STUDYING PLANT FIBER INTERFACE TOUGHNESS AND FRACTURE MECHANISMS USING MICRO-MECHATRONICS

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The use of plant fibers as reinforcements in composite materials or in textiles is growing in popularity due to their environmental benefits and interesting material properties. In order to transform the raw plant tissue to exploitable separated fibers, numerous steps are required[1]. The fist step consists of retting, a controlled plant degradation which eases fiber bundle separation. Various mechanical processes are then used to divide the fiber bundles in their individual components. Extraction procedures have a major impact on fiber quality and can be time consuming to optimize empirically for each fiber type.

Directly measuring the force required to separate an individual fiber from its bundle would allow to evaluate necessary retting times more precisely, in addition to adapting extraction processes to ensure proper fiber separation without damaging them. Observing the fiber interface at this scale also highlights complex mechanical phenomena such as cellulose microfibril pull-out and failure in nesting zones at the interface between individual fibers and cell wall sub-layers.

To be able to perform these measures, a specialized micro-mechatronical setup was developed to peel a single plant fiber from its bundle. A micro-gripper mounted on a linear actuator is used to pull the fiber. A force sensor, mounted behind the gripper, measures the applied force. The peeling zone is maintained under a camera during the whole test for observation purposes, with a constant peeling angle of around 90°, using a second actuator. The needed force for crack initiation and propagation can thus be measured. Furthermore, the influence of microfibrils and 'fiber nodes' on this can be quantified.

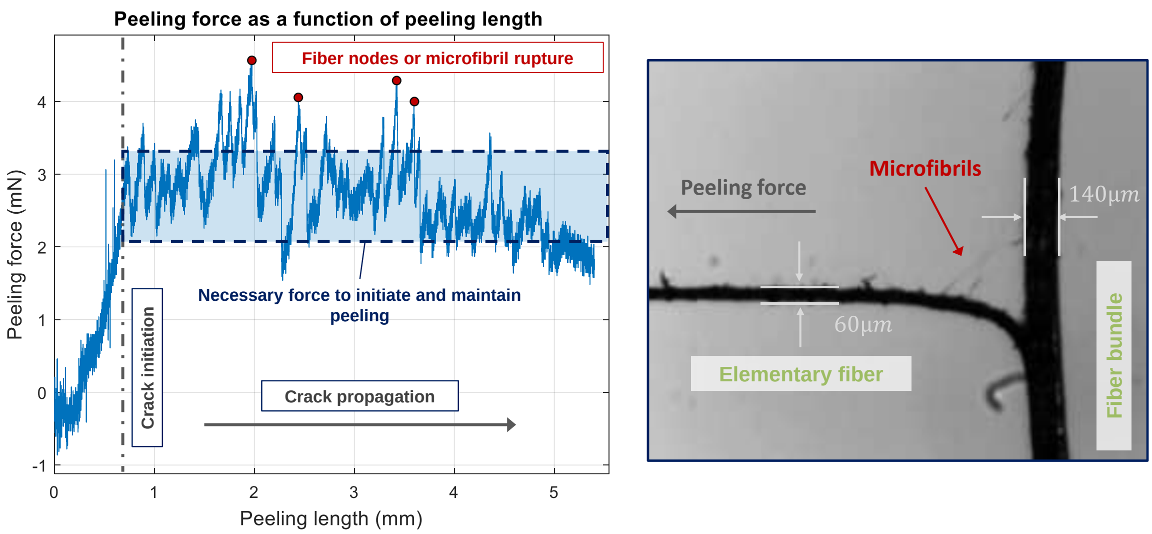

Figure 1: Results from nettle fiber peeling: peeling force evolution as a function of peeling length (left), peeling area with visible microfibrils (right).

[1] Bourmaud A et al. Towards the design of high-performance plant fibre composites, *Progress in Materials Science,* 97, 347-408, 2018