USE OF CHITOSAN IN THE COMPOSITION OF PAPER PACKAGING

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Abstract: Demand of renewable natural and biodegradable polymers, which can improve the properties of paper and facilitate recycling, is connected with chitosan. Use of chitosan in production of paper is possible because of its structural similarity with pulp and thanks to the fact that it is biodegradable, non toxic and ecological. Experimental results from different kind of paper with 0, 2%, 1% and 2% chitosan in composition are presented in this work. Samples of paper from mixture of bleached softwood sulphate pulp (100%, 80% and 50%) and bleached hardwood sulphate pulp (50%, 80% and 100%) were prepared. The mechanical and optical properties of these paper sheets are tested.

Kewords:paper, chitosan, bleached kraft pulp

Introduction

The interest of use of chitosan is connected with its properties as non toxicity, biocompatibility, biodegradability, antimicrobility and antibacteriality.

Paper with chitozan possesses smoother surface, better optical and mechanical properties and better wet stability.

Biodegradability of chitosan is important for polymer materials for packaging for food, which can degrade entirely in environment after use.[1]

Many polymer chemical additions are used in production of paper for improve or increase the strength and suitability of printing paper. One of the features of chitosan is its ability to form films, and to improve the surface properties of paper. There is an opinion that its ability to form films depends on its concentration and on mode of application. [2,3]

Mixtures of chitosan with biodegradable materials such as starch, collagen and soya protein possess good degradability and good mechanical properties and thermal stability, as well.[4]

Production of entirely degradable polymer composites, consisting of biodegradable matrix and filler attracts attention of many investigators. Series of biodegradable composites – chitosan and lignin were prepared. The solutions of chitosan and its derivates were added in different quantity during formation of sheets of paper. Chitosan improves interaction between pulp fibers and water and increases tensile strength of produced sheets of paper. Chitosan possesses amino- groups, which have ability of ionic and covalent bonding witch cellulose molecule. Addition of chitosan during production of paper improves mechanical properties of produces paper [5,6].

The purpose of present work is to investigate influence of chitosan on properties of paper from bleached pulps with different fiber composition.

Experimental

Materials and test methods

For experimental work bleached sulfate softwood pulp, bleach hardwood pulp, chitosan, rosin size and aluminum sulphate are used. Used chitosan possesses average viscosity and is produced by company “Fluka. The solution of chitosan contains 4 g

chitosan dissolved in 200ml 2% acetic acid is continuously stirred with magnet stirrer for twenty-four hours.

The paper sheets with grammage 70g/m^2 on Rapid –Ketten device were prepared. Samples of paper with different fiber composition from softwood and hardwood pulp were tested. The softwood pulp was beaten in Jokro-mill to 33^0 SR and hardwood pulp was beaten to 30^0 SR.

The follow fiber compositions were investigated: the first series – 50% sulphate softwood pulp and 50% sulphate hardwood pulp; the second series – 80% sulphate softwood pulp and 20% sulphate hardwood pulp; the third series – 100% sulphate softwood, the forth series - 100% sulphate hardwood pulp. The produced paper sheets contain pulp and 0, 2%, 1% and 2% chitosan. The sizing substances as rosin size and aluminum sulphate ($Al_2(SO_4)_3$) were added, as well. Optical, mechanical and capillary hygroscopic properties were tested.

Results and discussions

1. Samples from 50% softwood pulp and 50% hardwood pulp

After addition of 0, 2% of chitosan the number of double folds increases in comparison with the sample without chitosan. The best results are obtained with 2% of chitosan (about 78, 6% increase). Chitosan possesses a similar structure with the cellulose and its amino-groups with protons form ionic bonds with the components of cellulose materials and this is a reason for forming of stronger bonds between cellulose fibers. The addition of rosin size and aluminum sulphate increases the number of double folds, too, in comparison with the control sample. The results of test of folding strength are shown at Fig.1

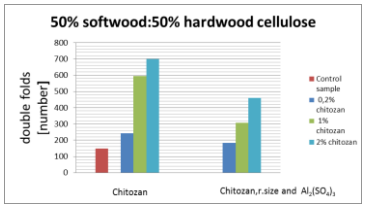

Fig.1 Research of folding strength of samples from 50% softwood pulp and 50% hardwood pulp, containing rosin size and $Al_2(SO_4)_3$.

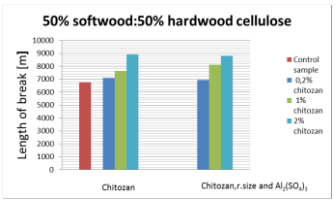

Fig.2 Research of tensile strength of samples from 50% softwood pulp and 50% hardwood pulp, containing rosin size and $Al_2(SO_4)_3$.

After addition of 0, 2% chitosan the breaking length increases in comparison with the sample without chitosan. There is a trend of gradually increase of breaking length with increase of quantity of added chitosan. This can be explained by increase of interaction between molecules.

Chitosan influences absorption of water – addition of 0, 2% chitosan decreases absorption in comparison with control sample without chitosan. Different sources confirm these results theoretically and practically. When increase the quantity of chitosan to 2% the absorption of water decreases. Joint action of chitosan, rosin size and aluminum sulphate decreases absorption of water tested by Cobb method.

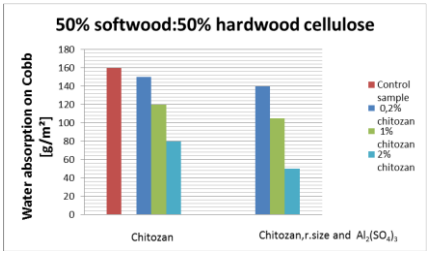

Fig.3 Research of absorption of water by Cobb method of samples from 50% softwood pulp and 50% hardwood pulp, containing rosin size and $Al_2(SO_4)_3$.

Addition of 0, 2%, 1% and 2% chitosan practically does not influence the degree of whiteness. Addition of rosin size and aluminum sulphate decreases the whiteness of paper a bit. The surface of paper becomes smoother.

2. **Samples from 80% softwood pulp and 20% hardwood pulp**

Test of samples from this fiber composition establishes that addition of minimum quantity of chitosan increases the number of double folds.

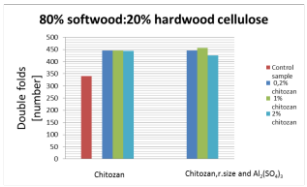

Fig.4 Research of folding strength of samples from 80% softwood pulp and 20% hardwood pulp, containing chitosan, rosin size and $Al_2(SO_4)_3$

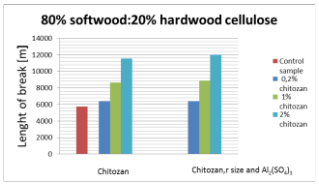

Fig. 5 Research of tensile strength of samples from 80% softwood pulp and 20% hardwood pulp, containing chitosan, rosin size and $Al_2(SO_4)_3$.

Fig.4 shows that addition of chitosan exerts favorable influence on strength and flexibility of paper samples. In this case the quantity of added chitosan is no importance, as the results are almost equal. It follows that desired effect can be reached by addition of only 0, 2% chitosan. For this fiber composition addition of sizing substances to samples with chitosan does not influence folding strength.

Fig.5 shows results from test of tensile strength. Addition of 0, 2% chitosan in this fiber composition increases breaking length by 10% in comparison with control sample without chitosan. The breaking length rises by addition of 1% and 2% chitosan and by addition of 1% and 2% chitosan, rosin size and aluminum sulphate. This result may be explained by increased intermolecular interaction, which, due to chitosan, stabilizes bonds between cellulose fibers.

Fig.6 shows results from test of absorption of water by Cobb method for samples of paper consisting from 80% softwood pulp and 20% hardwood pulp.

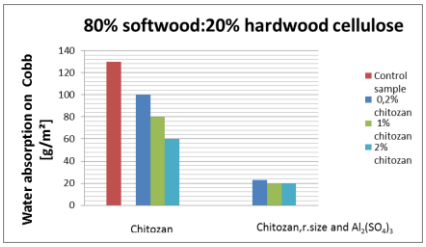

Fig.6 Research of absorption of water by Cobb method of samples from 80% softwood pulp and 20% hardwood pulp, containing rosin size and $Al_2(SO_4)_3$

The absorption of water is influenced at high degree by presence of chitosan in paper sheets. Addition of 0, 2% chitosan decreases absorption of water by 23% in comparison with control sample without chitosan. The best results are obtained when 2% chitosan were added. This result can be explained by chitosan`s relative hydrophobility. Similar results were obtained in case of chitosan, rosin size and $Al_2(SO_4)_3$. Sizing substances decrease absorption of water by 85 %.

3. **Samples from 100% softwood pulp**

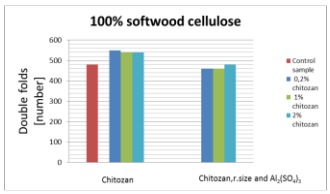

Fig.7 Research of folding strength of samples from 100% softwood pulp, containing rosin size and $Al_2(SO_4)_3$

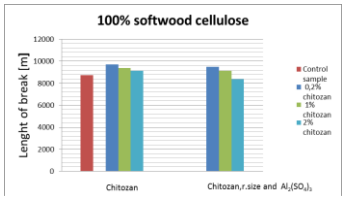

Fig.8 Research of tensile strength of samples from 100% softwood pulp, containing rosin size and $Al_2(SO_4)_3$

Addition of 0,2%, 1% and 2% chitosan exerts favorable influence on number of double folds for samples of paper from 100% softwood pulp. For this fiber composition the number of double folds increases by 14% in comparison with control sample without chitosan. This probably is connected with rise of flexibility and additional bonds between cellulose fibers.

The biggest increase of tensile strength was obtained after addition of 0, 2% chitosan (Fig.8)

For this fiber composition results are in close interval.

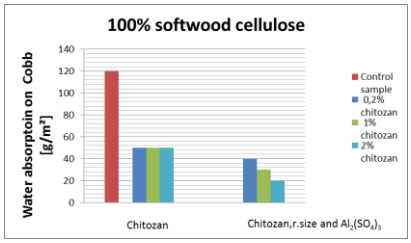

Fig.9 Research of absorption of water by Cobb method of samples from 100% softwood pulp, containing rosin size and $Al_2(SO_4)_3$

Fig.9 shows that after addition of 0, 2%, 1% and 2% chitosan absorption of water decreases by 58, 5 % in comparison with control sample without chitosan. It follows that desired effect can be reached by addition of only 0, 2% chitosan. Presence of rosin size and $Al_2(SO_4)_3$ additionally decreases ability of paper to absorb water.

4. **Samples from 100% hardwood pulp**

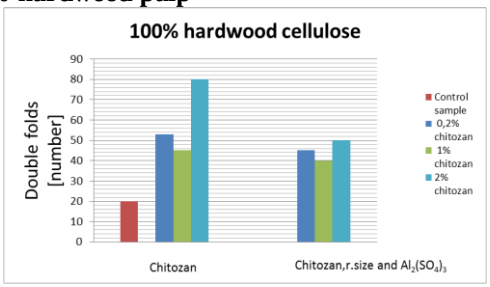

Fig.10 Research of folding resistance of samples from 100% hardwood pulp, containing rosin size and $Al_2(SO_4)_3$

Addition of 0, 2%, 1% and 2% chitosan increases number of double folds for samples of paper from 100% hardwood pulp. This can be explained by positive influence of chitosan on flexibility of pulp fibers, which are shorter and with ticker walls in comparison with fibers from softwood. The best results are recorded after addition of 2% chitosan. In this case the increase of number of double folds is by 75% in comparison with control sample without chitosan.

Fig.11 shows results after test of tensile strength for paper sheets from 100% hardwood pulp.

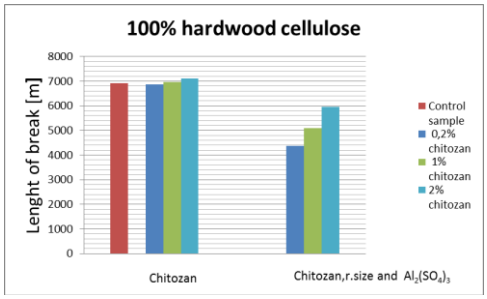

Fig.11 Research of tensile strength of samples from 100% hardwood pulp, containing rosin size and $Al_2(SO_4)_3$

There are not fundamental changes of breaking length after addition of different quantities of chitosan for this composition of paper. There are changes after addition of sizing substances.

Fig.12 shows results after test of absorption of water by Cobb method for paper sheets from 100% hardwood pulp.

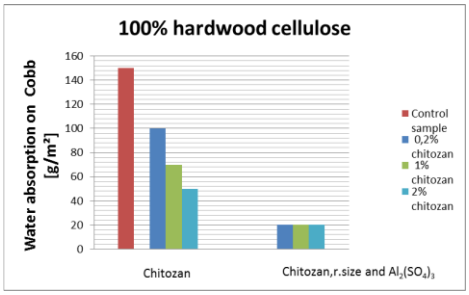

Fig.12 Research of absorption of water by Cobb method of samples from 100% hardwood pulp, containing rosin size and $Al_2(SO_4)_3$

Addition of chitosan decreases absorption of water of paper sheets from 100% hardwood pulp in comparison with control sample without chitosan. After addition of 0, 2% chitosan absorption of water decreases by 34 %. The best results are obtained after addition of 2% chitosan (67 % decreases). Addition of sizing substances additionally decreases ability of paper to absorb water by 86, 7 %.

Practically addition of chitosan does not influence the whiteness of paper. The results are the same for all tested samples of paper.

Conclusions

Addition of 0, 2%, 1% and 2% chitosan in composition of paper from bleached softwood and bleached hardwood pulp and their mixtures improves mechanical, optical and capillary hygroscopic properties.

Research of influence of chitosan on paper sheets from softwood and hardwood pulp shows that number of double folds, breaking length and elongation increase after increase of quantity of added chitosan - 0, 2%, 1% and 2%.

Tests of absorption of water by Cobb method show that chitosan decreases absorption.

For paper sheets from 100 % softwood pulp addition of 0, 2% is enough for partial hydrophobility. Addition of sizing substances and $Al_2(SO_4)_3$ after addition of chitosan additionally decreases ability of absorption of water.

For all tested composition of paper there is not a substantial change of degree of whiteness after addition of solution of chitosan and sizing substances, as results are in close boundaries.

Refernces

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