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Solubility and Viscosity of Organic-Seawater-Surfactant Solution

Miachel R. Banish
University of Alabama in Huntsville

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2016 Summer RCEU Program

Faculty Advisor: R. Michael Banish, Associate Professor, banishm@uah.edu
Chemical and Materials Engineering, EB117E
256-824-3544

Project Objective

The objective if this project is to determine the solubility and solution viscosity of selected organic-seawater-surfactant mixtures. This work will be an extension of research that has been started by the Faculty Advisor.

Project Summary

The FA has performed a series of preliminary measurements to determine the viscosity, density, and solubility behavior of Corexit®9500-sea or distilled water-tetradecane mixtures.

The behavior of Corexit®9500 is markedly different when mixed with distilled or seawater. This indicates that the thermophysical properties of surfactant mixtures depend on the salinity of the water column. Corexit9500 and distilled water are miscible across most of the concentration range. The FA has determined the viscosity and density of Corexit®-pure water mixtures at a range of concentrations and temperatures; these results are plotted in Figure 1. The density versus temperature data shown in Figure 1a highlights that the non-linear functional dependence of surfactant and water. As can be seen from Figure 1b, the kinematic viscosity of dispersant-distilled water increases rapidly from the boundaries and is almost a 100 times higher at the maximum.

The FA has also performed a series of solubility studies with Corexit®9500A-(synthetic) Seawater-tetradecane. A ternary phase diagram of these solutions is shown in Figure 2. In contrast to the behavior of Corexit-freshwater, Corexit-synthetic seawater are essentially immiscible in each other; the full solubility range of the ternary solution is very limited. Low concentrations of Seawater-Corexit solutions, 1-10 volume percent Corexit, form a milky solution, i.e., a micro-emulsion. This micro-emulsion does not dissolve tetradecane, an alkane, added after the micro-emulsion forms. This indicates that Corexit injected directly into Seawater, as opposed to freshwater, will be ineffective in oil spill mitigation; this behavior of not solubilizing alkanes may be different for cyclic or aromatic hydrocarbons. The mixing of Corexit®9500A and tetradecane has a different system response, Corexit® and tetradecane are soluble in each across limited ranges. What is of note is that the addition of small amount of seawater to a separated surfactant-organic mixture increases the miscibility of these solutions, gray circles in Figure 3.

Student Prerequisites

The student will have junior standing in the Department of Chemical and Materials Engineering. This requires that the student has completed CHE197, CHE198 (or equivalent), CHE244; and CHE294-5, with a GPA for these courses of 3.3 or better. Also, the student should have CH121, 123, and CH331, CH125, CH126, CH335, MA171, MA172, and PH111; the GPA requirement for these courses is 3.0.

Student Duties

The student will perform solubility studies of ternary selected organic-seawater-surfactant mixtures. The student will perform viscosity measurements on the various phases from these mixtures. A phase diagram and viscosity diagram will be produced from the result of this work

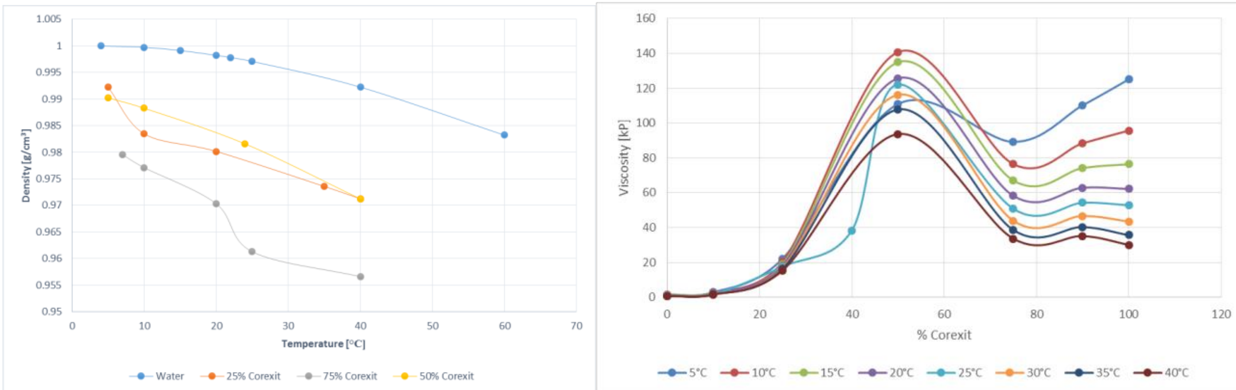

Figure 1. a) density versus temperature for a range of Corexit®-distilled water mixtures. The ρ(T) behavior is nonlinear and concentration dependent. b) Kinematic viscosity versus Corexit® concentration at a range of temperatures. The viscosity increases by two orders of magnitude.

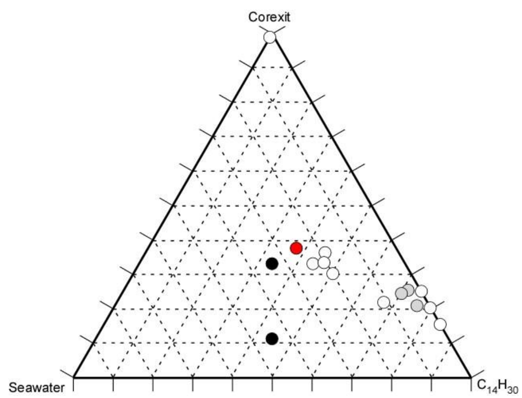

Figure 2 Ternary Phase Diagram of Corexit®9500-Tetradecane-Seawater, volume fraction. The temperature of these measurements was 4-30°C. The light gray circle represent concentrations that yield a single phase, open circles two phases, black-red circles three phases (red two or three phases depending on temperature). The volume of the two or three phases depends on the temperature. In general, there is less phase separation at lower temperature. As can be seen from the data, the region of a miscible single phase is of limited extent.

Mentor Supervision and Interaction

I will meet with the student on a near-daily basis. Depending on the results that the student has obtained these meeting may be less than 15 minutes or over an hour. As the experimental results are obtained we will discuss and plan the next set of analysis. The conduct of the experiments is not difficult. The equilibrium studies of solubility typically involved temperature stabilizing a solution over a day to several days. The viscosity determinations can be performed in less than an hour. However, repeat measurements of each sample are necessary, so this can be a time consuming process. It is expected that the student has the ability to "pay attention to detail".

Reporting of Results. It is expected that this project will result in a publication to a journal such as the International Journal of Thermophysics.