University of Colorado Boulder

Water Energy Nexus IRT

2018 Seed Grant Final Report

Title: Rapid Novel Agglomeration Process in the Water-Energy Nexus

PI Name: Robert H. Davis, 3/11/2019; **CoPI Name:** Sherri Cook

Research Objective(s): This research considered a new process for recovery of fine hydrophobic particles and organic droplets from water. It uses an emulsion binder of salt-water droplets covered by thin, surfactant-stabilized oil layers. The primary research objective was to model the rate of particle capture, as guidance for future experimental research and process development.

Research Activities/Methodology: The research activities included three components:

- *Model development* – Modeling work involved lubrication theory for the interaction of a particle and a nearby drop with a permeable interface (the oil layers are permeable) and a trajectory analysis to predict capture rates.
- *Supporting experiments* – A key parameter in the model is the oil-layer permeability, and so we designed an experiment to determine its value by measuring the rate of expansion of salt-water drops due to osmotic flow.
- *Environmental analysis* – A spreadsheet was developed by the co-PI to test and compare different scenarios for environmental impact and energy demand.

Results: The first task, to predict collision rates for nonexpanding drops with permeable interfaces, was completed and published (Davis and Zinchenko, 2018). Even a small dimensionless permeability (10^{-4}) gives a substantial collision efficiency (0.17), whereas the collision efficiency is identically zero without permeation. A second task, on particle-capture rates by drops that expand due to osmotic flow, is underway. The experimental design and acquisition of the necessary equipment and supplies are complete, and preliminary experiments are underway. The spreadsheet for environmental analysis is complete; we will used it once our collaborators have established their preferred operating conditions and input parameters.

Accomplishments:

- Davis, R.H., Zinchenko, AZ "Particle Collection by Permeable Drops," *Phys. Rev. Fluids* **3**:116661
- PENDING: American Chemical Society – Petroleum Research Fund, "Fundamentals of Hydrophobic Particle Capture," 9/1/2019 – 8/31/21, $110,000 (PI: Robert H. Davis)
- PENDING: Australian Research Council, "Centre of Excellence for Enabling Eco-efficient Beneficiation and Minerals", $35,000,000 AUD (PI: Kevin P. Galvin)
- DECLINED: Department of Energy, "Center for Harnessing Energy-water Interface Environments," $14,354,685, (PI: Dan Schwartz)
- DECLINED: National Science Foundation, "NRT-INFEWS: Food, Energy and Water Nexus - From Satellite to Village," $3,000,000 (PI: Robert H. Davis)
- Presentations: Three conference presentations and two invited seminars

Conclusions/Next Steps:

The WEN-IRT seed grant provided important help in initiating this project and supporting preliminary work that formed the basis for several follow-on proposals to ACS-PRF, ARC, DOE and NSF. If we receive one or more of these grants, then we will continue both modeling and experimental work to determine particle collect rates and optimal process conditions. At minimum, a master's student on the project will finish her work this summer, and we anticipate having a novel paper submitted on particle capture by expanding drops.