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Interactions of nanocrystalline cellulose with an oppositely charged surfactant in aqueous medium

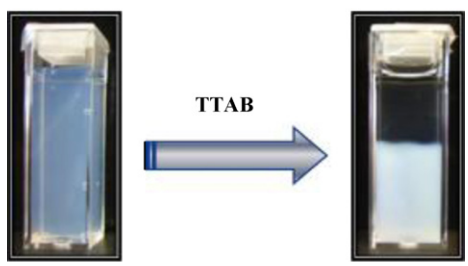
Neha Dhar[a], Daniel Au[a], Richard C. Berry[b], Kam C. Tam[a,*]

[a] *Department of Chemical Engineering, Waterloo Institute for Nanotechnology, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, Canada N2L 3G1*
[b] *CelluForce Inc., 625 Président-Kennedy Avenue, Montreal, Quebec, Canada H3A 1K2*

HIGHLIGHTS

- ► Positively charged surfactant binds to negatively charged nanocrystalline cellulose.
- ► Electrostatic attraction, reorganization, polymer induced and bulk micellization occur.
- ► NCC solutions become unstable and phase separate in the presence of TTAB.

GRAPHICAL ABSTRACT



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ABSTRACT

The interaction between negatively charged nanocrystalline cellulose (NCC) and a cationic surfactant, tetradecyl trimethyl ammonium bromide (TTAB) was examined by isothermal titration calorimetry (ITC), conductometric and potentiometric titrations and surface tensiometry. The interaction is controlled by electrostatic and hydrophobic interactions. ITC and surface tension measurements confirmed the formation of electrostatically driven NCC–TTAB complexes in the bulk and at the interface, which was followed by hydrophobically driven polymer-induced micellization of TTAB on NCC rods. The critical micelle concentration (CMC) of TTAB was shifted from 1.1 to 1.3 g/L in the presence of 0.655 g/L NCC. The settling and phase separation characteristics were quantified by determining the height of NCC flocs as a function of time, which describe the stability of NCC in the presence of TTAB. Zeta potential results revealed a charge reversal from negative to positive values with increasing TTAB concentration, confirming the formation of NCC–TTAB complexes in aqueous solutions. Based on the results, a physical mechanism on the interaction of NCC and TTAB is proposed.

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1. Introduction

Nanocrystalline cellulose (NCC) is a highly crystalline cellulosic material formed by sulfuric acid treatment of native cellulose rendering negatively charged sulfate ester groups on its surface. These negatively charged NCCs form stable aqueous dispersions due to the electrostatic repulsion between individual crystallites [1]. The rod-like crystals have the following typical dimensions: diameter in the range of 10–20 nm and lengths in the range of a few hundred nanometers [1,2].

Since NCC is derived from native cellulose (wood, cotton or plant fibers), it possesses a number of advantages, such as biodegradability, recyclability, non-toxicity and high functionality due to the presence of hydroxyl groups [3]. It can be used for a number of applications, such as security paper, colored pigments and filler materials for nanocomposites [2]. Because of its polyelectrolyte nature, NCC can also be used in personal care

* Corresponding author at: Department of Chemical Engineering, Waterloo Institute for Nanotechnology, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, Canada N2L 3G1. Tel.: +1 519 888 4567x38339; fax: +1 519 888 4347.
E-mail address: mkctam@uwaterloo.ca (K.C. Tam).

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