ABSTRACT

This thesis deals with processing of nanocellulose originating from pulps, with focus on mechanical pulp fibres and fines fractions. The nanocellulose materials produced within this research project were tested for different purposes ranging from strength additives in paper and paperboard products, via composite films to foam materials. TAPPI (Technical Association of Pulp & Paper Industry) has recently suggested a standard terminology and nomenclature for nanocellulose materials (see paper I). In spite of that we have decided to use the terms nano-ligno-cellulose (NLC), microfibrillated cellulose (MFC), nanofibrillated cellulose (NFC) and nanocellulose (NC) in this thesis . It is well-known that mainly chemical pulps are used as starting material in nanocellulose production. However, chemical pulps as bleached sulphite and bleached kraft are quite expensive. One more cost-effective alternative can be to use fibres or fines fractions from thermo-mechanical pulp (TMP) and chemi-thermomechanical pulp (CTMP).

In paper II-IV, fractionation has been used to obtain fines fractions that can easily be mechanically treated using homogenisation. The idea with this study was to investigate the possibility to use fractions of low quality materials from fines fractions for the production of nanocellulose. The integration of a nanocellulose unit process in a high-yield pulping production line has a potential to become a future way to improve the quality level of traditional products such as paper and paperboard grades.

Paper III describes how to utilise the crill measurement technique as a tool for qualitative estimation of the amount of micro- and nano-material produced in a certain process. The crill values of TMP- and CTMP-based nanocelluloses were measured as a function of the homogenisation time. Results showed that the crill values of both TMP-NLC and CTMP-NLC correlated with the homogenisation time. In Paper V pretreating methods, hydrogen peroxide and TEMPO are evaluated. Crill measurement showed that hydrogen peroxide pretreatment (1% and 4%) and mechanical treatment time did not improve fibrillation efficiency as much as expected. However, for TEMPO-oxidised nanocelluloses, the crill value significantly increased with both the TEMPO chemical treatment and mechanical treatment time. In paper V-VII TEMPO-mediated oxidation systems (TEMPO/NaBr/NaClO) are applied to these fibres (CTMP and Sulphite pulp) in order to swell them so that it becomes easy to disrupt the fibres into nanofibres with mechanical treatment.

The demand for paperboard and other packaging materials are steadily increasing. Paper strength properties are crucial when the paperboard is to withstand high load. A solution that are investigated in papers IV and VI, is to use MFC as an alternative paper strength additive in papermaking. However, if one wish to target extremely higher strength improvement results, particularly for packaging paperboards, then it would be fair to use MFC or cationic starch (CS). In paper VI CS or TEMPO-based MFC was used to improve the strength properties of CTMP-based paperboard products. Results here indicate significant strength improvement with the use of different levels of CS (i.e., 20 and 10 kg t^{-1}) and 5% MFC. The strengthening impact of 5% MFC was approximately equal to that of 10 kg t^{-1} of CS.

In paper VII, NFC and nanographite (NG) was used when producing composite films with enhanced sheet-resistance and mechanical properties. The films produced being quite stable, flexible, and bendable. Realising this concept of NFC-NG composite film would create new possibilities for technological advancement in the area of high-yield pulp technology. Finally, in paper VIII, a new processing method for nanocellulose is introduced where an organic acid (i.e., formic acid) is used. This eco-friendly approach has shown to be successful, a nanocellulose with a uniform size distribution has been produced.

Keywords: *mechanical pulp, thermo-mechanical pulp, chemi-thermomechanical pulp, fractionation, fines, homogenisation, nanocellulose, nano-ligno-cellulose, microfibrillated cellulose, nanofibrillated cellulose, paper, strength properties, crill, TEMPO, nanographite (NG), composite films*