Cellulose-Nanofibrils for Polymer Reinforcement

EMPA

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Objective: From Wood to Nanofibrils

Wood is a material perfectly adapted to the functions it has to fulfill. It combines high strength and elasticity at very low weight. Responsible for its extraordinary properties is the composite structure of its cell walls (Fig. 1). They consist of tensile strong cellulose fibrils which are embedded in a rigid lignin matrix – functionality that we strive for in synthetic materials too! If it is possible to transfer this composite principle and embed cellulose fibrils or threads from wooden cell walls in a polymer matrix, a functional and sustainable material should emerge, which could be used in a wide range of technical applications.

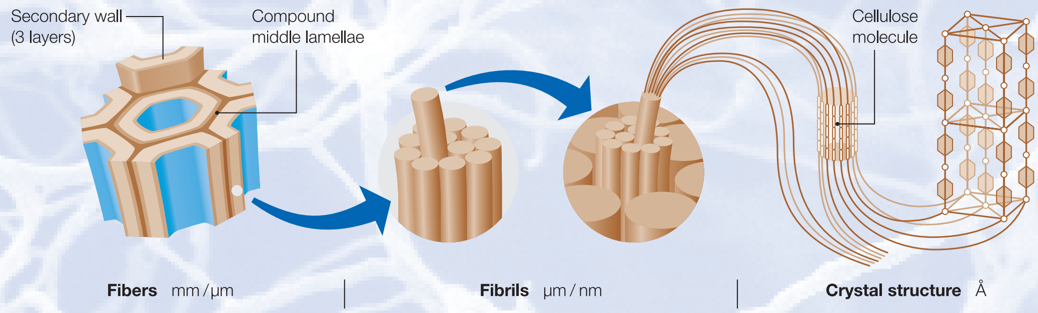

Figure 1: *Structure of a wood cell wall*

Methods & Results: Production of Nanofibrils and Composites

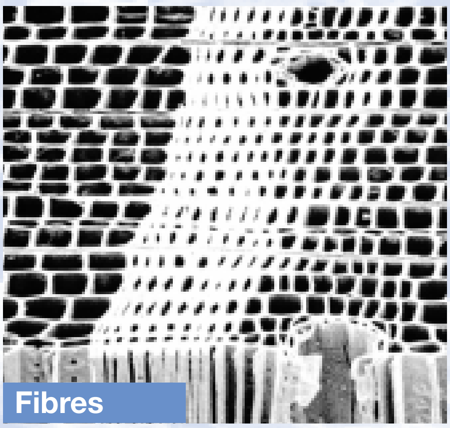

Figure 2: *FE-SEM micrograph: Picea abies, cross section and radial section*

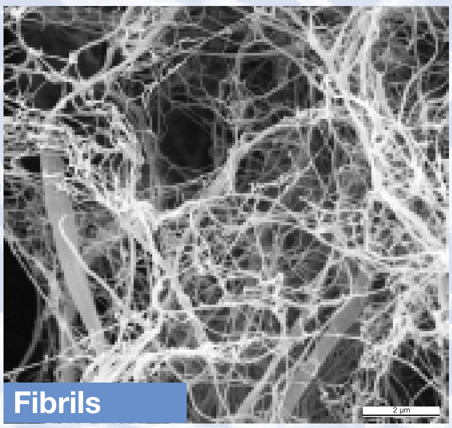

Figure 3: *FE-SEM micrograph: A fibril network of single traces with thickness' in the nanometer and lengths in the micrometer range becomes visible.*

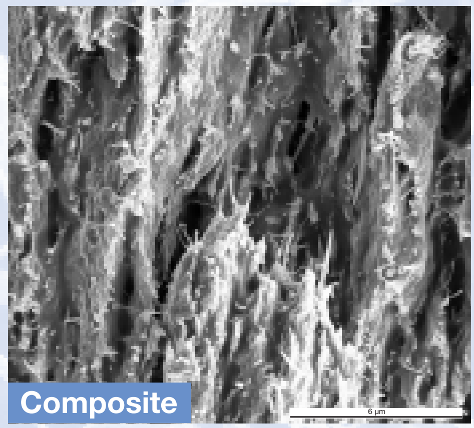

Figure 4: *FE-SEM micrograph: Tensile fracture surface of hydroxypropyl cellulose with a proportion of 20% of fibrils.*

The wood structure of softwood is composed to 90% of tracheids (Fig. 2). These are the basic fibers of sulphite pulp, which serves as raw material to separate cellulose fibrilar structures.

By a combination of chemical and/or mechanical processes cellulose fibrils with diameters between 20 and 100 nm can be isolated (Fig. 3). According to the isolation process, the fineness of the fibrils varies.

After the isolation process, the obtained cellulose fibrils were embedded into the water soluble polymer hydroxypropyl cellulose (Fig. 4).

Results: Nanofibrils reinforce Polymers

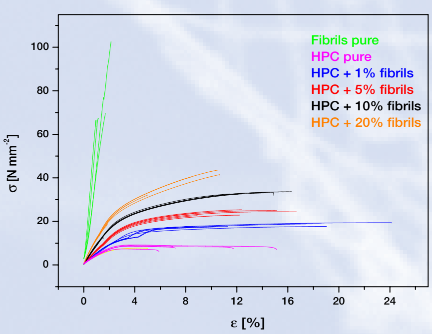

Figure 5: *Stress/strain characteristics of samples of mechanically solubilized cellulose fibrils, hydroxypropyl cellulose polymer (HPC) and composite materials containing varying proportions of fibrils.*

Strength tests show that as the proportion of fibrils raise the tensile strength of the composite increases (Fig. 5). Even though the fibrils are oriented at random in the matrix material, tensile strength arises by a factor of five compared to the unfilled polymer. Pure films of cellulose fibrils are reaching almost the strength properties of clear wood.

Outlook

Application areas of fibril reinforced biopolymers are conceivable where biodegradability and at the same time a high strength and visual transparency are required. Further, the fibrils could be used in adhesives (e.g. instead of synthetic fibres) to improve systematically their application and exploitation as well as thermal creep.

In next steps, larger quantities of cellulose fibrils will be produced and the embedding process into different polymers will be optimised.

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