LSI SUPPORT FOR PhD-STUDENTS IN APPLIED AREAS

Synchrotron-based analyses of nanostructures in technical filaments consisting of cellulose and lignin

THE PURPOSE OF THE PHD PROJECT

Co-processing of lignin and cellulose, the two main constituents of wood, has previously been identified as a potential route for production of inexpensive and bio-based carbon fibers. The first step for this production is to spin a precursor fiber. This can be performed by different techniques, where the PhD project focus on the specific characteristics of air-gap spinning of solutions containing lignin and cellulose. The overall aim of the PhD project is to investigate how the addition of lignin to a cellulose solution affect the spinnability, the coagulation process and the fiber structure and properties.

USING A LARGE SCALE INFRASTRUCTURE

Remaining questions regards how the cellulose and lignin are arranged within the fiber and how the concentration of lignin affects the cellulose structure, i.e., crystallization and orientation. The fibers spun within the project are in the range of 10 – 25 µm in diameter. Thus, to be able to analyze structural or compositional variations within the fiber and over a fiber cross section; a high spatial resolution is necessary. This cannot be achieved by homebased analytical tools but requires higher resolution. Analyses of fibers were performed at three beamlines and facilities. 3D tomography of fibers was performed at P03 of Petra III, Germany. In-situ fiber drying experiments using small-angle X-ray scattering (SAXS) was set up at CoSAXS of MAX IV in Lund. The analysis of fiber cross sections using scanning transmission X-ray microscopy (STXM) was done at i08 of Diamond Light Source, UK

RESULTS AND IMPACT

The experience resulted in substantial competence development in planning and performing synchrotron X-ray analysis.

The structural analysis of fibers was conducted to render a 3D image of cellulose crystallinity and orientation within the fiber. It could be determined that the structure varies both within the fiber, such as skin-core effects, and depends on e.g., the lignin content of the fiber.

In the in-situ SAXS analysis of drying of fibers it was possible to follow the structural development from wet to dry state in both pure cellulose and lignin-cellulose fibers.

The STXM analysis on cross sections revealed large differences between fibers with and without lignin, and the distribution of cellulose and lignin within the fiber could be mapped. Preliminary results show that the lignin and cellulose is not evenly distributed within the fiber and that the presence of lignin influences the cellulose alignment and crystallinity.

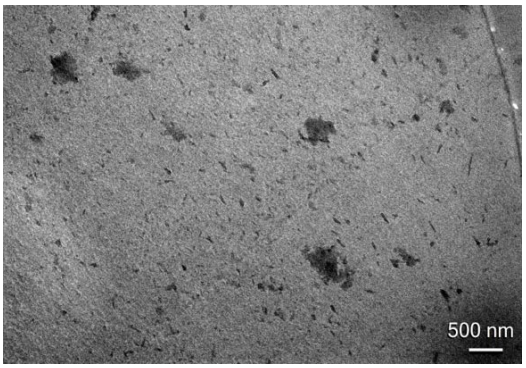

Figure 1. Fiber cross section captured with STXM, at i08 Diamond, showing inhomogeneities.

Figure 2. The PhD student Jenny Bengtsson at the CoSAXS beamline, MAX IV.

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