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Flax fiber cell walls characterization by Peak-Force Quantitative Nano Mechanics technology

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The industrial interest for vegetal bast fibers used as composite materials reinforcements increases. This tendency is explained by their low impact on the environment and their very interesting specific mechanical properties [1] which make them attractive for transported applications. The tensile properties of the elementary fibers are well described in the literature [2], but additional information at the cell wall scale is needed to better understand the relationship between their ultrastructure and their mechanical performance. The aim of this work is to present first results from manipulations performed in atomic force microscopy (AFM) associated with PeakForce Quantitative Nanomechanique (PF-QNM) mode.

In a first step, this tool was used to demonstrate a potential mechanical stiffness gradient in flax cell wall layers, using nanoindentation as a reference measurement. First, to validate the method and explore the imaging capabilities of a stiffness gradient, PF-QNM was used on aramid fibers, well known to possess a core-skin microstructure. Then, the methodology was transferred to the flax fibers; stiffness mappings were carried out at the nanoscale, both on developing (Fig.1) and mature cell walls.

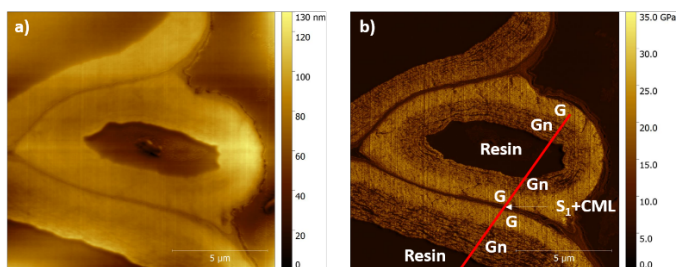


Fig. 1. Topography (a) et cartography of indentation modulus (b) obtained on a growing flax fiber cross section

These mappings demonstrate the presence of under layers G and Gn within the secondary cell wall for developing fibers [3]; On the other hand, no mechanical property gradient could be detected in the sections of mature fibers.

In a second step, we used the PF-QNM method to better understand the impact of a thermal cycle during the manufacturing of a composite on flax cell wall mechanical properties. Previous work has shown that the mechanical performance of flax single fiber was altered from 210°C for a heating time of 8 mn [4]. In the present work, stiffness

measurements were carried out both by nanoindentation and PF-QNM on flax fiber cross sections with or without polymer matrix. They allowed us to show decreases in nanoscale stiffness with thermal exposure; The latter are more pronounced when the fibers are included in a thermoplastic matrix. At the same time, a significant increase in hardness was measured by nanoindentation.

These studies validate the measurement method but also to suggest the full potential of the PF-QNM technology for the fine fiber characterization of plant cell walls. This tool provides an access to new information and open the way for many future applications.

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