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Chemical aspects of hydrophobization technology for secondary cellulose fibers at the obtaining of packaging papers and cardboards

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Abstract- The article presents the results of the analysis concerning the hydrophobic components chemical nature influence on wet strength and sorption properties of the base paper. The effect of the composite structure and the nature of input hydrophobizing component on the strength and sorption properties of paper (cardboard) is studied. The relationship between the amount of water-repellent component and capillary-porous structure of the cellulose substrate is examined. The basic laws for the formation of capillary-porous structure of the base paper are considered. The influence of the strength and adhesive properties of the source fiber raw material on the quality of a finished product is studied. The methods of cellulose base chemical modification with cation-modified forms of starch are proposed to improve the performance properties of the paper package.

Keywords: fiber, cellulose, base paper, cardboard, sorption properties, sizing, sizing materials, adhesion, cationic-modified starch, quality, packaging.

Introduction

The adhesive properties of paper and cardboard are determined most of all by sorption rates, which in its turn are directly dependent on the absorbency of the cellulosic substrate. The structure and properties of the fibrous substrate are determined by the composition content of a fiber, as well as by the amount of sizing and filling materials used in the technology of cellulosic composition production [1 - 6].

The production of many kinds of packaging paper and cardboard, involves the use of waste paper as the main raw material [7 - 9]. It is known that the efficient use of waste paper in a wide range for the production of pulp and paper products, demands its deep refinement with a high degree of papermaking properties recovery, which require significant investment. The fact is that by using a low-quality fibrous semifinished products in papermaking in general and recycled materials in particular a number of problems occur which demand serious logistic elaborations. The materials obtained from such raw materials do not have a sufficient level of strength, stiffness and surface purity [5, 10 - 12].

For many years the modification of the sorption properties for wrapping paper (or cardboard) surface demanded the use of native starches. Their main advantage is low cost, but their main drawback is the high cost of a ton of products and the slowing down of dehydration process [1, 13 - 15]. Currently, native starch is rarely used as a binder and sizing component because of the inherent shortcomings noted above. It was replaced by modified starches of various kinds [3, 6, 16].

The studies proved that on the basis of starch one may create polyelectrolyte flocculants, if you introduce ionizable groups in the macromolecules of amylose and amylopectin [10, 17]. Simultaneously, it was found that the treatment of starch by oxidants, enzymes, the grafting of carboxymethyl and hydroxypropyl groups could significantly improve the functional properties of native starch by gluing, surface sizing and as a binder in coating pastes [1, 13, 15].

Recently cation modified forms of starch are applied widely in the manufacture of paper and cardboard. It has been established that they have a strong adsorption to the fiber and are well retained in the mass, thereby cover the most part of the fiber surface and provide good internal adhesion at low flow rates. Besides, cationic starches are an effective means of retaining fines, fillers and harmful resins. If the retaining of cationic starches in the paper reaches 95%, then they behave as polymer flocculants, which is usually typical for low-molecular cationic polymers. At that soft flocculation allows to obtain small plagettes instead of the huge ones, which is important in terms of the paper clearance heterogeneity index [1, 2, 11, 18, 19]. It is known that the cellulose fibers are charged negatively. So, many reputable scientists, including V.I. Yur'ev [19] and T. Lindstrem [20] believed that the primary cause of a negative charge occurrence on the surface of cellulose fibrils dispersed in water is the ionization of the carboxyl groups and the dissociation of all electrolytically active groups on the cellulose surface. At that the actual content of carboxyl groups (in which so many hydroxyl groups could be oxidized theoretically) is negligibly small to generate such a strong charge [21], and the charge of the cellulose

surface is caused likely by the orientation of water dipoles [17, 22].

It was found that interaction of the cationic starch with negatively charged cellulosic fibers proceeds by the mechanism of mosaic clutch: polymer chains of positively charged starch are deposited like mosaic elements on fibers and in the filler particles, thereby recharging only separate areas. The interaction of oppositely charged areas leads to mosaic clutch of particles with the development of cohesive macroflocculus relatively resistant to the impact of shearing forces [19, 20].

The performed literary analysis showed that the physical and chemical aspects of cellulose fibers hydrophobization by cationic starch forms are described in general. At that it was noted that the effectiveness of application and the use of cationic starch should be developed individually for each company based on the characteristics of the used raw materials and technological equipment.

Methods

We used general scientific and special methods of study. During the implementation of the experiments the standard and generally accepted methods for the estimation of native and modified starch properties: electrophoretic, microstructural, viscometric; to determine the quality of the obtained product samples the physical, mechanical, chemical and sorption methods of analysis were used. Adhesion processes were considered using the example of cardboard processing methods, namely, in the processes of corrugated board, glued and laminated cardboard production. The experimental data processing was carried out on the basis of mathematical statistics using the software Statistika 6.0 and Microsoft Excel.

Research

The main objective is the creation of different cellulosic composite materials, preferably from recycled pulp fibers (up to 60%) with the set balance of hydrophobic-hydrophilic properties of the cellulosic substrate surface. The waste mass of cardboard and corrugated cardboard was used as the feedstock. Quaternary aromatic amines were used as a cationic modifier of native starch.

Based on the obtained results, it was found that the efficiency of the adhesion process at various methods of composite material production directly depends on the structure of the base paper and its absorbency. At that it was noticed that the composite stability of the material is determined by the chemical composition and the nature of the applied polymers; in the case of cardboard lamination the adhesion mechanism is realized by viscous polymer flowing into the paper pores, followed by solidification of the polymer; in case of water-based adhesives application (when glued and corrugated cardboard is produced) - the adhesion is performed at the expense of intermolecular interactions between the functional groups of the applied polymer and the functional groups of cellulose.

The values of modified starch colloidal particle ζ-potential were determined by electrophoresis. According to the research it was found that the introduction of cationite with the weight fraction up to 12% the total neutralization of a negative surface charge of native starch particles (isoelectric point of the condition is reached). At further introduction of cationite been a slow recharge of the starch particles is observed and the cationite content of more than 18% the value increase of colloidal particle ζ-potential is almost not recorded. In further studies cationic starch was used containing 18% of the cation exchanger.

A serious drawback of cationic starch use is the limitation of its quantity. The introduction of cationic starch excess amount will lead to total cationization of particles concerning all colloidal system of the charge. This should not be allowed as the overcharging would drastically decrease the performance of a paper machine wet section, to the deterioration of the overall starch retention on cellulose fibers.

The "cationic demand" of pulp depends on the type and the structure of the fibrous raw material, as well as on the pH solution and the background electrolyte composition as the cationic starch performs a dual role and serves as polyelectrolyte to reduce the negative charge of the fiber surface and simultaneously as a fixing polymer of anionic impurities [6, 10].

The work determined experimentally the "cationic demand" of the studied cellulose mass i.e. the waste paper of different brands and corrugated cardboard. According to the obtained results an effective content of cationic starch provides the necessary sorption properties on the base paper used in the production of packaging cardboard (glued, corrugated, etc.) and is determined by the ratio of 8 kg/t. At that the degree of starch retention on fiber made over 95%.

Summary

Hydrophobization technology of cellulose base (in weight) of catione modified starch is effective for obtaining the packing kinds of paper and cardboard. This technology makes it possible to produce the packaging from recycled materials with the required sorption and barrier properties. Besides, the variability of the obtained results demonstrates the possibility of targeted basis production in accordance with the requirements of a particular customer.

Conclusion

- the efficiency of adhesion processes under various methods of cellulosic packaging materials obtaining (the wastepaper share content up to 60%) depends directly on the structure of the base paper and its sorption properties;

- The optimum adhesion is possible at little penetration of the adhesive into the paper surface, and this indicator can be controlled;

- To improve the adhesion processes of cellulosic materials, it is reasonable to vary their surfaces with absorption properties by the cation exchange of fibrous substrate;

- It is efficient to use the compound of quaternary aromatic amines as a cationic modifier of native starch suspension;

- "Cationic demand" of pulp fibers derived predominantly from waste paper of different cardboard and corrugated cardboard grades (up to 60%) and makes 8 kg/t.

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