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Combining rheology and small-angle scattering of neutrons and X-rays for dynamic assessment of microfibrillated cellulose under shear

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Cellulose fibre is a natural food component present in fruits and vegetables. Presence of the cellulose fibre in the diet aids digestion and helps in preventing a variety of diseases. Cellulose fibres also provide texture to food products. The texturing capacity of cellulose fibres can be enhanced by defibrillation under high shear. Dispersions of microfibrillated cellulose form a 3D soft space-filling network, which can, for example, mimic the texture of fat-based products. Critical for the consumer perception of microfibrillated cellulose networks are spreadability and mouthfeel. The microstructural features that underly these rheological parameters are poorly understood. Small-angle scattering of neutrons (SANS) and X-rays (SAXS) provides structural information in a wide range of length scales. Combination of rheological data with SANS/SAXS measurements of the samples under shear conditions sheds light on the mesoscale structural dynamics that underlie the peculiar flow of microfibrillated cellulose under industrial processing conditions and during consumer use and consumption.
Recent studies 1 have shown nonlocal flow behaviour of microfibrillar cellulose suspensions. Based on Rheo-MRI data two different hypotheses to explain such nonlocality were suggested: flocculation of cellulose microfibrils and formation of a liquid-crystal like phase in these suspensions. To validate these hypotheses we constructed a special sample cell, which allows for SANS/SAXS on the materials under shear with spatial resolution (100 µm) across the velocity gradient direction of the cell. No alignment of microfibrills was observed at shear rates from 1 to 300 s-1. The scattering invariant calculation indicates a homogeneous density distribution of cellulose microfibrils across the gap at all applied shear-rates. This implies that no shear-induced aggregation and concomitant migration of cellulose over the gap occurs. The shear-SAXS experiments are in line with the flocculation hypothesis with the flock sizes much larger than 200nm (maximal accessed in the performed experiment).

https://events01.synchrotron.org.au/event/72/images/311-Velichko_Shear-cell_image.jpg Figure 1. Schematic view of the developed shear-SANS/SAXS cell.

1 D. W. Kort et al., Soft Matter, DOI: 10.1039/c5sm02869h (2016).

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