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Executive Summary

This project concerns the development of improved methods for describing the dispersion of colloidal particles in suspensions using surfactants (dispersants). YEAR 2 efforts focused on analyzing data on suspensions of carbon black in non-polar fluids. These efforts resulted in robust identification of surface activity parameters and a strong correlation with the rheology of suspensions prepared using the studied dispersants. A manuscript has been published. A second effort targeted the study of surface activity using a custom designed flow-through adsorption apparatus. Finally, a third related effort was started examining the role of electrostatics on dispersion of cellulose nanofibrils. This third effort involved collaboration with the light scattering facility at Yale. Details regarding these efforts are described below.

Research Narrative

Carbon Black Flow-through Adsorption:

A custom column apparatus was designed, **Figure 1**, to better assess kinetics of dispersant adsorption onto the surface of carbon black particles. The column was packed with a nanocomposite of carbon black particles tethered to a microporous PVDF support that was created by solvent induced phase inversion, **Figure 2**.

Figure 1. Column apparatus for assessing dispersant adsorption onto carbon black.

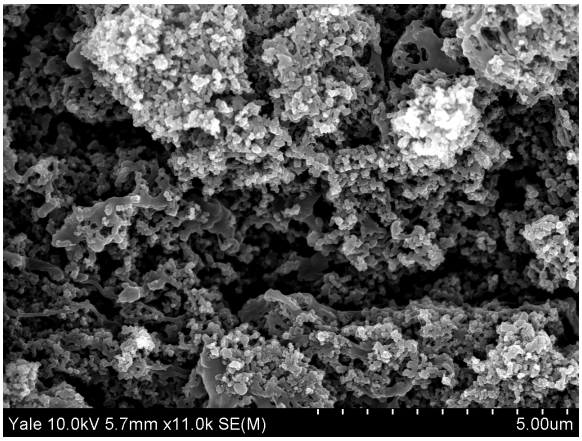

Figure 2. Phase inversion (precipitation) of a mixture of carbon black particles with PVDF polymer results in a microporous material with exposed carbon black particle surfaces tethered by PVDF.

The column functioned in a manner analogous to a chromatography column. The absorption of dispersant onto the carbon black surface was monitored by UV-Vis spectroscopy. **Figure 3** shows data regarding the adsorption of the dispersant onto the carbon black particles, and desorption, as a function of time.

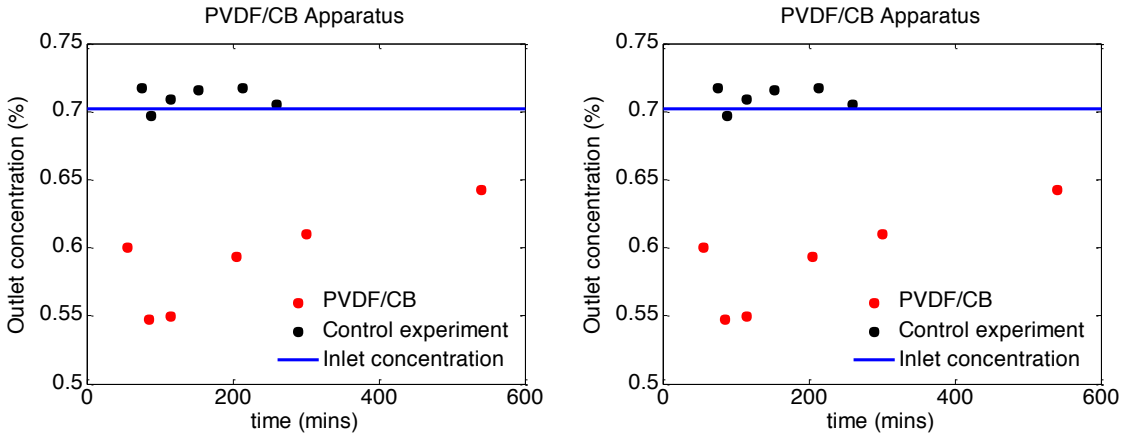

Figure 3. *Left*: Concentration of dispersant as a function of time for solutions run over PVDF/carbon black material, relative to the control experiment, where the dispersant is run over only PVDF. The data demonstrate that the dispersant does not adsorb onto PVDF. *Right*: Desorption experiments showing that the concentration of dispersant falls over time when the column is rinsed with solvent devoid of dispersant.

Role of Electrostatics in Rheology of Cellulose Nanofibrils

This project was an exploratory effort to address how electrostatic interactions affect the flow behavior of cellulose nanofibrils (CNF). Preliminary data from light scattering experiments and rheological measurements are shown below. The data suggest that a modest screening of electrostatic interactions first acts to liberate internal modes of CNF. Modest association among CNFs results in a weak display of strain hardening in the strain sweep experiments.

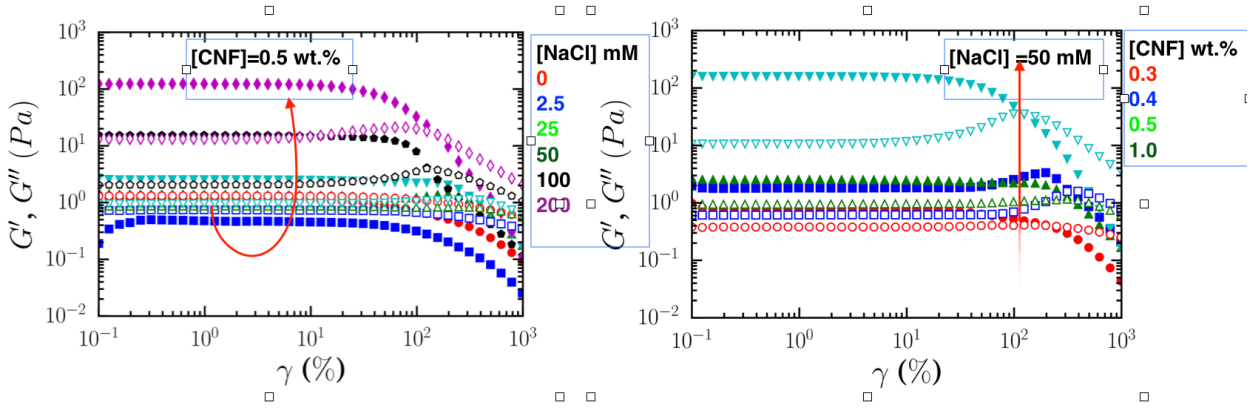

Figure 8. *Left*: Strain sweeps of 0.5 wt.% CNF as a function of added salt showing a decrease, then increase, in the dynamic modulus. *Right*: Strain sweep behavior at constant salt concentration, for different CNF concentration. There is a modest window in which strain stiffening is observed.

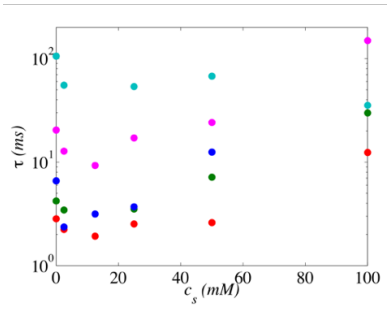

Figure 9. Salt addition results in acceleration, then slowing of dynamics, across a broad range of CNF concentration.