

## MATERIALS ENGINEERING

### SEMINAR

#### “SYNTHESIS AND CHARACTERIZATION OF FATTY ACID AMIDE-BASED SURFACTANTS AND PHYSICOCHEMICAL PROPERTIES OF EMULSIONS STABILIZED WITH MIXED NONIONIC AND ANIONIC SURFACTANTS”

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Purdue MSE Ph.D. Final Exam

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#### ABSTRACT

Surfactant is a type of surface-active molecule with wide industrial applications, such as personal care products, antibacterial products, surface modification, etc. Due to environmental concerns, bio-based surfactants derived from renewable sources are of great interest. In the first part of this work, bio-based quaternary ammonium (QA) amphiphiles are synthesized from soybean oil via a two-step reaction. For example, fatty acid amides (FAAs) were first synthesized through direct amidation of soybean oil. The FAAs exhibited different liquid-solid phase transition behavior depending on their saturation and chain length. A general trend of increasing enthalpy of fusion, narrower phase transition temperature range, higher melting temperature, and better thermal stability was observed with increasing chain length and saturation. Overall, fifteen green, organic PCMs were synthesized with the comparable latent heat of fusion to petroleum based PCMs.

Bio-based QA surfactants were successfully synthesized with comparable surface activity to cetyltrimethylammonium bromide (C<sub>16</sub>TAB) by alkylating FAAs into quaternary ammonium (QA) compounds. The water solubility of long-chain (C18) QA surfactants was improved by introducing two or more QA groups in the headgroup, or unsaturation in the tail group. All the surfactants exhibited positive charge with high stability against varying pH. Surfactants derived from fully hydrogenated soybean oil (FHS) and diethylenetriamine (DETA) showed lower critical micelle concentration (CMC) and surface tension in water (SFT) than C<sub>16</sub>TAB. All the other five surfactants had surface activity comparable to C<sub>16</sub>TAB and C<sub>12</sub>TAB. These bio-based surfactants are potential alternatives to commercial petroleum-derived QA surfactants.

The second part of this work is devoted to understanding the effect of mixed surfactant composition on emulsion stability, and formation is beneficial for optimizing the wastewater treatment process. Emulsion behavior in a saline environment was studied with mixed anionic and nonionic surfactants: sodium lauryl sulfate (SLES) and Triton X-100. It was found 500 ppm total surfactant concentration was sufficient to stabilize 5 wt. % mineral oil against coalescence, regardless of the surfactant ratio. Compared to Triton X-100-rich emulsions, SLES-rich ones had higher stability against flocculation and creaming. SLES-rich emulsions had twice as much remnant oil in the supernatant as Triton X-100-rich samples, which is undesirable in wastewater treatments. The relation between spontaneous emulsion behavior and the HLD model was studied with SLES-Span-80 surfactant mixtures. The influence of salinity, oil type, and surfactant composition was investigated. Spontaneous emulsification could only be observed when the systems have HLD values close to 0 (-0.96 ~ 1.04). A combined effect of bicontinuous-phase formation and ultra-low interfacial tension led to spontaneous emulsification. This work proposes a practical approach to predict emulsion compositions that result in spontaneous emulsification.

**Date: Wednesday, March 8, 2023**

**Time: 1:00 P.M.**

**Place: ARMS 1021 or via the link: <https://purdue.webex.com/meet/martin19>**