Waste Streams for Sustainable Materials

A new cellulose-based material obtained from the extraction of nanocellulose fibres of root vegetables was characterized by synchrotron ultra-small-angle X-ray scattering and synchrotron wide-angle X-ray scattering (USAXS-WAXS). The team of CelluComp, Danish Technology Institute (DTI) and DESY came together at PETRA III to better understand the mechanical properties of the renewable material for several applications.

CHALLENGE

CelluComp is a Scottish-based company located in Fife, near Edinburgh. The principal activity is to develop and commercialize Curran®, a material developed from the extraction of nanocellulose fibres of root vegetables, primarily from sugar beet pulp, which is a by-product of the sugar industry.
The product named Curran® offers exceptional mechanical and rheological properties for numerous applications, such as paints and coatings, inks, personal care, home care, paper, food, concrete, drilling fluids, composites and other potential applications. Curran® and other bio-based products can be used to reduce use of plastics and synthetic coatings.
Curran® is a complex hierarchical natural structure containing natural polymers, including cellulose, in the form of micron sized platelets. Each platelet is formed from interwoven cellulose nanofibers embedded in non-crystalline polymers. For bio-based materials, like Curran®, which are usually weak X-ray scatterers, in combination with structures at different length scales, lab-based X-ray sources are not optimal suited.

Figure 1: The product Curran® extracted from by-products of the sugar industry.

METHOD

USAXS and WAXS were used at DESY's synchrotron facility PETRA III. The beamline P03 offers extraordinary conditions, X-ray energy and brilliance and experience for analyzing cellulose and other bio-based materials. Both methods record a transmission scattering pattern from monochromatic X-ray radiation, but at different distances between sample and detector. The WAXS scattering pattern is collected close to the sample and the USAXS detector is placed far away, up to 10 meters, from the sample.

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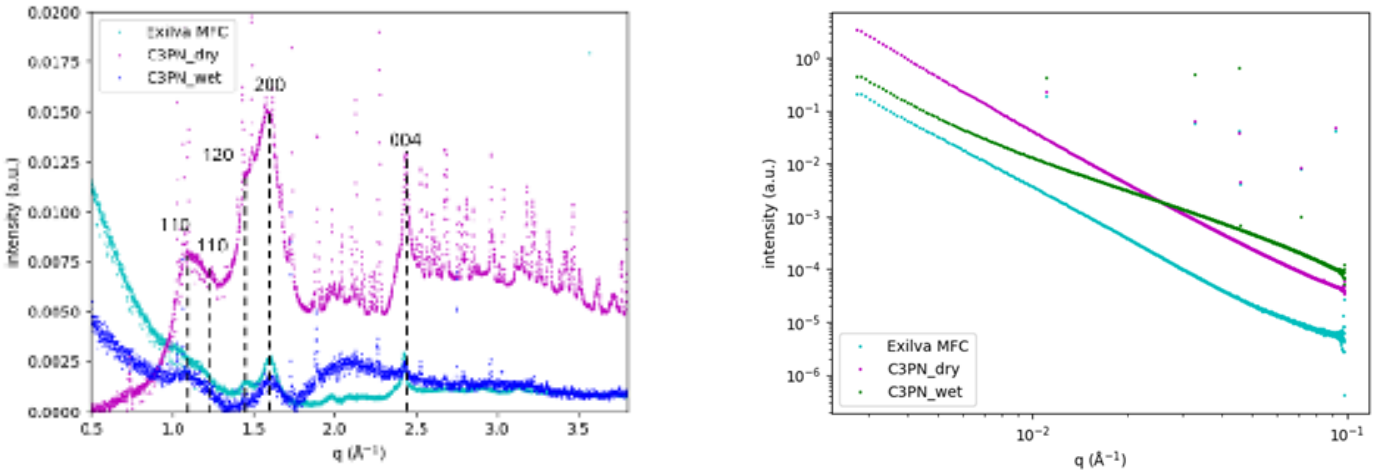

Figure 2: USAXS (right) and WAXS (left) data in arbitrary units for the material in a wet or dry state and the reference material Exilva® MFC.

INSIGHTS AND ANALYSIS

The high-quality data obtained at PETRA III confirmed the formation of nano-structures in aqueous conditions as well as the presence of cellulose containing crystalline and amorphous domains that could influence the mechanical properties of the cellulose-based material. WAXS and USAXS data for some samples can be found in figure 2.

BENEFITS

The strong collaboration between the Danish Technological Institute and the Deutsches Elektronen-Synchrotron DESY allowed the use of ultra-small and wide-angle X-ray scattering methods (USAXS-WAXS) with synchrotron radiation to better understand the different production and process conditions that may affect the structures of Curran® when going from dry to wet conditions.

"The service was very professional, with clear explanations of the technology and how it works, good project planning and thorough analysis and explanations of the results."

Dr. David Hepworth
Founder and Technology Director,
CelluComp Ltd

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