Elucidating the Demulsification Mechanisms of Functionalized Spherical Silica

Background: With global energy demand increasing and the exploration of more offshore wells, produced water is an area of growing environmental concern. Produced water is the largest waste steam from the petroleum industry and often contains hydrocarbons and inorganic materials, which can cause environmental damage. Therefore, produced water is treated using biological means, membranes, and other methods to meet regulations (Fakhru'l-Razi 2009). However, these techniques fail to efficiently remove hydrocarbons from produced water. Spherical silica nanoparticles may provide an alternative separation method.

As a fluid moves up a well, it flows though chokes to control flow rate and pumps to move the fluid at the surface. These processes impart stress on the fluid, causing the breakup of oil droplets in a continuous phase of water. Generally, as oil droplet size decreases the effort required to separate, or demulsify, the two fluids increases. As a well ages, the water cut (fraction of produced fluid that is water) increases, which exacerbates this issue (Morales 2012).

Due to the ubiquitous nature of emulsions, the fundamental insight from this work will have broad impacts in the biotechnology, agriculture, and the food industry in addition to the petroleum industry.

Research Plan: The plan is to quantify the effect of particle hydrophobicity on the stability of emulsions. We will also investigate the separation of solid particles from the oil phase after demulsification. The goal is to separate the water from the oil droplets in a short time. Introducing hydrophobic particles to the emulsion may accelerate the separation process. Preliminary data show demulsification can be achieved rapidly. This work will also explore the interaction between particles and brine and the resulting emulsion stability.

The proposed work builds on my current work on replicating a procedure for the functionalization of spherical silica nanoparticles. Because silica is naturally hydrophilic, a reaction step is used to replace surface hydroxyl groups (hydrophilic) with methyl groups (hydrophobic) using a silane agent, thereby imparting hydrophobicity to the particles. We will develop a correlation between the amount of silane agent and the hydrophobicity or surface chemistry of the particles. With this, it would be possible to target a certain level of hydrophobicity and achieve that level using the correlation. The proposed work will leverage my laboratory and analytical research skills from prior projects. From this experience, I had the opportunity to contribute on a peer-reviewed manuscript published in 2016 and present at a national research conference.

Resources: From experience in my faculty mentor's research group, I have the following resources available: faculty mentorship, graduate student mentorship, weekly research meetings, microscope, rheometer, and access to SEM and TEM imaging systems. These resources will ensure the completion of this project.

Expected Results and Timeline: This project is expected to elucidate the effect of particle hydrophobicity on demulsification of produced water emulsions (high water cut) for application in treating produced water. The data generated in this project will be used to predict demulsification rates of produced water emulsions and thereby lead to the development of enhanced produced water treatment strategies.

September	October	November	December	January	February	March	April	May

Refine procudure for controlling particle wettability → Develop surface chemisty correlation from amount of silane → Test particles on model emulsions at various water cuts → Elucidate the impact of brine

References

1. Fakhru'l-Razi, A., A. Pendashteh, L. Abdullah, D. Biak, S. Madaeni, and Z. Abidin. "Review of Technologies for Oil and Gas Produced Water Treatment." Journal of Hazardous Materials 170.2-3 (2009): 530-51. Web. 11 Feb. 2017.
2. Morales, Rosanel, Eduardo Pereyra, Shoubo Wang, and Ovadia Shoham. "Droplet Formation Through Centrifugal Pumps for Oil-in-Water Dispersions." SPE Journal 18.01 (2012): 172-78. Web. 11 Feb. 2017.