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ADSORPTION OF CATIONIC STARCH ONTO PEROXIDE BLEACHED TMP

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ABSTRACT

An investigation concerning the interactions between cationic starch and peroxide bleached thermomechanical pulp (TMP) has been carried out. The influence of electrolytes, pH, temperature, a fixing agent and charge density of the starch is discussed.

The adsorption of cationic starch onto dispersed and dissolved wood substances and unwashed fibres was reduced by an increase in NaCl concentration. The adsorption onto washed fibres, however, showed a maximum with increasing NaCl concentration. The adsorption onto dispersed and dissolved substances and unwashed fibres increased and reached a plateau level as function of increasing pH.

Onto washed fibres, the adsorption was reduced as pH was increased from 5 to 8. An increase in temperature affected only the adsorption onto washed fibres. A fixing agent retained the dispersed and disolved wood substances more effectively than the ordinary cationic starch but the amount of adsorbed cationic starch remained unaffected by the presence of the fixing agent. Cationic starch of medium charge density (degree of substitution, D.S.,: 0.035) aggregated turbid

substances more effectively than cationic starches of low charge density (D.S. 0.015) and of high charge density (D.S. 0.05).

INTRODUCTION

Mechanical pulp is used as raw material in standard newsprint grades and other printing papers (1,2). It gives the paper high bulk, good opacity, high compressibility and a high ink absorptivity (2). Moreover, it is low in cost due to the high yield (almost 100 %) as compared to chemical pulp (yield of about 60 %). One of its restrictions is the lower bonding ability of the fibres (3). It is of interest to find out whether the bonding ability can be improved by chemical means, i.e. by dry strength additives like cationic starch.

A prerequisite for a successful utilisation of dry strength additives is to know the composition of the pulp. Mechanical pulping is lignin preserving, which means that the fibres still contain lignin. Wood also contains lipophilic extractives and hemicelluloses. During mechanical processing, some of the lignin, the extractives and the hemicelluloses are dispersed/dissolved into the water (4). During peroxide bleaching, some chromophoric changes in the lignin take place as well as introduction of carboxylic acid groups into the lignin structure. The lipophilic extractives are mainly composed of fatty- and resin acids, triglycerides, steryl esters and lignans. Peroxide bleaching does not greatly affect these extractives. The hemicelluloses in thermomechanical pulps are mainly galactoglucomannans and arabinoglucoronoxylanes. In peroxide bleaching (4), some of the galactoglucomannans are deacetylated and deposited onto the fibres. Moreover, hemicelluloses rich in galacturonic acid (pectic substances) and xylose (xylans), respectively, are released into the water. The hemicelluloses rich in galacturonic acid probably account for a substantial part of the cationic demand of the dispersed and dissolved wood substances in peroxide bleached TMP suspensions (5). The main charged groups on the fibres, fines, lipophilic extractives and galacturonic acids are carboxylic acid groups (6,7,8). The mass- versus size distribution of the dispersed substances shows three fractions (9).

Potato starch is a commonly used dry strength additive. It is composed of glucose units. It also contains some phosphate ester groups which gives native starch a

slightly anionic character (1). Cationic groups, usually quaternary ammonium salts or tertiary amines, are introduced to increase its retention.

Wågberg and Kolar (10) have found that wood components in the water consume a considerable part of added cationic potato starch, which is in agreement with our results (9). In the same study (10) it was also calculated that the dissolved and colloidal substances were retained by a charge neutralisation mechanism and it was shown that cationic starch is adsorbed onto washed peroxide bleached TMP fibres by a charge compensation mechanism.

The aim of this work was, first, to clarify which substances of the peroxide bleached TMP interact with cationic starch, secondly, to find out under which conditions these interactions take place and finally, to explain the mechanisms by which cationic starch interact with TMP fibres and wood substances dispersed and dissolved in the water.

EXPERIMENTAL

Cationic starch

The cationic starches used throughout the study were potato based starches. The cationic group in these was a quaternary ammonium group which is cationic over the whole pH range (1). The starches were thermally gelatinized according to the batch process recommended by the manufacturer (11). Gelatinized starch was always used within 6 h after preparation. In this work, two methods have been used to study the adsorption of cationic starch. In some of the experiments the cationic starch in aqueous samples was degraded to glucose and detected by a gas chromatographic method (12). In the other experiments, the radioactive isotop ¹⁴C was introduced into the cationic starch was detected in aqueous samples by liquid scintillation.

Fixing agent

The fixing agent used consists of a highly charged cationic starch with low molecular weight (13).

Peroxide bleached TMP

Peroxide bleached TMP was stored in a freeze until used. The thawed pulp was preheated for 3 h at 60 °C under gentle stirring before the adsorption experiments. This was done in order to disperse and dissolve substances that may have been aggregated or/and deposited onto the fibres during freezing. Washing of peroxide bleached TMP fibres was done in a consistent manner by suspending the TMP in distilled water and dewatering it on a filter. This washing procedure was repeated ten times and removes the most loosely bound lipophilic extractives, hemicelluloses and lignin. In the experiments with a fixing agent the raw material was an unbleached TMP which was bleached in our laboratory according to the method described by Sundberg, A. et. al. (14).

Fractionation and characterization of the peroxide bleached TMP

By comparing filtrated and unfiltrated water samples separated from the peroxide bleached TMP suspension at two different centrifugal forces, $G_{av} = 850$ g and 7000 g respectively, we could draw the following conclusions:

- a) lipophilic extractives and hemicelluloses were stable to centrifugation
- b) hemicelluloses and colloidal lipophilic extractives can be separated using filtration
- c) about 20 % of the turbidity value of water samples received at 850 g was due to substances other than lipophilic extractives

Colloidal substances in TMP suspensions consist of lipophilic extractives and two kinds of fiber fragments; fibrous and plate-like microfines (15). The fibrous microfines can be separated from the lipophilic substances by ultracentrifugation. In this study, water samples containing dispersed and dissolved substances were obtained by centrifugation of the fibre suspension for 30 min. at a centrifugal force at 850 g. The samples are therefore, at least, composed of lipophilic extractives, hemicelluloses and microfines. The turbidity is caused by both colloidal lipophilic extractives and hemicelluloses was done by filtration of the samples on a 0.1 μ m filter, so filtrated samples contain mostly hemicelluloses.

Adsorption experiments and analyses

Except for the experiments with the fixing agent, all experiments were performed at room temperature and under slow agitation. Cationic starch was added to samples of the fibre suspension or to samples containing only dispersed and dissolved substances under gentle stirring with a magnetic stirrer. The samples were allowed to react with the starch during 30 min., after which they were centrifuged and the supernatant was pipetted off and analysed. Consequently, only such interactions that lead to aggregation of dispersed and dissolved substances were detected.

The experiments with fixing agents were performed in a Dynamic Drainage Jar (DDJ). The fixing agent was first added to the suspension. The reaction time for the fixing agent was 2 min after which the cationic starch was added and allowed to react 5 min before dewatering in the DDJ. The filtrate was collected and centrifuged in order to remove unretained fibres and the supernatant was pipetted off and analysed.

Lipophilic extractives in the supernatants were analyzed by a gas chromatographic method (16) and carbohydrates also by a gas chromatographic method (12). UV-lignin (16) and turbidity were measured with a spectrophotometer. The adsorbed amount of cationic starch was measured by the indirect method (17).

RESULTS AND DISCUSSION

Interactions between cationic starch and dispersed and dissolved wood substances

Analysis of changes in concentrations of carbohydrates upon addition of cationic starch showed that aggregation of pectic substances with cationic starch takes place. Minor changes in the concentration of other carbohydrates, such as xylos, was also observed. The aggregation of pectic substances was, however, most evident. No remarkable influence of cationic starch on UV-lignin could be observed. Considerable structural changes in the pectic substances upon treatment with different chemicals have been reported (8,18,19). General theories for polyelectrolytes must therefore be implemented with caution.

Pectic substances were aggregated with cationic starch at a $CaCl_2$ concentration of 0.0001 M. The aggregated amount was still higher at a higher $CaCl_2$ concentration (0.001 M). (Figure 1). The result was confirmed by a higher adsorbed amount of cationic starch onto the filtrated sample at the higher $CaCl_2$ concentration. (Figure 2). Specific interactions between pectic substances and calcium ions giving rise to so called calcium pectates/pectinates can take place (8,19). With regard to this, the increase in aggregation can be a result of interactions between cationic starch and calcium pectates/pectinates.



Figure 1. Residual concentration of galacturonic acid as function of added starch onto a filtrated water sample at CaCl, concentrations of 0.0001 M and 0.001 M, respectively. (fibre conc. 5 g/L, 20 °C, pH 5, cationic starch: D.S. 0.035)



Figure 2. Adsorption of cationic starch onto a filtrated water sample at $CaCl_2$ concentrations of 0.0001 M and 0.001 M, respectively. (fibre conc. 5 g/L, 20 °C, pH 5, cationic starch: D.S. 0.035).

In a previous work (20) we have studied the influence of NaCl and found that the aggregation of pectic substances with cationic starch was reduced as the NaCl concentration was increased from 0.0001 M to 0.1 M.

The pectic substances were aggregated less by cationic starch at pH 9 than at pH 5 (Figure 3), which was confirmed by a higher adsorbed amount of starch onto the filtrated sample at pH 5 (Figure 4). This is quite surprising, since the dissociation of carboxylic acid groups on polygalacturonic acid increases with increasing pH (18) and dissociation of carboxylic acid groups promote interactions of an electrostatic nature. Again, this unexpected result may be explained by structural changes in the pectic substances. Results by Cesaro et al (18) show that some intramolecular conformational transition takes place in polygalacturonic acid upon titration with HCl. The formation of real aggregates is however uncertain. It is also believed that the "superstructure" of pectic substances, possibly made up of hydrogen bonds between intramolecular carboxyl grups, is affected by alkali (8). It is therefore possible that structural changes in the pectic substances at higher pH were responsible for the decrease in aggregation by cationic starch.



Figure 3. Aggregated amounts of galacturonic acid as function of added cationic starch in a filtrated water sample at pH 5 and pH 9 (fibre conc. 5 g/L, 20 $^{\circ}$ C, 10⁴ M NaCl, cationic starch: D.S. 0.035)



Figure 4. Adsorption of cationic starch onto a filtrated water sample at pH 9 and pH 5. (fibre conc. 5 g/L, 20 $^{\circ}$ C, 10⁻⁴ M NaCl, cationic starch: D.S. 0.035, added amount 62.5 mg/g fibre)

The adsorption of cationic starch onto all dispersed and dissolved substances was studied at different concentrations of NaCl at pH 8. At the plateau level of adsorption (maximum adsorption level), the adsorbed amount decreased as function of increased NaCl concentration (Figure 5). This behaviour can be expected from purely electrostatically interacting substances (21) and is due to screening of adsorption sites. With regard to this, the result suggests that the dominating interaction between cationic starch and dispersed and dissolved substances was of an electrostatic nature.



Figure 5. Adsorption of starch onto a water sample at the plateau level of adsorption (added amount 62.5 mg/g fibre) as function of NaCl concentration (fibre conc. 5 g/L, pH 8, temperature 20 °C, cationic starch: D.S. 0.037)

The flocculation rate of turbid substances increased at increasing ionic strengths. This can be explained by a compression of the electrostatic double layers due to the increased concentration of counter ions.

The flocculation of turbid substances was studied for three different cationic charge densities, D.S. 0.015, 0.035 and 0.05. The starch with medium charge density had the highest flocculation efficiency (Figure 6). Further study is needed to explain this result.



Figure 6. Flocculation of turbid substances in a water sample as function of added amount of cationic starch with D.S. 0.015, 0.035 and 0.05, respectively. (fibre conc. 5 g/L, pH 5, temperature 20 °C)



Figure 7. Adsorption of cationic starch onto a water sample at pH 5, 8, and 9, respectively. (fibre conc. 5 g/L, temperature 20 °C, cationic starch: D.S. 0.037)

The interaction between cationic starch and all the dispersed and dissolved substances was studied at different pH values. The adsorbed amount of starch was higher at pH 8 than at pH 5 (Figure 7), which may be explained by the deprotonization of carboxylic acid groups.

As follows, the decrease in flocculation rate of turbid substances observed upon an increase in pH from 5 to 8 (Figure 8) may be explained by the extension of the electrostatic double layer due to deprotonization of carboxylic acid groups.



Figure 8. Flocculation of turbid substances in a water sample as function of added amount of cationic starch at pH 5, 8 and 9, respectively. (fibre conc. 5 g/L, temperature 20 $^{\circ}$ C, cationic starch: D.S. 0.037)

However, at pH 9 the adsorbed amount was about the same as at pH 8 (Figure 7). and the flocculation rate of turbid substances was even lower than at pH 8 (Figure 8). This result can be explained by the behaviour of the resin acids. Resin acids were found to become released from the dispersed colloidal resin (and the fibres) when pH was increased, as shown in figure 9, and thereby the charge density of the dispersed colloidal droplets was reduced. A detailed study of the behaviour of resin acids upon addition of cationic starch at different pH values is presented in figure 10 and shows that dissolved resin acids were not aggregated by cationic starch. The dissolution of resin acids in mechanical pulp suspensions is probably due to saponification in alkaline conditions (22).



Figure 9. Concentration of resin acids in water samples and filtrated water samples at pH 5, 7 and 9, (temperature 20 $^{\circ}$ C, fibre conc. 5 g/L).



Figure 10. Flocculation of resin acids in a water sample as function of added amounts of cationic starch at pH 5, 7 and 9, respectively. (fibre conc. 5 g/L, temperature 20 $^{\circ}$ C, cationic starch: D.S. 0.035)

The influence of temperature on the adsorption of cationic starch on the dispersed and dissolved substances was studied. The adsorbed amount was reduced by an increase in temperature (Figure 11). The reason for this is unknown.



Figure 11. Adsorption of cationic starch onto a water sample at temperatures of 20, 40 and 60 °C, respectively. (fibre conc. 5 g/L, pH 8, cationic starch: D.S. 0.037)

The fixing agent retained wood substances more effectively than the cationic starch (Figures 12 and 13). Since the fixing agent was a cationic starch with lower molecular weight and a higher charge density than the ordinary cationic starch, this indicates that a reduction in molecular weight and/or an increase in charge density promote the interaction with dispersed substances. The adsorbed amount of the ordinary cationic starch was not influenced by the action of the fixing agent (Figure 14).



Figure 12. Residual concentration of lipophilic extractives upon addition of a fixing agent and cationic starch, respectively, to an unwashed fibre suspension. (DDJ experiment, fibre conc. 10 g/L, pH 5, temperature 60 $^{\circ}$ C, cationic starch: D.S. 0.035)



Figure 13. Residual concentration of galacturonic acids upon addition of a fixing agent and cationic starch, respectively, to an unwashed fibre suspension. (DDJ experiment, fibre conc. 10 g/L, pH 5, temperature 60 °C, cationic starch: D.S. 0.035)



Figure 14. Adsorption of cationic starch onto an unwashed fibre suspension in the presence and absence of a fixing agent. (DDJ experiment, fibre conc. 10 g/L. pH 5, temperature 60 °C, cationic starch: D.S. 0.035)

Interactions between cationic starch and TMP fibres

The adsorption of cationic starch in the fibre suspension was studied at different NaCl concentrations (0.0001- 0.1 M) at pH 8. Interestingly, the adsorbed amount of cationic starch at the plateau level adsorption was relatively unaffected by an increase in NaCl concentration from 0.0001 M to 0.001 M (Figure 15). In order to clarify whether this was due to the fibres, adsorption studies were also made with washed peroxide bleached TMP fibres. Onto these, the adsorbed amount of cationic starch even increased up to a NaCl concentration of 0.01 M (Figure 16). A resent theory for polyelectrolyte adsorption predicts that an increase in adsorption upon increasing the ionic strength only shows up when some non-electrostatic interaction with the surface is present (21). With regard to this, the increase in adsorption of the cationic starch onto washed fibres as function of increasing NaCl concentration clearly shows the presence of non-electrostatic interaction. The following decrease in adsorption is probably due to specific adsorption of counter ions onto e.g. resin acids on the fibres. This behaviour is in accordance with theories for ion competition (21, 23). Further, a comparison between the washed and the unwashed pulp shows that the contribution of non-electrostatic interactions

to the total interaction is higher for the washed fibres. This is due to the removal of charges, i.e. dissolved and dispersed substances, from the water and from the fibre surfaces by washing the TMP. As shown in the previous chapter, the interaction between these substances and cationic starch was electrostatic in nature. Therefore, the non-electrostatic interaction was more clearly exposed after that the concentration of them was decreased.



Figure 15. Adsorbed amount of cationic starch onto an unwashed fibre suspension at the plateau level (added amount 62.5 mg/g fibre) as function of electrolyte concentration (fibre conc. 5 g/L, pH 8, temperature 20 °C, cationic starch: D.S. 0.037)



Figure 16. Adsorbed amount of cationic starch onto washed fibres at the plateau level (added amount 62.5 mg/g fibre) as function of electrolyte concentration (fibre conc. 5 g/L, pH 8, temperature 20 °C, cationic starch: D.S. 0.037)

The influence of temperature on the adsorption of cationic starch in the peroxide bleached TMP suspension is shown in figure 17. The adsorbed amount of cationic starch was higher at higher temperatures. Moreover, the relative increase in adsorbed amount as temperature was raised from 20 to 60 °C was considerably higher for washed fibres than for the unwashed pulp (Figure 18). Considering that the adsorption of cationic starch onto the dispersed and dissolved substances was reduced by an increase in temperature it can be concluded that the increase in adsorption resulted from specific (non-electrostatic) interactions between cationic starch and TMP fibres.



Figure 17. Adsorption of cationic starch onto an unwashed fibre suspension at temperatures 20,40 and 60 °C, respectively. (fibre conc. 5 g/L, pH 8, cationic starch: D.S. 0.037)



Figure 18. Relative influence of the temperature on the adsorption of cationic starch (D.S. 0.037) onto the washed and unwashed fibre suspension

The influence of pH on the adsorbed amount of cationic starch onto peroxide bleached TMP is shown in figure 19. The adsorbed amount of cationic starch was higher at pH 8 than at pH 5. Between pH 8 and pH 9 there was no increase in adsorbed amount. This result is in agreement with that for the dispersed and dissolved substances.



Figure 19. Adsorption of cationic starch onto an unwashed fibre suspension at pH 5 and 8, respectively. (fibre conc. 5 g/L, 20 °C, cationic starch: D.S. 0.037)

For washed fibres, however, the adsorbed amount was higher at pH 5 than at pH 8 (Figure 20). By reducing the pH from 8 to 5 the carboxyl groups become more protonized. For the washed fibres, the contribution from non-electrostatic interactions to total interaction was high enough to show the increase in adsorption at pH 5. The result is in agreement with theoretical calculations by van de Steeg and coworkers (21) which predict that a reduction in surface charge density can mean a shift from the screening-reduced regime to the screening-enhanced regime, i.e. an increase in the ratio non-electrostatic : total interactions. In practise, the result shows that hydroxyl groups are involved in the non-electrostatic interactions. The results also indicate that washed peroxide bleached TMP fibres are different from bleached chemical fibres, which constantly adsorb more cationic starch as pH is increased (24).



Figure 20. Adsorption of cationic starch onto washed fibres at pH 5 and 8, respectively. (fibre conc. 5 g/L, 20 °C, cationic starch: D.S. 0.037)

CONCLUSIONS

The results show that cationic starch interacted with turbid substances, pectic substances and fibres. The adsorption mechanism was different for different substances. The results indicate that the dominating interaction between cationic starch and dispersed and dissolved substances is electrostatic, while the interaction between cationic starch and TMP fibres is both non-electrostatic and electrostatic. The extent of the electrostatic interaction between the fibres and cationic starch was dependent on the concentration of dispersed and dissolved substances on the fibres and was diminished as the concentration of these was reduced. Among the dispersed and dissolved substances, especially the pectic substances and the resin acids seemed to have a pronounced influence on the adsorption of cationic starch. Saponified resin acids were not aggregated by the starch. The interaction between pectic substances and cationic starch in a filtrated sample was promoted by a low pH value and the presence of Ca^{2+} ions. The adsorption of cationic starch onto pectic substances in a filtrated sample was considerable, but further study need to be carried out to evaluate the influence of these in the presence of other interacting substances.

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REFERENCES

- 1. Eklund, D., Lindström, T.: in Paper Chemistry an Introduction: DT Paper Science Publications: Grankulla, Finland: 1991
- 2. Leask, R.A.: in Pulp and Paper Manufacture, volume 2: Mechanical Pulping: edited by R.A. Leask and M.J. Kocurek: 1-17: 1987
- Nordman, L., in Pulp and Paper Manufacture, volume 2: Mechanical Pulping: edited by R.A. Leask and M.J. Kocurek: 272-281: 1987

- Holmbom, B., Ekman, R., Sjöholm, R., Eckerman, C., Thornton, J.: Chemical Changes in Peroxide bleaching of Mechanical Pulps: das Papier: 45(10A): V16-V 22: 1991
- Thornton, J., Ekman, R., Holmbom, B., Eckerman, C.: Release of potential "anionic trash" in peroxide bleaching of mechanical pulp: Paper and Timber: 75(6): 426-431: 1993
- Sjöström, E.: The origin of charge on cellulosic fibers: 1:st Int. Paper Chemistry Symposium: Stockholm: 1988
- 7. Back, E.L.: Fysikalisk-kemiska aspekter på hartsproblem: Svensk Papperstidning 72(6): 182-189: 1969
- Keretesz, Z.I.: The pectic substances: Interscience publishers inc.: New York: 1951
- Bobacka, V. and Eklund, D.: Der Einfluss anionisher Störsubstanzen auf die Adsorption von kationischer Stärke an thermomechanische Fasern: Wochenblatt für Papierfabrikation: 124 (3): 106-109: 1996
- Wågberg, L., Kolar, K.: Adsorption of Cationic Starch on Fibres from Mechanical Pulps: Berichte Bunsengesellschaft für Physikalische Chemie: 100 (6): 984-993: 1996
- 11. Raisio Chemicals Oy: Osa Suomalaista Paperia: Product specification of Raisamyl starches: pamphlet
- 12. Eckerman, C., Ekman, R.: Report B4-90 at the Laboratory of Forest Products Chemistry, Åbo Akademi University: 1990
- 13. Vihervaara, T., Paakkanen, M.: Raifix new cationic polymers for controlling wet-end chemistry: Paper and Timber: 74(8): 631-633: 1992
- Sundberg, A., Ekman, R., Holmbom, B., Grönfors, H.: Interactions of Cationic Polymers with Components in Thermomechanical Pulp Suspensions: Paper and Timber: 76(9):593-598: 1994
- 15. Nylund, J., Lagus, O., Eckerman, C.: Character of colloidal substances in a mechanical pulp suspension: Colloids and Surfaces A: Physiochemical and Engineering Aspects: 85: 81-87: 1994
- Örså, F., Holmborn, B.: A convenient method for the determination of wood extractives in papermaking waters and effluents: JPPS: 20(12): 361-366: 1994
- Fleer, G.J., Cohen Stuart, M.A., Scheutjens, J.M.H.M., Cosgrove, T., Vincent, B.: Experimental methods: in Polymers at interfaces: 1st ed.: Chapman & Hall: 49: 1993

- Cesaro, A., Delben, F., Paoletti, S.: Thermodynamics of the proton dissociation of natural polyuronic acids: Int. J. Macromol.: 12(3): 170-176: 1990
- Aspinall, G.O.: in The Carbohydrates: 2nd ed. by Academic Press: 515-521: 1970
- Bobacka, V., Näsman, J., Eklund, D.: Influence of electrolytes on the adsorption of cationic starch onto peroxide bleached TMP: Preprint, 1996 International Paper and Coating Chemistry Symposium: Ottawa 10-13/6 1996
- van de Steeg, H.G.M., Cohen Stuart, M.A., de Keizer, A., Bijsterbosch,
 B.H.: Polyelectrolyte Adsorption: A subtle balance of Forces: Langmuir 8(10): 2538-2546: 1992
- Ekman, R., Eckerman, C., Holmbom, B.: Studies of the behaviour of extractives in mechanical pulp suspensions: Nordic Pulp and Paper Res. J.: 5(2): 96-102: 1990
- Fleer, G.J., Cohen Stuart, M.A., Scheutjens, J.M.H.M., Cosgrove, T., Vincent, B.: Electrostatic effects: in Polymers at interfaces: 1st ed.: Chapman & Hall: 346-368: 1993
- 24. Hedborg, F., Lindström, T.: Adsorption of cationic starch onto bleached softwood cellulosic fibres: Nordic Pulp and Paper Res. J.: 8(2): 258-263

Transcription of Discussion

Adsorption of Cationic Starch onto Peroxide Bleached TMP

Dr Veronica Bobacka, Consultant, University of Abo Akademi, Finland

William Scott, Chair, Miami University, USA

Sometimes I've heard that when you make a solution of starch you don't end up with a true molecular solution but with aggregates of starch molecules. Do you have any evidence for that in your work or know anything about that?

Veronica Bobacka

We heated the starch solution according to a procedure recommended by the manufacturer and that should dissolve it. There might of course be some aggregates but I am not aware of the influence of those.

Professor Per Stenius, Helsinki University of Technology, Finland

The adsorption would be quite dependent on the degree of substitution of the starch. Have you any idea of the charge density of the starch?

Veronica Bobacka

The degree of substitution was 0.035 so it is a medium cationic starch. Indeed, it will have great influence on the adsorption and the flocculation.

Dr Richard Bown, Research & Technology Director, ECC, UK

On the subject of the adsorption of the starch have you any idea why the sensitivity to temperature is as it is, why it should increase when the temperature goes up? I would have expected it to be the other way round.

Veronica Bobacka

It might be that the flexibility of the chain increases, therefore it might come closer to the surface. Another thing is that the diffusion of this starch might well increase and I think that will affect collisions between small cationic starch molecules and large fibres.

Dr Theo van de Ven, Director, Paprican/McGill, Canada

Do you think that some of your starch adsorbs inside the fibre wall? If you look at the amount absorbed per gramme the figure is rather high.

Veronica Bobacka

Yes, this is a very interesting point. I don't think we have evidence as to whether it absorbs on the internal or the external sites of the surfaces but I think since we have pores it might also be possible that it will diffuse into the fibres in some amount.