Microstructure and flow behavior of cellulose nanocrystal stabilized emulsions with repulsive and attractive interactions

Abstract
Surface properties of nanoparticles have a direct effect on the microstructure and rheological properties of the emulsions. In this thesis, I have utilized oscillatory shear rheology in conjunction with confocal microscopy and Cryo-SEM to understand the role of surface charge of Cellulose nanocrystal (CNCs) on the microstructure and rheology of dodecane in water emulsions. These fundamental understandings...
Rheology study indicates that the resulting emulsions are attractive emulsions with typical shear-thinning gel characteristics. The underlying emulsion stabilization mechanism is a combination of Pickering and network mechanisms. It is believed that the amphiphilic character of cellulose nanocrystals resides in the crystal organization at the elementary brick level. Two different desulfation approaches were employed to modulate the surface charge of the CNCs. CNCs desulfated using hydrochloric acid (a-CNCs) were highly aggregated in water and shown to adsorb faster to the oil-water interface, yielding emulsions with smaller droplets sizes and a thicker CNC interfacial layer. CNCs desulfated using sodium hydroxide (b-CNCs) stabilized larger emulsion droplets and had a higher amount of non-adsorbed CNCs in the water phase. Rheological measurements showed that emulsions stabilized by a-CNCs formed a stronger network than for b-CNC stabilized emulsions due to increased van der Waals and H-bonding interactions that were not impeded by electrostatic repulsion. Based on these observations the conformance control performance and plugging efficiency of a-CNC stabilized emulsions through sandpack flow experiments was tested. The injected emulsions were aged inside the porous media for one day to develop a strong droplet network. The aged emulsions showed a promising selective phase blocking behavior with a very large pressure gradient required for water to flow as compared to dodecane. This selective phase blocking behavior can be specifically useful for near wellbore water shut-off treatment. The results of this investigation demonstrate the unique interactions between nanoparticles surface charge and the resulting emulsion properties which showed an interesting selective phase blocking behavior in porous media.

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Surface/interface modifications of cellulose nanocrystals for the development of novel biomaterials with attractive structural and functional properties.- The scientific bases for developing cellulose-based nanomaterials with advanced functionalities for industrial/medical applications and consumer products.  Suspensions 4.5.4 Temperature Effects on the Microstructure and Rheological Properties of CNC Suspensions 4.5.5 CNCs Surface Charge Effects on the Microstructure and Rheological Properties of CNC Suspensions 4.5.6 Ionic Strength Effects on the Microstructure and Rheological Properties of CNC Suspensions.