ESRF	**Experiment title:** The arrangementof the elementary cellulose fibrils in a single native wood cell	**Experiment number**: LS-348
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Report:

Wood is a cellular material composed of parallel hollow tubes (the wood cells) with walls made of a composite of cellulose fibrils and a lignin/hemicellulose matrix. The outstanding mechanical properties of this material depend to a large extend on the structure and relative arrangement of these components. To investigate the relation between structure and mechanical properties, we are using sprucewood as a model system because it has a relatively simple anatomy with 95% of all cells being tracheids.

From previous measurements with Small-Angle X-ray Scattering (using a conventional point x-ray source) we know that the diameter of the elementary cellulose fibrils is constant (and roughly equal to 2.5 nm) throughout the year-rings of a stem and also between different trees (1). Moreover, the fibrils were found to spiral around the cell axis with an angle that depends strongly on the mechanical function of the cell. Indeed, this angle is different in early- and in latewood (2), as well as in branches (3) on the upper and lower side (which are typically under tension and compression, respectively). The main drawback of the approach using conventional sources is that the x-ray beam hits many cells at the same time which blurs the image. Hence, beamtime was applied for at the ESRF microfocus beamline.

The experiment at ESRF was started to try to elucidate whether the fibrils are spiralling only with one given angle α or with $+\alpha$ and $-\alpha$. Indeed, this question is of primary

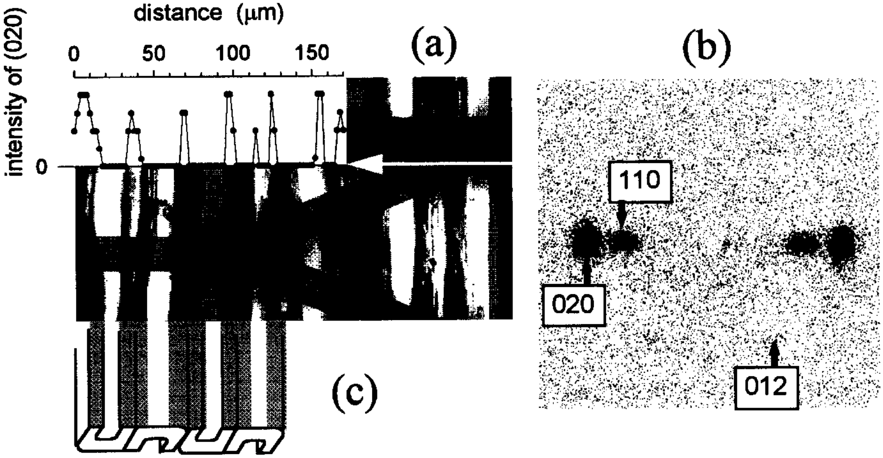

Fig. **1: (a)** Light microscopic image of a **10μm** thick section of spruce latewood. Scattering spectra were obtained every **2μm** along the line shown by arrow. The measured intensity of the cellulose (020) reflection is shown as a function of position in the insert. The vertical stripes correspond to successive wood cells (shown schematically in perspective in (c)). The other stripes are the shadow of an electron microscopy (copper) grid fixed onto the specimen to define a coordinate system. (b) shows a typical x-ray scattering spectrum from cellulose at a position where the (020) intensity is high.

importance for understanding the mechanical properties of wood cells under tension. For this purpose, we have prepared **10μm** thick sections, so that only individual cell walls would be present in the specimen (the cells having a diameter of **20-40μm,** see Fig. 1). Unfortunately, using a very fine x-ray beam with **2μm** diameter (defined by a capillary), it was technically not possible at the time of the experiment to collect small-angle scattering patterns, which would have made the decision about fibril directions straightforward.

Consequently, we focussed on the wide-angle patterns which give the orientation of the cellulose crystal lattice inside the fibril (instead of the orientation of the fibrils themselves). The extremely striking result is shown in Fig. 1 for one of the specimens. The Bragg-reflections turned out to be extremely narrow (in contrast to similar measurements using a wide beam) and the intensity of the strongest reflection (the (020)-reflection of cellulose I) varied according to the orientation of the cell wall with respect to the beam. This may be indicating that cellulose has a well-defined crystallographic orientation with respect to the cell wall surface, a result that would have immediate implications for the understanding of how cell walls grow. To ascertain this finding, texture measurements on single cell walls will be necessary. Work supported by FWF Grant P10729-BIO.

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