Wetting and tensile deformation of single spruce wood fibres followed by Raman microscopy

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ABSTRACT

To meet the natural demands of a tree, wood tissues are formed in various ways with different anatomical, chemical and physical characteristics and as a result wood properties differ widely. To gain insights at a molecular level during tensing and wetting, Raman spectra are acquired *in situ*. Molecular changes are monitored by following changes in Raman bands attributed to characteristic functional groups of the wood polymers. In a normal dry spruce wood fibre the band at 1095 cm^{-1}, corresponding to the stretching of cellulose (C-O-C), is shifted during tensing linear towards shorter wavenumbers (-8 cm^{-1}), demonstrating that the cellulose molecule is subjected to a uniform stress deformation [1-2].

Juvenile wood is less stiff and has a higher microfibril angle and the stress strain curves show clear differences in the dry and wet state. Wetting the fibre under tension (30mN), the load on the fibre and cellulose molecule is relieved, as seen in a drop in the force as well as in the shift of the 1095cm^{-1} band back to initial values (Fig. 1A). The continued force-elongation curve in the wet state is less steep and the 1095cm^{-1} band correspondingly. A second stop at 60 mN leads to a relaxation (drop in force), but the load on the cellulose (1095cm^{-1}) is constant and at the end slightly increasing. Ongoing tensing leads again to a stiffening and an increased stretching of the cellulose, followed by slipping and finally rupturing (Fig. 1A).

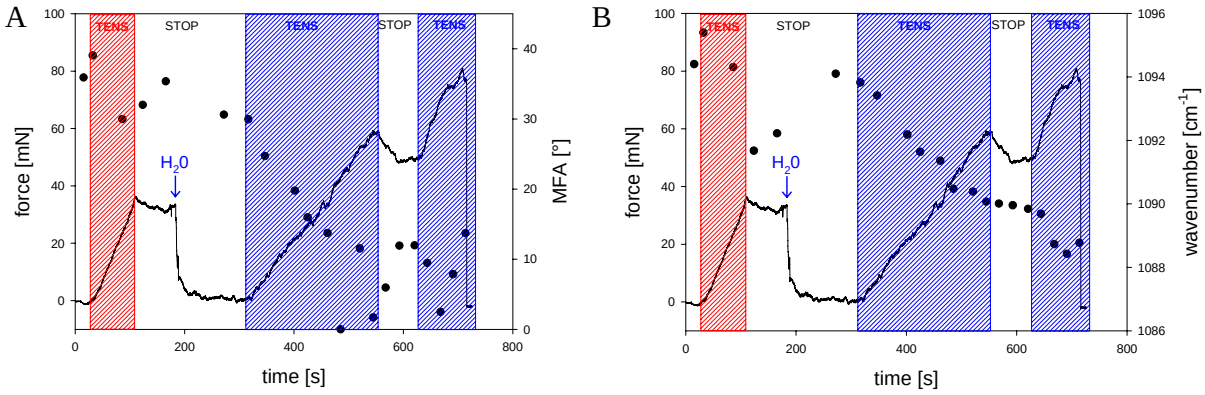

Figure 1: Changes in force (black line) and A) the load on the cellulose molecule by plotting the position of the 1095cm-1 band (black dots) and. B) change in orientation of the cellulose microfibril (microfibril angle MFA, black dots) during tensing and wetting of a dry single spruce juvenile wood fibre.

From the band characteristics also conclusions on the cellulose microfibril orientation can be drawn [3]. Plotting the microfibril orientation changes during wetting suggests a straightening of the crystalline cellulose chains by swelling of amorphous components (Fig. 1B). During tensing in the wet stage further reorientation was seen (Fig. 1B).

References

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