Institut für Physik
Montanuniversität Leoben

A-8700 LEOBEN, Franz Josef Straße 18, Austria
Tel: +43 3842 402-4601, Fax:+43 3842 402-4602
e-mail: physics@unileoben.ac.at

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Micromechanical characterization of wood pulp fibers

Dr. Caterina Czibula[1-3]

[1] *Institute of Bioproducts and Paper Technology, Graz University of Technology, Austria*
[2] *Institute of Physics, Montanuniversitaet Leoben, Austria*
[3] *Christian Doppler Laboratory of Fiber Swelling and Paper Performance, Graz University of Technology, Austria*

Wood pulp fibers are extensively used in paper and textile industries, but structure-property relations on the fiber scale are quite complicated and not yet fully understood. Changes in moisture content of single fibers have a strong impact on the physical properties and performance of paper. Since the fiber cell wall consists of different layers which differ in thickness, chemical composition, and alignment of cellulose microfibrils, wood pulp fibers have anisotropic properties. The S2 layer is the thickest layer, and there the cellulose microfibrils arrange close to the long fiber axis. Therefore, this layer dominates the mechanical behavior of the fibers, especially in longitudinal direction [1,2].

To mechanically characterize wood pulp fibers in different directions, atomic force microscopy-based nanoindentation (AFM-NI) methods have been applied. In AFM-based mechanical characterization, a probe tip is in contact with the surface of the wood pulp fiber. By controlling the force, the indentation depth over time is recorded. These experiments are performed at varying relative humidity (RH) levels. By inducing plastic deformation of the surface with the AFM tip, values for the indentation modulus M and the hardness H can be obtained similar to common procedures in conventional nanoindentation. Furthermore, local creep curves can be recorded and by combining adhesive contact mechanics and empiric spring-dashpot models, the viscoelastic properties of the wood pulp fiber can be characterized at a low frequency range (10^{-3}–1 Hz) [3]. The evaluation of the experimental data combines contact mechanics and viscoelastic models which consist of springs and dashpots in series or parallel describing elastic and viscous behavior, respectively [4].

Here, it will be demonstrated that the so-called Generalized Maxwell model (GM) yields reasonable results for single fibers in transversal and longitudinal direction. The influence of RH as well as the difference in viscoelastic behavior for the two main fiber directions will be discussed. With increasing RH, the elastic and viscous parameters decrease in both directions.

1. Salmén, L. Wood Cell Wall Structure and Organisation in Relation to Mechanics. In *Plant Biomechanics*; Geitmann, A., Gril, J., Eds.; Springer: Cham, 2018; pp. 3–19.
2. Gibson, L.J. The hierarchical structure and mechanics of plant materials. *J. R. Soc. Interface* **2012**, *9*, pp 2749-2766.
3. Czibula, C.; Ganser, C.; Seidlhofer, T.; Teichert, C.; Hirn, U. Transverse viscoelastic properties of pulp fibers investigated with an atomic force microscopy method. *J. Mater. Sci.* **2019**, *54*, 11448–11461.
4. Ganser, C.; Czibula, C.; Tscharnuter, D.; Schöberl, T.; Teichert, C.; Hirn, U. Combining adhesive contact mechanics with a viscoelastic material model to probe local material properties by AFM. *Soft Matter* **2018**, *14*, 140–150.