MECHANICAL & INDUSTRIAL ENGINEERING COLLOQUIUM: ME 794

Wednesday, February 22, 2012

1:00 – 2:30 PM
224 MEC

Morphology and its influence on rheology of clathrate-hydrate forming emulsions

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Multiphase transport in petroleum pipelines may be plagued by the formation of clathrate hydrates. Clathrate hydrates, or simply "hydrates" are unusual crystalline solids formed of water and a guest molecule such as methane. Hydrates pose potentially severe hazards to subsea hydrocarbon transport due to the possibility of blockage of a pipeline by a hydrate plug: such plugs are notoriously difficult to remediate as will be discussed.

While hydrates of gases form at high pressure, cyclopentane forms hydrate under atmospheric pressure and serves as a very good laboratory model for high-pressure gas hydrates. This work addresses the morphological characteristics of cyclopentane as well as pentane gas hydrates and their relation to the bulk rheological properties of the CP hydrate emulsion. We use a combination of crystal morphology visualization at a single water drop and rheometric studies using density-matched water-in-oil emulsions (to avoid sedimentation/creaming effects). The work discussed here will focus on the effect of an oil-soluble surfactant sorbitan monooleate (Span 80). In the absence of surfactant, a faceted polycrystalline hydrate shell develops around the water drop limiting transport of hydrate former cyclopentane to the free (liquid) water which remains trapped inside the hydrate layer. The presence of Span 80 at concentrations greater than 0.01% by volume in the oil phase leads to a hairy or mushy hydrate morphology. A detailed analysis is presented to explain the role of Span 80 on transport and driving force for the morphological development. The impact of this morphology on the rheology of the emulsion includes cases of large viscosification and jamming. A mechanism for the evolving rheological behavior is presented.

BIOGRAPHY

Dr. Morris is Professor of Chemical Engineering in the Levich Institute at the City College of New York, the primary engineering campus of the City University of New York. He received the bachelor's degree from Georgia Tech in 1989, and a Ph.D. from Caltech in 1995, both in Chemical Engineering. He then spent a year as a postdoctoral researcher at the Shell Research laboratory KSLA in Amsterdam. He was a member of the faculty in Chemical Engineering at Georgia Tech from 1996-2002 and from 2002-2004 was with Halliburton Energy Services, where he served as a Senior Scientific Advisor. He joined the Levich Institute at CCNY in 2005. He has held Visiting Professor positions at the Université de Paris Sud (at the Laboratory FAST) and Université de Provence (at the Laboratory IUSTI), and is a visiting Director of Research of the CNRS in France. The Morris research group is interested in developing a fluid mechanical description appropriate for complex fluids, particularly suspensions, colloids, and emulsions. Applying simulation and experiment, combined with ideas of statistical and continuum mechanics, the research seeks to develop understanding of flow-induced microstructure and the resulting mixture rheology. With E. Guazzelli, Morris is the author of "A Physical Introduction to Suspension Dynamics" published by Cambridge University Press.

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