DEPARTMENT OF **CHEMICAL & ENVIRONMENTAL ENGINEERING**

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NANO-PARTICLES IN HYDROCARBON ENERGY PRODUCTION

New phase formation is an integral part of hydrocarbon production from the subsurface. Water and light components of petroleum fluids may form hydrate crystals at temperatures as high as 25 ^{o}C. In deep water in offshore Brazil (largest project in the world), US Gulf of Mexico, and the North Sea, where large quantities of hydrocarbons are being produced, the seabed temperature is around 4 ^{o}C. At such a condition, formation of hydrate crystals is a major concern. In the recent oil spill disaster in the Gulf of Mexico, formation of large pieces of hydrates resulted in the failure of oil capture from the dome placed on top of the flowing well. In one very large natural gas project in the North Sea, more than 50% of world's production of monoethylene glycol is required to change bulk phase properties to avoid formation of hydrate crystals in flowlines.

A very different new phase formation in petroleum fluids is the formation of asphaltenes in the subsurface, and flowlines. The energy industry uses large quantities of aromatic solvents to change bulk phase properties to avoid deposition of asphaltene phase.

This presentation will focus on the vast opportunities in the production of hydrocarbons from the formation of new phase in the form of nano-particles and micron-scale particles by the change of surface properties. The major objective is the use of the least amount of surfactants to avoid aggregation and growth of particles. The talk is divided into two parts. In the first part our recent experimental success with use of surfactants which can induce electrostatic interaction between particles will be discussed. The focus of the work in the literature on hydrates has been mainly on steric repulsion which may not be as efficient as electrostatic repulsion. The combined use of two different surfactants and small amounts of alcohol cosurfactant in hydrate nano-particles may result in significant improvement in stabilization of hydrate particles and may also have a drastic improvement in kinetic of the process such as increase in induction time. For asphaltene stabilization, our work reveals that a 10 ppm surfactant additive can be more effective than an alcohol solvent with several orders of magnitude higher concentration. In the second part of the presentation, the molecular thermodynamic framework is introduced to model the self-assembly of different types of molecules in a mixture of oil, water, salt, alcohol, and surfactant. The long term goal of modeling is description of our experimental data and tuning the size and electrostatics. Even in its present stage the theory has been a useful guide in the selection of some of the additives.