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Physical and Mechanical Modification of Starch

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ABSTRACT. The article analyzes the physical and mechanical methods of starch modification for its use in textile and other industries. A brief description of the works of the authors is given. The authors note that any methods of oxidized modification of starch lead to a decrease in viscosity. In other words, it is not possible to obtain a sufficiently plastic dressing with the required viscosity from starch hydrogels modified by the oxidation method in the absence of special synthetic polymer additives.

KEY WORDS. Starch, mechanochemical processes, physical and chemical methods, starch oxidation

I.INTRODUCTION

As a rule, chemical modification of starch is a multi-hour and multi-stage process, which is associated with high energy costs.

Physical methods of modifying starch for use in textile and other industries have not yet found wide application, but interest in these methods has recently increased markedly. Under the physical methods of modification of starch can be understood purposeful exposure to ultrasound, cavitation, as well as the action of hard radiation and mechanical methods.

In the works [1-3] attempts were made to depolymerize potato, corn and wheat starch by radiation exposure of dry product doses of 43-200 kg/h. It is shown that the viscosity of the samples decreases by 1.5-2 times with increasing radiation dose, and the concentration of the water-soluble fraction increases by 5-10 times, the pH and the degree of retrogradation decreases, the content of pathogens significantly decreases.

The authors subjected corn starch isolated from grain to dextrinization and irradiation with gamma rays of Co^{60} (the first dose is 700 krad, the second 70 Mrad). It was found that dextrinization and irradiation with a dose of 70 Mrad increases the acidity of starch. It is suggested that the bonds between 2-3 carbon atoms of the terminal glucose residue break during irradiation.

For the modification of starch, mechanical methods are also used. The most famous type of mechanical modification of starch is extrusion [4]. This process is widely known, well studied and used in industry. The extrusion process is based on three factors: pressure, temperature (150-190 ^{0}C) and shear.

The most often apply not purely physical impact, and combination of chemical and physical method. The use of a combination of chemical and physical effects can reduce the duration of chemical processes and increase the degree of conversion of starch. For example, researchers [5] by radical initiation of the redox system H_2O_2 +ascorbic acid or γ - irradiation at a dose of 0.8 - 1.0 Mrad obtained strongly swelling polymer hydrogels based on starch modified by grafting acrylic acid. Karosserie obtained polymer gels are able to swell up to 2000 ml/g. effects of hydrogen peroxide and γ - irradiation duration of the process of modification of the starch is reduced in two times. To reduce the time of the oxidation process, the authors [6] proposed to use the oxidation of starch in ultraviolet light for 5 hours at a temperature of 20 ^{0}C. The resulting oxidized starch contains significant amounts of carboxyl and carbonyl groups.

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II. EXPERIMENTAL PROCEDURE

When starch is treated with 0.1 % peroxide solution followed by short-wave treatment on an IR radiation unit at a temperature of 140-180°C and for a duration of 2 to 10 minutes, a modified starch containing 0.003-0.006 % carboxyl groups is obtained [7]. The effect of these reactive mixtures and hydrogen peroxide itself on starch is specific, despite the fact that the oxidation chemistry is the same and probably represents the following scheme: the oxidation of starch occurs under the action of an atom of active oxygen, it is accompanied by hydrolytic cleavage of glucoside bonds and the addition of oxygen to hydroxyl groups.

The authors [8] investigated the effect of the initial monomer type (acrylamide, acrylic acid) and plasma treatment conditions on the gain of the starch copolymer. Plasma was found to be an effective initiator of the reaction. The maximum amount of copolymer was obtained at a pressure of 0.02 Torr, a voltage of 20 V.

One of the new, little-studied methods of combined modification of starch is mechanochemical modification, [9-10] the essence of which is the imposition of high-energy mechanical effects on the starch-water-reagent system. The new properties of the polymer achieved in this case are the total consequence of physical effects on the material (high-speed deformation shifts, mechanical vibrations of the sound and ultrasonic frequency range, cavitation) and mechano-catalyzed chemical transformations in the substrate macromolecules under the action of a chemical reagent. Mechanochemical processes are processes based on methanomicrobia or mechanicals chemical transformations in the substrate. Starch can be machined, both in the gelatinized state and in the form of an aqueous suspension.

When machining gelatinized starch in the activator of the rotary pulse type, as has been proved by various physical and chemical research methods [11-12], the following processes take place .

- destruction of starch grains;
- formation of a new gel structure as a result of cooperative orientation-associative processes in the shear field;
- mechanicalsystems and mechanoenzymes chemical transformations in polymer;
- homogenization of mixed materials, increasing the compatibility of ingredients.

The authors of investigated the possibility of using mechanicaldamage oxidation of starch hydrogel for the preparation of starch thickener. For this purpose, mechanical treatment of starch paste was carried out in a rotary pulse activator in the presence of a complex chemical modifier of oxidizing action. The eight-percent starch thickener obtained in this way had the same dynamic viscosity as the ten-percent starch thickener obtained by the traditional thermochemical method (acid hydrolysis with HCI) provided an increase in the degree of fixation of active dyes by an average of 15-20%. Increasing the viscosity of thickeners, prepared by the mechanochemical method, apparently, is associated with the occurrence of adverse reactions of crosslinking. Between activated fragments of starch macromolecules in the presence of an oxidant under the action of ultrasonic cavitation, causing the formation of free radicals in the system. In the mechano-chemical method of preparing thickeners, the splitting of starch grains is achieved by passing the starch paste through the radial gaps between the rotor and stator elements due to the action of high-speed shear loads.

It should be noted that if the breakdown of starch grains in the preparation of starch thickener, a single transmission of the paste through the plant [13], to achieve high degrees of conversion of the reagent during chemical modification of starch is to be processed in recirculation mode. A limitation in the use of thickeners, mechanochemically modified starches in the gelatinized state, can be relatively high, in comparison with the treatment in suspension, specific energy costs associated with the need for recycling and high viscosity of the gelatinized mass. More promising for use in the textile industry is the second method of mechanochemical modification, in which the starch suspension is processed in a rotary pulse activator. Unlike paste, in suspensions starch grains are present in the solid state, in the form of spherical particles of 20-30 microns in size. In the results of industrial development of mechanochemical technology for obtaining a starch thickener. The main element of the mechanochemical technology is the installation of the rotor-pulse type of the original design, in which the starch suspension is machined. The use of mechanochemical modified starch thickener will significantly reduce the unit cost of starch and the cooking time of the thickener and to increase color and strength characteristics of the printed pattern and to provide more soft tissue neck. Mechanochemical technologies have not yet found wide application in industry. Apparently, this is due to the lack of sufficient theoretical developments on this issue. Analysis of the literature data on the use of various dressing

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ingredients shows that in order to obtain a good quality of the coated yarn, one condition is necessary that the components used in dressing contain a certain number of carboxylic groups, regardless of their location in the polymer chain. The use of various modifications of natural polymers in order to give them properties similar to potato starch or PVA is an interesting and promising direction.

III.RESULTS AND DISCUSSION

A promising method that allows to modify the starch and bring it closer to the properties of the best PVA is a soft oxidation of hydroxyl groups with the preservation of glucoside bonds. As a result of the carboxyl groups in the polymer chain reduces the ability of starch to interact with the functional groups of sericin and PAA, which leads to increased cleusa ability shishtawy composition. The involvement of synthetic polymers in the dressing polymer composition contributes to the process of dressing without difficulty dressing does not stick on the drying drums dries quickly on the threads, forming a smooth elastic film, due to the low viscosity of the working solutions of the dressing polymer composition easily penetrates into the inter-fiber space and firmly glues the individual fibers together.

Oxidation of starch with potassium permanganate is of great practical interest. The high oxidizing potential of potassium permanganate makes it possible to save the amount of the drug, which has a positive impact on the cost of the final product.

But it should be noted that any methods of oxidized modification of starch lead to a drop in viscosity. In other words, from starch hydrogels modified by oxidation in the absence of special synthetic polymer additives it is not possible to obtain a sufficiently plastic dressing with the required viscosity.

Thus, we can conclude that the search for new more effective ways to modify starch attracts the attention of numerous researchers. Research is aimed at improving the technological properties of starch and increasing the degree of its useful use, and to reduce the duration and energy intensity of the process of preparation of gel-like starch materials for their use in the textile industry. The involvement of synthetic polymers in the dressing polymer composition contributes to the process of dressing without difficulty dressing does not stick on the drying drums dries quickly on the threads, forming a smooth elastic film, due to the low viscosity of the working solutions of the dressing polymer composition easily penetrates into the inter-fiber space and firmly glues the individual fibers together.

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IV.CONCLUSION

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