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INFLUENCE OF RHEOLOGICAL MODIFIERS ON THE PROPERTIES OF FILMS OF THE ADHESIVE COMPOSITIONS BASED ON OXIDIZED STARCH

Abstract. The article studied the hydrodynamic properties of adhesives based on oxidized starch with rheological modifiers. The development is aimed at solving the problems of wet strength of glue joints based on them when used for surface gluing of corrugated boards.

Keywords: adhesive, oxidized starch, rheology, modifiers, wet strength, glue, corrugated board.

1. Introduction

Starch is one of the oldest and most common auxiliaries used in the manufacture of paper and board. It is one of the main binding materials used in paper production,and, moreover, the cheapest compared to other binders [1]. The main use of starch is to increase the strength of paper (especially surface strength). The use of modified starches gives an additional effect associated with an increase in the retention of fine fibers, filler, optical bleaching, and sizing agents by them [2].

This effect is expressed in a decrease in the uneven properties of the paper on the sides of the sheet, which is especially important for those types of products in which both sides are working, for example, paper for writing and printing. The addition of starch to the mass reduces the dustiness of the paper, increases the retention of fillers, and improves and stabilizes the rosin sizing [3]. The production of many types of packaging papers and boards, such as board for flat layers, corrugated paper, and wrapping paper, uses recycled paper as the main raw material. This range requires the lowest cost per ton of product. In order to use waste paper in a wide range of pulp and paper products, it must be subjected to deep refining with a high degree of recovery of paper-forming properties, which requires significant investments. Materials obtained from such raw materials do not have a sufficient level of strength, rigidity, and surface finish [4].

One of the significant disadvantages of cardboard is its weak wet strength. This significantly narrows the scope of its application in cases where it is required to maintain the strength of the package in conditions of high humidity. At the same time,a decrease in the wet strength of cardboard also negatively affects its adhesive properties, which in turn increases the number of manufacturing defects [5].

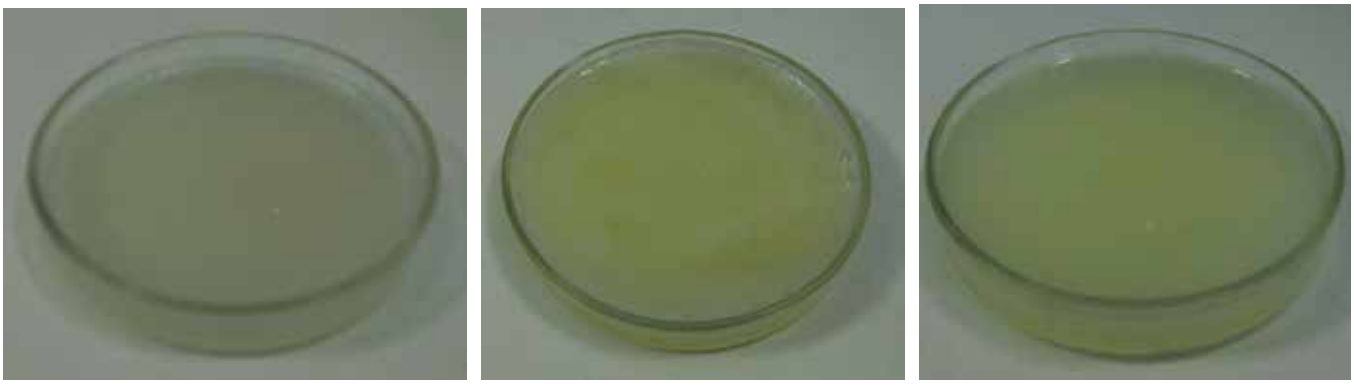
With insufficient water-holding capacity of the adhesive, a rapid loss of the first portions of moisture occurs. With a lack of moisture, starch is simply not able to gelatinize and show its adhesive properties. The moment when the starch is able to gelatinize with the manifestation of adhesive properties stops when the moisture content in the starch suspension becomes less than 60%. If up to this point, the starch grains have not had time to gelatinize, then further they behave as an inert filler of the glue joint [6].

Therefore, it is important that the adhesive has increased water-retaining capacity at the initial stage, when starch gelatinization occurs, and quickly dries at the second stage after gluing, so as not to reduce the productivity of the equipment. This problemcan be reduced by developing new formulations of adhesives for the production of corrugated cardboard. Namely, by introducing water-retaining additives and additivesinto the composition of the adhesive, which would accelerate the drying of the adhesive at the stage of drying out of the adhesive joint [7]. So, referring to the properties and glue compositions of adhesive materials, we have developed other compositions based on corn starch oxidized by H_2O_2 [8].

2. Practical part

The methods for preparing adhesives from oxidized starch (OS) granules may for convenience be classified under three main headings: 1) Heat treatment of OS gelatinized pastes with Na_2SiO_3 paste. 2) Polyacrylamide (PAA) treatment of the OS as paste; 3) Preparation of the adhesive based on OS formed by the addition of PAA and Na_2SiO_3. Various modifying agents such as PAA and Na_2SiO_3 were added to the adhesive of OS formed to ensure that a suitable working consistency was obtained and also to effectively prolong the shelf time of the adhesive composite formed.

The results of experimentalstudies have shown that when using various modifications of glue based on corn starch, the following patterns can be traced. First to obtain an adhesive of optimal composition, studies were carried out on homogeneity, medium, viscosity and humidity [9]. The humidity of adhesive films directly affects to wet strength of corrugated board. The resulting compositions by adding the components step by step gave a homogeneous adhesive composition with a yellowish tint. Forming of adhesives based on OS are shown in the (figure 1).



A B C

Figure 1. Glues based on OS with PAA (A), with Na_2SiO_3 (B) with all of them (C)

It is interesting that the resulting pastes have different attitudes to different solvents when obtaining their films. Five films formulations were prepared using the concentration of oxidized starch varied from 6 to 8 g and included sodium silicate in relation to the dry weight of starch from 0.1 to 0.3 g and polyacrylamide from 1.2 to 1.8 g and distilled water to complete 100 g of solution. A two-component paste containing OK in each and silicate or PAA was prepared, followed by a variation of the mixture of the latter with OK in a three-component composition. The solvents used were ethyl acetate, dioxane, and propyl alcohol. Some

formulations did not give good films with, some with propanol and some with dioxane. For example, the composition OK-silicate gives a very brittle film with propanol. A mixture of OK-PAA with ethyl acetate did not give an equal film thickness. Some of these good films obtained with solvents are shown in (Figure 2).

A B C

Figure 2. The films obtained from pastes OS with PAA in dioxane (a), with Na_2SiO_3 in ethyl acetate (B), and with all of them in propanol (C)

The shown film drawings show that adhesive mixtures give good films in the indicated solvents, but these mixtures did not give good films in other solvents. If we compare the strength characteristics of films, it turns out that with an increase in the size of supramolecular formations, the strength of the film and its elongation increase (table). But in the table given also the values of physical-mechanical properties of glues without OS were no in (Figure 1.2) also.

Table 1.– Physical-mechanical properties of films based on OS, PAA, and Na_2SiO_3

Contain solution (in mass.%)	**Tensile Strength, (MPa)**	**Elongation of break (%)**	**Contain solution (in mass.%)**	**Tensile Strength, (MPa)**	**Elongation of break (%)**
OS (8) – Na_2SiO_3(0.1)	1.4 ± 0.1	7.2 ± 0.2	OS (6) – PAA (1.6)	4.3 ± 0.3	14.3 ± 0.8
PAA (1.8)	2.1 ± 0.2	8.1 ± 0.3	OS (7) – – Na_2SiO_3(0.2) – PAA(1.2)	5.5 ± 0.5	18.2 ± 0.9
Na_2SiO_3 (0.3) – PAA(1.4)	3.2 ± 0.4	12.4 ± 0.6			

The noted tendency of an increase in the tensile strength of the film with the introduction of PAA is apparently related to the acceleration of the process of formation of supramolecular formations during formation from the studied highly dispersed systems (rather large supramolecular formations already exist), which, in turn, causes an increase in the degree of crystallinity of the films. An increase in elongation at break indicates the influence of an additional factor inherent in systems containing additives of highly dispersed PAA. Obviously, the introduction of PAA prevents the mutual ordering of the formed enlarged supramolecular formations.

As a result, under tension, the process of mutual ordering of crystallites makes a significant contribution to the magnitude of deformation, which can explain the increase in the elasticity of films obtained from polymer compositions containing OS-PAA-Na_2SiO_3. It follows that when PAA is introduced into the composition, the elastic-viscous solid-like system transforms into an elastic-plastic system, which is one of the important requirements for the properties of adhesives.

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