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Fluid physics as a tool for fabrication of continuous filaments from nanocellulose

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Spinning of cellulosic filaments is far from a novelty, viscose filaments could be spun already in the late 19th century. Today there is a wide variety of filament materials originating from cellulose that are spun under industrial conditions using well-understood spinning processes. Furthermore, significant efforts have been made on the fabrication of filaments from cellulose nanofibrils (CNF) during the last decade and they generally apply conventional spinning processes and aim at achieving favourable properties by developing spinnable liquids that allows the use of these processes. However, given the nature of CNF, being very slender particles, the application of existing knowledge on macroscopic fibre suspension flows provides insights that offer new routes process routes that gives improved mechanical performance.

The principles of forming a filament is quite straightforward, the CNF dispersion should by some means be shaped into a thread that is subsequently dried to form the final filament. If elongation of the thread can be introduced during processing it should also cause alignment of the CNF along the thread, which according to the understanding of spinning from polymer melts and solutions should give increased mechanical performance such as increased tenacity (specific strength). The ideal process would thus align CNF in the direction of the formed thread and by some means preserve this controlled structure during drying.

A process was presented by Håkansson et al 2014, which seems to be able to achieve a significant improvement of the mechanical properties of the CNF-filament. The concept of this process can be seen in Figure 1. The concept is based on controlling the time-scale of alignment through elongation in relation to the time-scale for gelling time by diffusion of Na^+ and the time-scale of rotary diffusion caused by Brownian motion. The results described as being obtained at low concentration, and as it turns out this is most probably very important reason for the excellent mechanical properties.

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