Rheological properties of aqueous nano-cellulosic dispersions

Tobias Moberg[1,5], Karin Sahlin[2,5], Kun Yao[3,5], Shiyu Geng[4,5], Gunnar Westman[2,5], Qi Zhou[3,5], Kristiina Oksman[4,5] and Mikael Rigdahl[1,5]

[1]Chalmers University of Technology, Department of Materials and Manufacturing Technology, SE-412 96 Gothenburg, Sweden
[2]Chalmers University of Technology, Department of Chemistry and Chemical Engineering, SE-412 96 Gothenburg, Sweden
[3]Royal Institute of Technology, School of Biotechnology, SE-100 44 Stockholm, Sweden
[4]Luleå University of Technology, Division of Materials Science, SE-971 87 Luleå, Sweden
[5]Wallenberg Wood Science Center, Chalmers University of Technology, SE-412 96 Gothenburg and Royal Institute of Technology, SE-100 44 Stockholm, Sweden

There are several methods described in the literature for producing nano-cellulosic material. For example, by using mechanical shearing[1], often combined with chemical or enzymatic treatments[2,3], disintegration of the cellulose fibres can be achieved yielding cellulose nanofibrils (CNF). By instead using acid hydrolysis of the cellulose, cellulose nanocrystals (CNC) can be formed[4]. These two materials have very different geometries (and usually also surface characteristics); the nanofibrils are flexible in an aqueous phase, are long in relation to their width i.e. have a high aspect ratio typically in the order of 100-150[5], and form, an entangled network at very low concentrations, whereas the CNCs have a significantly lower aspect ratio typically 10 to ca 65[4], displaying a colloidal behaviour usually. It is thus not unexpected that these two types of nano-cellulosic materials will exhibit quite different rheological properties (viscosity and moduli) in an aqueous medium even though the raw material is the same. This includes also the effect of concentration on their rheology. However, differences in the surface charge density of these nanomaterials will also contribute to their rheological behaviour making it difficult to distinguish geometrical effects (on the rheology) from those associated with the surface characteristics of the material. In the production of CNF the fibres are usually modified in some way, changing the surface properties of the fibrils, this is done to decrease the energy consumption used in the mechanical shearing step. When making the acid hydrolysis used for creating CNC one can also introduce other chemical groups to the surface of the cellulose fibrils that can influence the rheological behaviour of the materials.

In this study, the rheological properties of aqueous nano-cellulosic dispersions with different particle/fibre geometries have been evaluated. The aim has been to keep the surface charge density of the different materials as close as possible in order to demonstrate and clarify the geometry effect of the rheology (viscosity and moduli) of the dispersions. Three types of nano-cellulosics dispersions were used; one CNF, one CNC obtained from acid hydrolysis of cellulose, and one CNC-similar dispersion obtained from homogenisation of a bioethanol residue. The latter particles had a shape which was more fibrillar-like than the CNC obtained from acid hydrolysis as can be seen in Fig 1. By using AFM and TEM it is possible to image the cellulose materials in order to assess the aspect ratio of the particles. In a

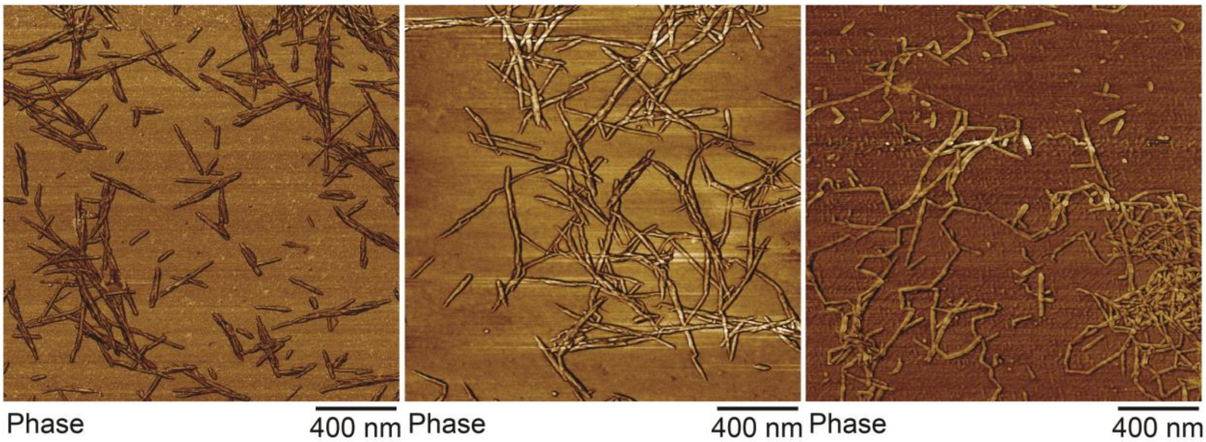

Figure 1, Three different cellulosic dispersions. The leftmost is a CNC dispersion made by acid hydrolysis of cellulose, the middle one is CNC made from bio-ethanol residue, the rightmost is CNF obtained from TEMPO-mediated oxidation followed by mechanical shearing.

series of experiments, some of these materials were also grafted with poly(ethylene glycol). The effect of this grafting on the rheological behaviour will be discussed.

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