



## Study Of the Structural-Mechanical and Rheological Properties of The Polymer Composition

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### ABSTRACT

The article investigates the degree of thixotropic reduction, yield stress and viscosity of sizing polymer compositions based on rice starch, hydrolyzed acrylic emulsion and hydrolyzed polymethyl acrylate. It is shown that the introduction of an acrylic emulsion and hydrolyzed polymethyl acrylate into the composition of the sizing polymer composition improves its rheological properties. The results of experiments on studying the effect of GAE and GPMA, which are part of the sizing composition, on the structural and mechanical properties of starch solutions are presented.

### Keywords:

Component, Starch, Viscosity, Size, Degree of Thixotropic Reduction, Ash, Gel, Starch Paste.

The structural-mechanical or rheological properties of fluid systems are the behavior of polymer systems during deformation. They determine the dependencies which relate stresses at different temperatures and deformation modes for polymer systems and provide valuable information about their properties, structure, and structural transformations. They are of great importance not only from the point of view of studying the systems themselves and studying the changes occurring in them, but also from the viewpoint of the problems associated with the use of such systems in technological processes.

In sizing processes, sizing compositions undergo various thermal and mechanical effects, and the rheological properties of sizing composition systems change. In this regard, we studied the rheological properties of a sizing polymer composition based on rice starch, hydrolyzed acrylic emulsion (HAE) and

hydrolyzed polymethyl acrylate (HPMA). It could be expected that, due to the reaction of starch complexation with hydrolyzed acrylic emulsion, the rheological properties of the systems should undergo significant changes [1, 2].

The inclusion of synthetic polymers, such as GAE, HPMA, into the composition of starch dressings leads to significant properties, including structural and mechanical ones. To the advantage of polyacrylate compositions as a sizing tool we can include its high adhesive properties. Moreover, polyacrylates can be obtained of a homopolymeric and copolymeric nature, with the production of acrylic and methacrylic acid derivatives, which makes it possible to combine a different ratio of monomers in a polymer molecule and obtain a wide range of physical and chemical properties in the synthesized polymer [3,4].

Solutions of polymers, including starches, are not structureless. The structure

of solutions is understood as the mutual arrangement of solvent and polymer molecules, the conformation of macromolecules, and the interaction between polymer macromolecules. The stability of the structure can be judged from the values of the degree of thixotropic recovery given in Table 1.

Table 1.

Yield strength and degree of thixotropic recovery of starch dissolution with the appointment of GAE and HPMA

Composition and content of components			Limit Fluidity, (Pa)	Degree Thixotropic recovery, %
Starch, %	GAE	HPMA		
	% by weight of starch			
5	-	-	3,61	82,46
5	1	10,0	15,16	90,03
5	2	10,0	17,31	93,70
5	3	10,0	24,51	95,69
5	4	10,0	35,32	96,52
5	5	10,0	45,65	98,31
5	1	12,0	17,54	91,30
5	2	12,0	19,56	95,12
5	3	12,0	25,04	97,74
5	4	12,0	37,15	98,53
5	5	12,0	48,01	99,39

Thixotropy is the ability of structures after their destruction, as a result of some mechanical action, to spontaneously recover in time, i.e. thixotropy is the ability to reversibly isothermally convert a sol to a gel. Table. 1 shows that starch pastes containing HAE and HPMA are characterized by higher values of the degree of thixotropic reduction.

Such a gradual restoration of the structure and, consequently, an increase in its strength occurs not only when the system is at rest, but when the system flows at a speed lower than that which caused the given degree of destruction of the original structure. However, during the reverse transition from the steady flow regime at high speed to flow at a lower speed, some restoration of the structure occurs and, accordingly, the effective viscosity and strength of the structure increase and, the higher the content of HAE in the system, this effect is more pronounced. Thus, the introduction of GAE and HPMA starch into the paste leads to an increase in the thixotropic reduction coefficient, i.e. an increase in the rate of relaxation processes. Due to their high adhesion properties, polyacrylate compositions are gaining more and more importance as a sizing agent for cotton yarn sizing. Changing the chemical composition of these compounds makes it possible to widely vary their properties, which is much more difficult for polymers of other groups. Therefore, this article presents the results of an experimental study of the effect of HAE and HPMA, which are part of the sizing composition, on the structural and mechanical properties of starch solutions.

The study of the rheological properties of 5% pastes based on rice starch with the addition of small amounts of HAE (1.0-5.0% by weight of starch) and HPMA (10-12% by weight of starch) showed that the rheological properties of the systems change significantly with introduction of GAE and GPMA.

In table 2 shows the change in the viscosity of 5% starch pastes (at  $\gamma = 27 \text{ cm}^{-1}$ ) as a function of the content of the introduced HPMA at different temperatures. It follows from the table that the addition of HPMA to the starch system causes an increase in the viscosity of the system. This fact testifies to the complex formation reaction of HPMA with starch, since in the polymer chain of starch (more precisely, its components - amylose and amylopectin) it is likely that there are hydroxyl groups in a position convenient for complex formation (at a distance of  $2.42 \text{ \AA}$  at an angle of  $190^\circ$ ). The formation of complexes is possible

both within one polymer chain and between two chains.

Table 2

Changes in the viscosity of 5% starch paste from the content of HPMA at different temperatures

Temperature, K	Dressing viscosity (Pa.s) at various HPMA concentration, % of starch weight				
	4,0	6,0	8,0	10,0	12,0
298	0,42	0,76	1,22	1,34	1,76
313	0,34	0,68	1,13	1,28	1,63
323	0,26	0,61	0,98	1,22	1,55
333	0,21	0,57	0,84	1,16	1,43
343	0,14	0,50	0,72	0,94	1,44
353	0,10	0,42	0,76	0,89	1,23

The formation of such knots can lead to a decrease in the mobility of the chains; limiting their thermal motion, increasing the structure of the system and the formation of a more rigid chain, and as a result of all this, to an increase in the viscosity of the system.

It is obvious from Table 2 that, for all systems, as the temperature rises, the viscosity decreases. This can be explained by the fact that with an increase in temperature, the energy of thermal motion of polymer units increases sharply and, at certain values, this energy increases the energy of intra-intermolecular interaction.

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