Strength and Water Interactions of Cellulose I Filaments Wet-Spun from Cellulose Nanofibril Hydrogels

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Hydrogels comprising cellulose nanofibrils (CNF) can be used in the synthesis of continuous, renewable filaments via wet-spinning as demonstrated earlier.[1-4] However, understanding has been limited concerning the effects determining the spinnability of CNF and the interactions of the ensuing filaments with water. In this study, hydrogel viscosity and spinnability, as well as orientation and strength of the spun filaments, were found to be strongly affected by the osmotic pressure as determined by CNF surface charge and solid fraction in the spinning dope. The strength of filaments with a 83% degree of orientation as shown by wide-angle X-ray scattering (WAXS) reached remarkable values, as high as 297 MPa and 21 GPa for the tensile strength and Young's modulus, respectively. A thorough investigation of the interactions with water using dynamic vapour sorption (DVS) measurements revealed the role of sorption sites in the stability of the filaments in wet conditions. DVS analysis during cycles of relative humidity (RH) between 0 and 95% revealed major differences in water uptake by the filaments spun from alternative types of hydrogels. It is concluded that the mechanical performance of filaments in the

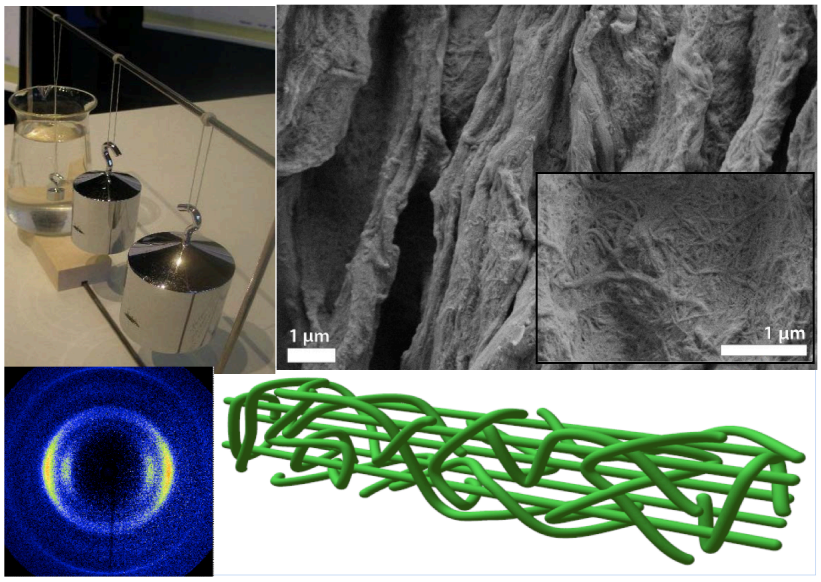

Figure 1. Left, top: Bundles of CNF filaments holding probing weights. Right, top: SEM micrographs of filament surface. Left, bottom: X-ray diffractogram of a filament. Right, bottom: graphical representation of the arrangement of CNF in the filament.

presence of water deteriorates drastically by the same factors that facilitate fibril alignment (WAXS) and, consequently, dry strength. For the most oriented filaments, the maximum water sorption (RH 95%) was 39% and degree of hornification 9%.

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