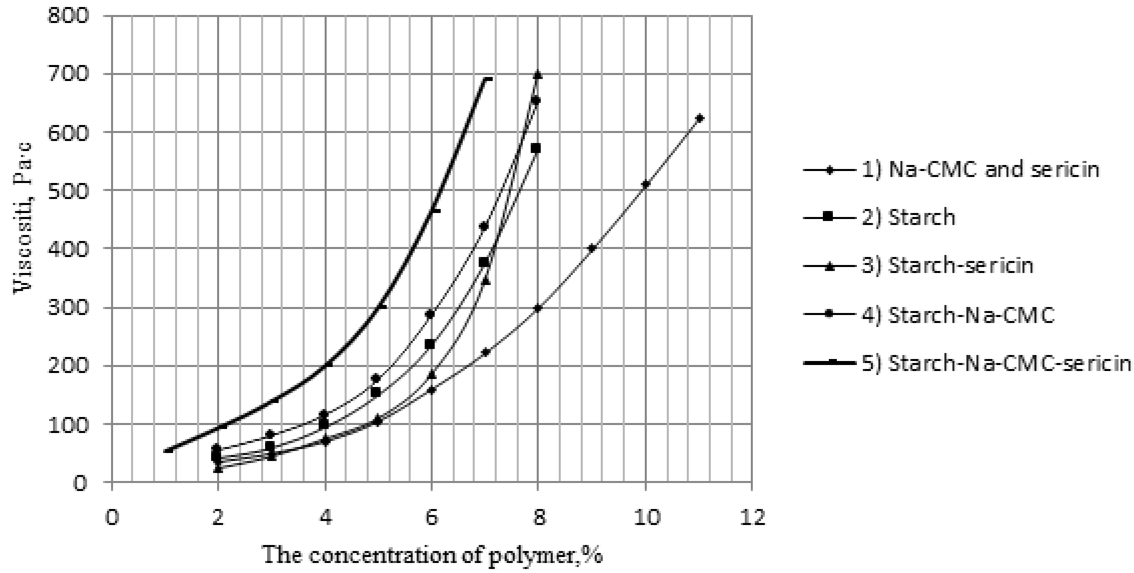
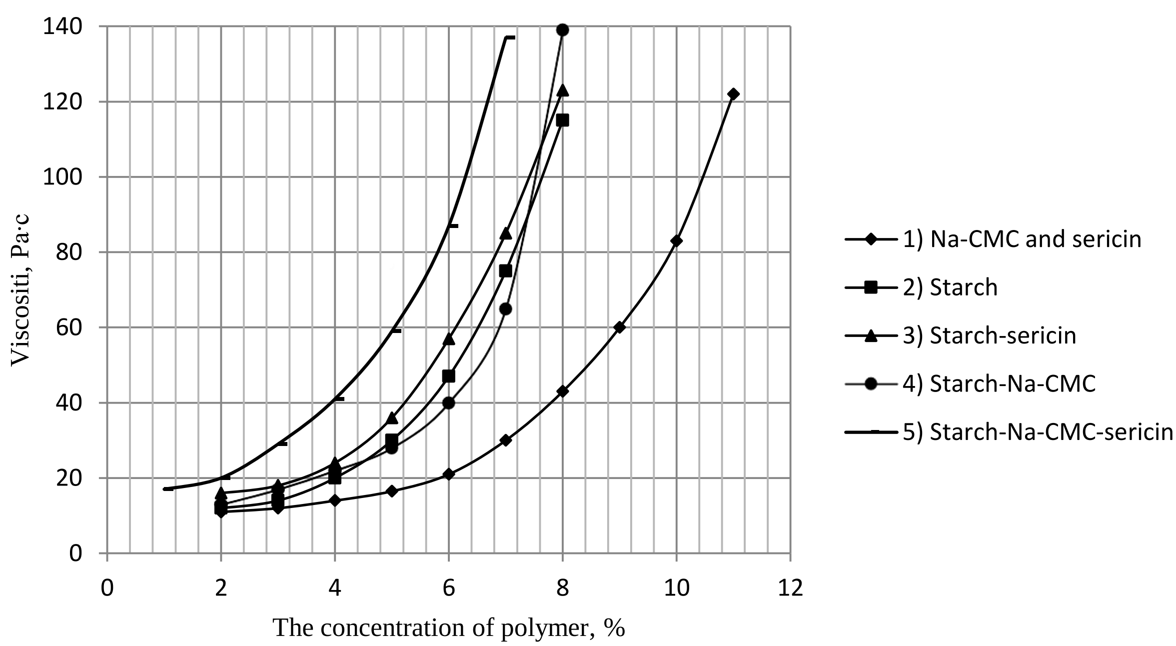
	-	0,1	25.126	84,2	38,56	53,4
	-	0,2	27.447	86,3	36,15	54,2
	-	0,3	29.165	95,1	33,47	58,1
	3,0	0,3	35.284	97,6	34,23	75,6
	2,0	-	47.182	88,4	25,11	57,8
	3,0	-	51.723	91,5	23,64	59,7
	4,0	-	55.641	97,6	20,78	63,4
6	-	0,1	31.142	85,3	26,24	52,1
	-	0,2	34.284	87,8	25,18	53,6
	-	0,3	40.166	96,2	22,34	55,4
	3,0	0,3	62.787	98,7	19,26	73,2

Good stability is characterized by porous structures of "alkaline" viscous compositions, which contain as natural starch and synthetic polymers Na-CMC and sericin. The stability of such compositions prepared from polymer solutions of various concentrations was evaluated by the viscosity of the systems immediately after preparation and after exposure for a day. Corresponding dependencies are shown in fig. 3 (a, b).





Rice. Fig. 3. Dependence of the viscosity of gel-like thickeners on the concentration of the components of the thickening ingredients and the exposure time

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Thickener based on: 1. Na-CMC and sericin; 2. Starch; 3. Starch-sericin; 4. Starch - Na-CMC; 5. Starch-Na-CMC-sericin

a) Freshly prepared system;

b) Viscous system after 24 hours of exposure

It can be seen from the graphs that the most preferable is the use of viscous systems based on starch, Na-CMC and sericin (Fig. 3. curve 1), moreover, the compositions of starch, Na-CMC and sericin have the necessary dynamic viscosity (308 Pa ·c) at a starch concentration of 5.0%, Na-CMC-3.0% and sericin 0.3%, and after keeping the composition for a day, it decreases to 136 Pa·s. The possibility of preparing thickening three-component compositions from starch, Na-CMC and sericin is not excluded and the most effective are low-concentrated systems based on starch, Na-CMC and sericin and at 5.0; 2.0 and 0.3%, respectively [9].

It was found that the introduction of starch and polymers such as Na-CMC and sericin into the composition of the thickener of printing inks leads to the formation of a film with increased elasticity and fluidity.

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