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# Fundamental Studies on Nanocrystal Stabilized $CO_2$ Foams and Emulsions

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This project is aimed at investigating fundamental interfacial effects affecting the properties of $CO_2$/brine Pickering foams and emulsions stabilized by cellulose nanocrystals (CNC). It is expected that success on this project will lead to dry, $CO_2$ based, fracking fluids to improve the sustainability of traditional fossil fuels. The $CO_2$ based fluid would trap the greenhouse gas underground while allowing extraction of natural gas and oil.

The work during the first year of study has focused on assessing the ability of CNC to stabilized highly non-polar organic fluids like dodecane, heptane and perfluorooctane in American Petroleum Institute (API) brine. These fluids are being used as model compounds to mimic the solvent properties of high pressure $CO_2$. In addition the synergistic effect of surfactants like dodecyltrimethylammonium bromide (DTAB), sodium dodedecyl sulfonate (SDS) and bis(2-hydroxyethyl) cocoalkylamine (CAA), and the thickener guar gum has been investigated.

Surface tension measurements were used to confirm the adsorption of CNC onto the dodecane/brine interface and the adsorption of surfactants on the CNC surface. It was found that the positively charged DTAB has minimal adsorption onto the CNC surface, while CAA and guar gum adsorb readily. The result has been attributed to the high ionic strength of API brine and the ability of CAA and guar gum to adsorb onto CNC. It was also found that surfactant adsorption lower the stability of most dodecane/brine emulsions at the conditions tested; the only exception being DTAB, which in synthetic seawater and large dodecane/brine volume ratios increased emulsion stability. These results are reported in a paper currently under consideration for publication. Remarkably, it was found that CNC on their own stabilize 75% oil/brine emulsions for more than 8 months.

The high pressure apparatus to test $CO_2$ foam stability and viscosity was almost finished during the first year of the project. The apparatus is scheduled to be completed during the first quarter of the second year. A high pressure cell to measure interfacial tension in supercritical $CO_2$ was also purchased and is being fitted to an optical tensiometer.

Work for the second year will focus on stabilizing high oil to water volume ratio emulsions using CNC and surfactants. The goal is to achieve stable 90% to 95% oil/brine emulsions of heptane and perfluorooctane in API brine. The results will then be validated with supercritical $CO_2$/brine foams.

There have been three undergraduate students and one graduate student involved on this project during the first year. After the first year, one of the undergraduate students graduated and found a job as a Mud Engineer at Halliburton. Another undergraduate student worked in the group for 1 year and then decided to focus more on her classes; however was able to get an internship. Two students have been hired to continue their work. So far, one manuscript has been submitted for publication with the graduate student as the first author and one of the undergraduates as a co-author. The same graduate student also gave two talks, one at the 2017 AIChE National Meeting in Minneapolis and a second one at the 92nd ACS Colloid & Surface Science Symposium. Receiving this grant has helped our research group to establish collaborations with researchers inside and outside the University of Mississippi which resulted in two externally funded research grants, one from the National Science Foundation and the other from the National Institute of Food and Agriculture.