PREPARATORY INDUSTRIAL PROJECT

Investigating the potential of advanced X-ray techniques for in situ characterization of functional cellulose-based fibre materials

THE INDUSTRIAL CHALLENGE

The development of cellulose-based fiber-materials for applications such as industrial wipes, hygiene products and wound care products requires a detailed understanding of the distribution of additives and active ingredients, both within and on the surface of the fiber material. It is also crucial to understand how the material properties, in terms of water uptake and wet strength, are affected by incorporation of such substances.

WHY USING A LARGE SCALE FACILITY?

To understand the relationship between water uptake and fiber strength as well as the distribution of additives over a wide range of length scales, characterization techniques with high spatial and temporal resolution are required. In addition, good penetration power, multiscale probing from millimeter to submicron and/or good water sensitivity are desirable. Synchrotron radiation imaging could easily fulfill the time and/or space resolution, which are essential for the quick in situ tensile and hydration measurement, while neutron scattering techniques are sensitive to water and heavy water via the contrast-matching mechanism, both of which outperform lab-based optical and X-ray methods.

THE RESULTS AND EXPECTED IMPACT

Lab-based Fourier transform infrared spectroscopy (FTIR) and scanning electron microscopy (SEM) was performed to acquire preliminary structural information to support the discussions.

To meet the challenge of characterizing water uptake and wet strength with sub-second temporal resolution and micron-scale spatial resolution, X-ray techniques were concluded to be more suitable than neutron scattering. In-situ moisture and mechanical tests coupled with X-ray tomography was suggested to be performed at the TOMCAT beamline at the Swiss Light Source of PSI and the P05 beamline at the Petra III in Hamburg, or other similar beamlines. The tensile tester could be available in several facilities, while the moisture impact could be tested on pre-conditioned sample at different relative humidity (RH). For real time RH controlling, a modification might be needed upon the discussion with beamline scientists.

To characterize the distribution of additives, high spatial resolution and chemical contrast between organic components are crucial requirements. It was therefore concluded that scanning transmission X-ray microscopy (STXM), for example at the SoftiMAX beamline at MAX IV in Lund, would be a suitable choice. In this case, sample preparation via focused ion beam or ultramicrotome is needed, which is available via the NanoSPAM platform.

As a result of this project, Essity, RISE and Chalmers have advanced a mutual understanding of both research questions and LSRI technical solutions, developing unified terminologies for an efficient communication and a solid ground for further collaboration, especially involving LSRI techniques for in situ/high resolution studies.

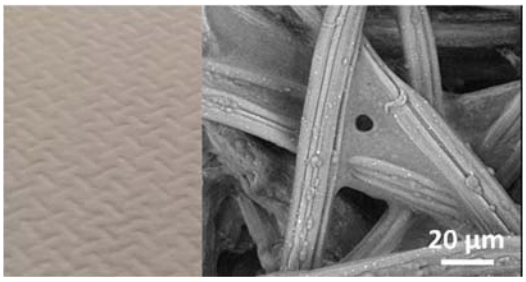

Figure. Photo (left) and SEM micrograph (right) of the nonwoven tissue material.

"Advanced X-ray techniques show a high potential for a deeper understanding of materials. To see the unseen supports building new explanation models and to optimize utilization of fibers in a network."
/Lars Fingal, Essity

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