Influence of deep eutectic solvent on structure and behaviour of wood based cellulose fibres

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INTRODUCTION

Deep eutectic solvent (DES) composed of choline chloride (ChCl) and urea can be used as a swelling agent and rheological modifier for wood based cellulose fibres. It has been shown that this particular mixture has an ability to disperse pulp fibres, leading to the formation of a gel-like suspension. Therefore, as we have previously demonstrated, the utilization of DES enables fibre yarn manufacturing directly from dried pulp without altering the original crystalline structure of cellulose I. (Tenhunen et al. 2016, Hakalahti et al. 2015).

In this work, the influence of DES on the surface structure of cellulose fibres and swelling behaviour was examined. Cellulose fibres from different stages of DES treatment procedure were investigated using AFM, TEM, FiberLab, QCM-D and XPS in order to reveal the systematic information on e.g. swelling ability of DES. These findings can be regarded relevant when considering efficient utilization of novel solvent systems for cellulosic materials to be exploited for example in composite and textile applications.

RESULTS

FiberLab detects changes in fibre fibrillation

Carbohydrate analysis show no dissolution of hemicelluloses

Hypothesis about dissolution of hemicelluloses during DES treatment has been presented in order to partially explain the effects of DES on cellulose (Sirviö et al. 2014). Carbohydrate analysis was done using acid hydrolysis following the analysis of monosaccharides by HPLC (Tenkanen et al. 2000). According to the preliminary carbohydrate analysis, DES does not dissolve hemicelluloses. In addition, XPS analysis indicated that surface chemical composition remained unaltered during the DES treatment procedure.

AFM images did not indicate significant changes on fibre surface

AFM (Nanoscope Illa Multimode scanning probe microscope, Digital Instruments Inc., Santa Barbara, CA, USA) was used to study the surface morphology. Reference sample (A) and DES treated sample (B) did not indicate any significant differences. The typical granular structure previously observed for Cellulose II and amorphous cellulose induced by mercerization (C) (Eronen et al. 2009) was not observed for DES treated samples further supporting that change in crystallinity is not occurring.

SEM images suggest increased fibrillation and peeling of S1 layer

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CONCLUSIONS

- DES composed of choline chloride and urea appears to have an mild effect on fibres, but not by dissolution.
- Choline chloride and urea DES does not dissolve hemicelluloses
- DES appears to enhance fibrillation on fibre surface by partially peeling off the S1 layer
- Increased fibrillation on the fibre surface may facilitate the yarn formation

References:

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