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Biochemical functionalization and modification of nanocellulose

My PhD work has a starting point in nanocellulose and its interactions with proteins and enzymes. Nanocellulose is a processed form of cellulose with nano scale width and nano to micron scale length. Due to its high aspect ratio it has superior mechanical properties as well as good filming and barrier properties compared to cellulose. The research focuses on how enzymes can be used to modify the functional and structural properties of nanocellulose as well as using the possibilities of characterization that nancellulose offers to give new understanding in how cellulose is enzymatically degraded. Recombinant proteins are also used to functionalize nanocellulose for self-assembly and composite materials.

It was demonstrated recently that recombinant proteins can be used to introduce new properties to nanocellulose, especially surface activity. This was achieved by using a fusion protein containing two cellulose binding domains (CBD) and a protein amphiphile hydrophobin (HFBI). The two CBDs bind the fusion protein specifically to nanocellulose surface and HFBI introduces the surface activity to the fibres (figure 1). It was shown that in this way nanocellulose can be self-assembled to air-water (figure 2), oil-water and solid-water interfaces and used for e.g. stabilizing emulsions and drug-nanoparticles. (Varjonen et al. *Soft Matter*, 2011)

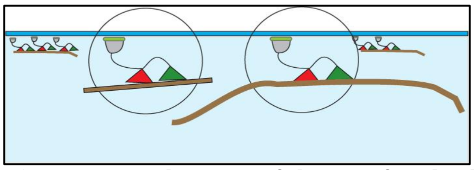

Figure 1. A schematic of the interfacial self-assembly of nanocellulose and HFBI-double CBD fusion protein (HFBI-DCBD) at air-water interface.

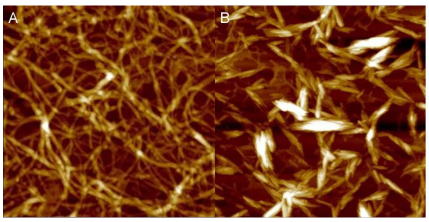

Figure 2. AFM topography images of films formed at air-water interface by HFBI-DCBD with different nanocelluloses and picked up from Langmuir trough at 30 mN/m surface pressure. A) Nanofibrillated cellulose from birch, scan size 2x2µm, height 40 nm. B) Cellulose nanocrystals from Whatman paper, scan size 2x2 µm, height 40 nm.

Publications

Suvi Varjonen, Päivi Laaksonen, Arja Paananen, Hanna Valo, Hendrik Hähl, Timo Laaksonen and Markus Linder *Self-assembly of cellulose nanofibrils by genetically engineered fusion proteins* Soft Matter 2011;7:2402.
Suvi Arola, Tekla Tammelin, Harri Setälä, Antti Tullila and Markus Linder *Immobilization–stabilization of proteins on nanofibrillated cellulose derivatives and their bioactive film formation* Submitted