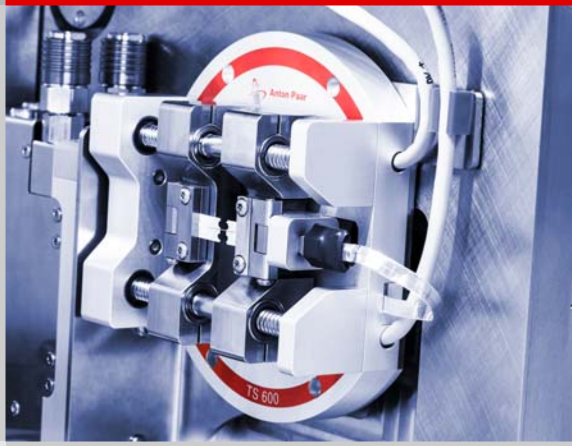
::: Application Flash

Coir fibers - SWAXS studies of structural changes induced by tensile stress



Microfibril angle in coir fibers during tensile straining was studied using the SAXSpace system operated in point collimation mode in combination with the integrated TS 600 tensile stage. The experiment demonstrates the possibility to characterize structural changes in complex materials during mechanical tests.

Introduction

Microfibril angle (MFA) in lignocellulosics, the essential structural feature of wood and natural fibers, represents the angle of the helical windings of cellulose microfibrils in the secondary cell. Nature can tune the MFA in order to optimize mechanical properties of tissues such as Young’s modulus, fracture stress and strain.

Coir fiber is obtained from the mesoscarp of coconuts. It is a very common natural fiber which consists mainly of lignin and cellulose. The fiber is optimized for a maximal fracture strain and therefore possesses also a maximal possible MFA of about 45°. Previous studies of coir deformation behaviour under tensile stress using synchrotron radiation have shown that the microfibril angle (MFA) of the cellulose fibers is directly proportional to the magnitude of the applied strain.[1] These experiments were now repeated using the laboratory small- and wide-angle system SAXSpace with an integrated tensile stage TS 600.

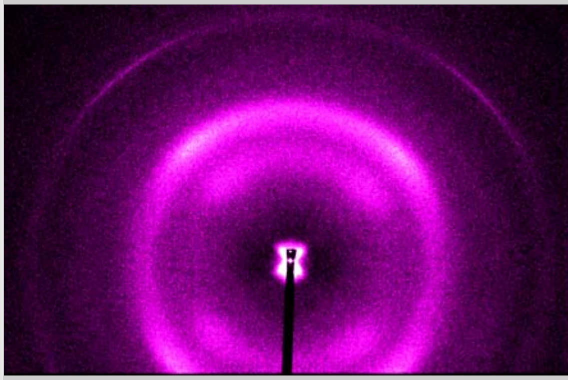


Fig. 1 2D diffraction pattern of coir fibre mounted in the TS 600 tensile stage while straining the sample.

Experimental and Results

Coir fibers (identical to those analyzed in a previous study)[1] were fixed on a plastic support and mounted into the TS 600 tensile stage. 2D diffraction patterns of individual fibers at different strain levels were acquired using the SAXSpace system operated in point-collimation mode. As the cellulose fibers diffract at relatively large diffraction angles of about 23 degrees, the signal was collected in wide-angle mode. The obtained 2D diffraction data (Fig. 1) of each strain level was integrated azimuthally along the Debye-Scherrer rings of the cellulose 200 reflections by using the SAXSquant software package.

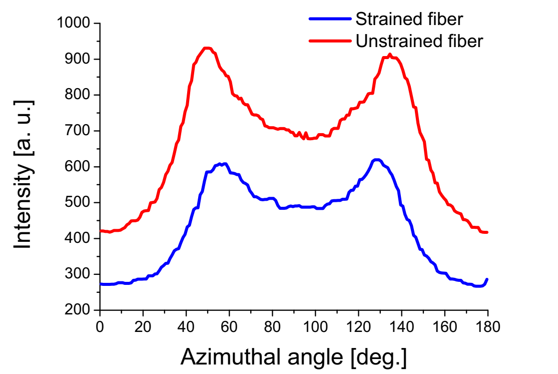


Fig. 2 Azimuthal integration along the 200 reflections. The position of the maximum is shifted to the center for the strained fiber.

In the unstrained fiber the microfibril angle between the cellulose fibers was found to be around 45°. When stretching the fiber, no significant change in the MFA was found until a strain of 3 % was reached. Above this treshold the MFA between the cellulose fibers was found to decrease; for a strain level of about 7 % a decrease of the MFA to a value of about 38° was observed (Fig. 2).

The experiment has documented that the combination of SAXSpace with an integrated TS600 tensile stage represents a powerful tool to in-situ analyze structural changes in materials during mechanical tests. In this way, structure-property relationship in thin foils of biological materials, polymers and metals can be studied in laboratory conditions.

1. K. J. Martinschitz, P. Boesecke, C. J. Garvey, W. Gindl, J. Keckes, J. Mater. Sci. 43 (2008) 350.
Samples kindly provided by Dr. Jozef Keckes, University of Leoben, Austria