SAND2011-2446C

Microfluidic Experiments for Mass Transport

Christine Roberts, Martin Nemer and Anne Grillet

Engineering Sciences External Panel Review
April 14, 2011

Sandia is a Multiprogram Laboratory Operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy Under Contract DE-ACO4-94AL85000.

NNSA National Nuclear Security Administration

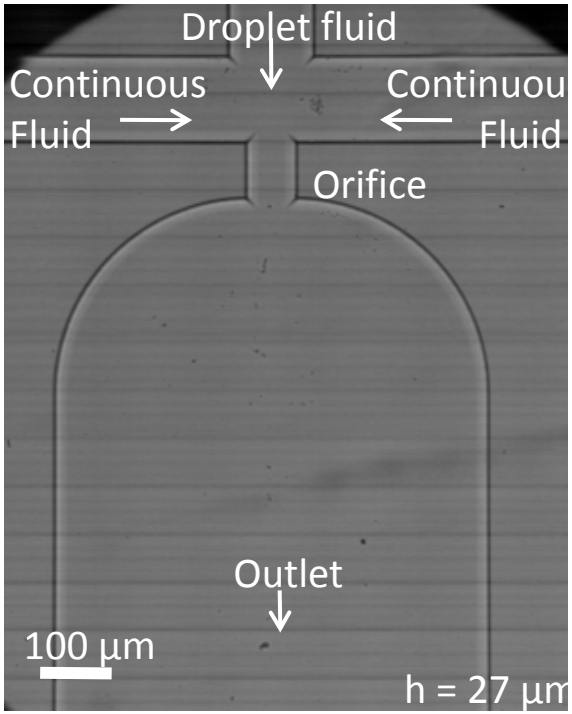
LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

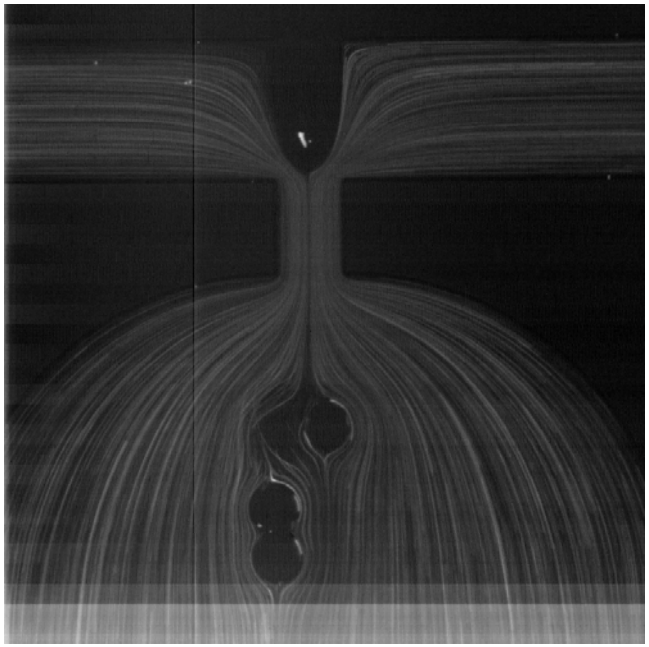
Sandia National Laboratories

Droplet-scale Experiment in Microfluidic Device

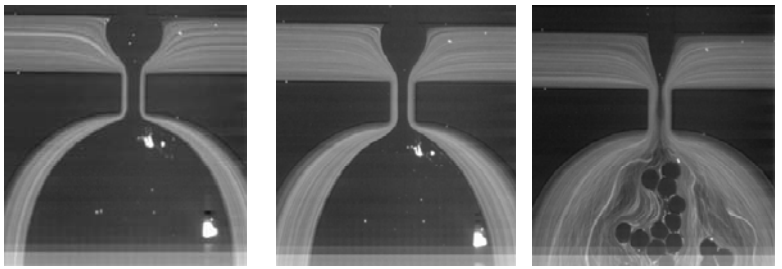
Goals:

- Create uniformly sized droplets
  - ➢ *Flow Focusing Microchannel*
- Understand flow field inside/around droplets
  - ➢ *Phantom high speed camera*
- Understand liquid-liquid mass transfer
  - ➢ *Ocean Optics spectrophotometer*



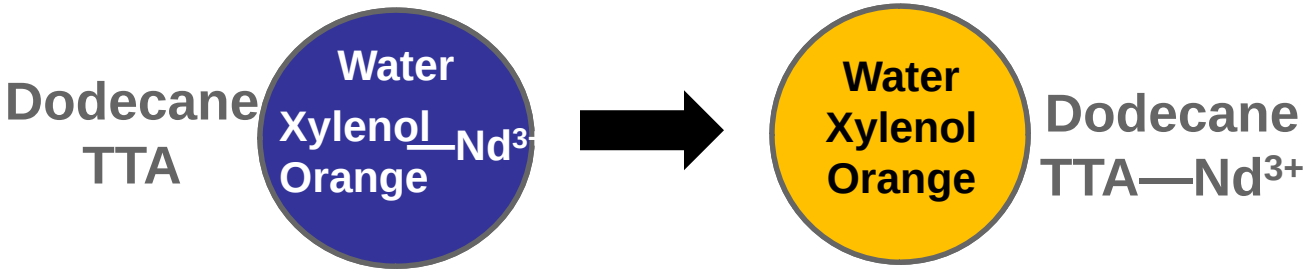


Decreasing inner flow rate

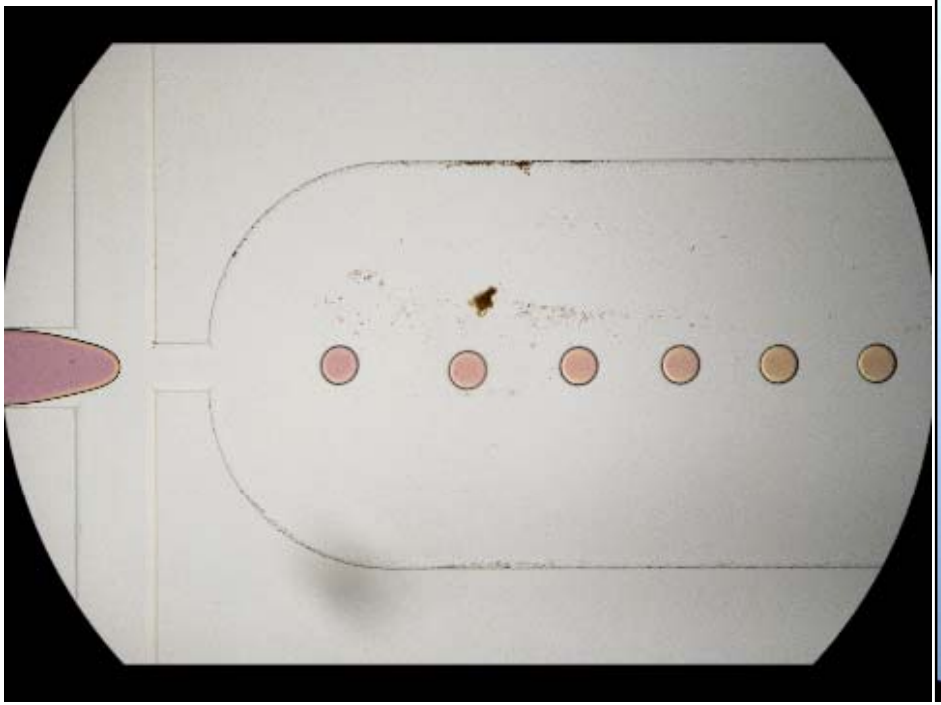


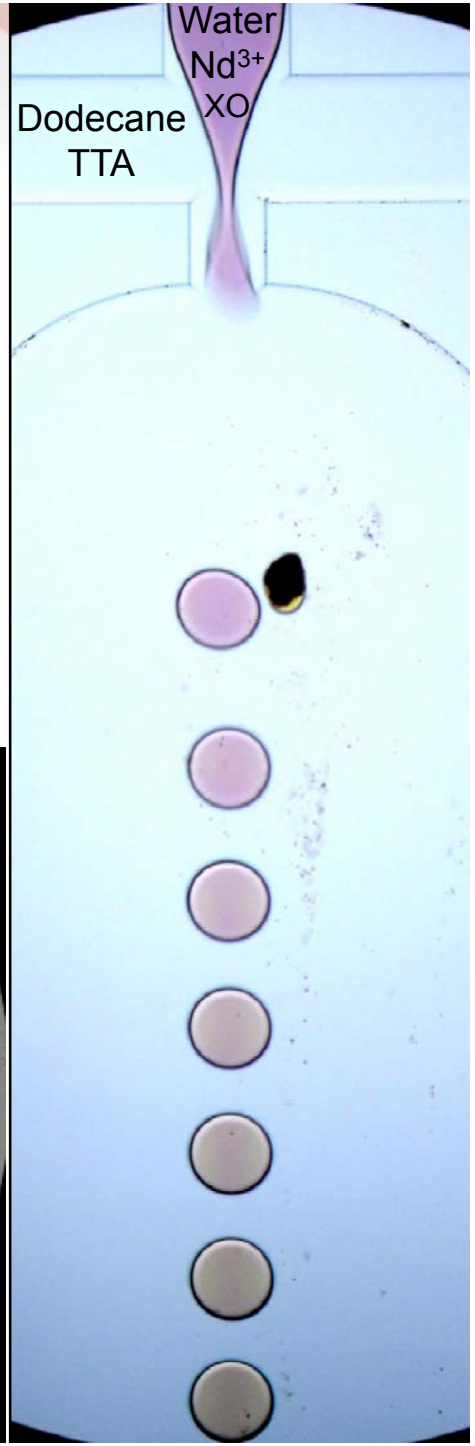
Model System Developed for Mass Transfer Validation

- A model system was chosen based on Nd



- A spectrophotometer is used to watch Nd^{3+} transfer from the water to the dodecane





National Nuclear Security Administration

Accomplishments and Future Work

- Droplet-scale model using CDFEM have been developed and verified on a published 2D benchmark problem from Hysing et al, 2009
- Mass transport has been incorporated into the CDFEM model
- A model system was developed using Nd and xylenol orange, with a new spectrophotometer to give quantitative mass transport data for the validation study
- A quantitative droplet-scale mass transport validation experiment is underway using the spectrophotometer
- Advanced thermodynamic models have been developed are under development for the Nd system
- Single-phase turbulent contactor simulations have been completed
- Working towards modeling two-phase flow in a contactor using first a diffuse level set method and then CDFEM
- Collaboration with Marianne Francois (LANL) for DOE/NEAMS
- Hired post-docs Christine Roberts, Nick Wyatt and staff Martin Nemer
- Network modeling and criticality modeling will be a focus of next FY

Presentations and Publications

Presentations/Panels/Minisymposia

- RR Rao, DR Noble et al, “Predicting Interfacial Mass Transport Using the Conformal Decomposition Finite Element Method ,” Finite Elements in Fluids, March, 2011
- RR Rao, DR Noble, MB Nemer, CR Roberts, HK Moffat, “Mass Transfer from a Buoyant Droplet Using the Conformal Decomposition Finite Element Method,” USCCM11, July, 2011
- M Loewenberg, RR Rao, “A simplified model for the evolution of the drop size distribution in an emulsion under strong-flow conditions,” Keynote, 27th Annual Meeting of PPS, Marrakesh, Morocco, May, 2011
- Invited Posters: LDRD Day, Albuquerque, NM, 2010; NNSA TriLAB LDRD Symposium, Washington, DC 2011
- Invited seminars: Los Alamos National Laboratory; Proctor and Gamble
- RR Rao invited to participate in NSF panel on Mass Transport
- **RR Rao and DR Noble organized FEF11 and USNCCM11 Minisymposia on CFD for Moving Boundaries**

Publications

- Featured Project, 2010 LDRD Highlights, Sandia National Laboratories
- M Loewenberg, RR Rao, “A simplified model for the evolution of the drop size distribution in an emulsion under strong-flow conditions,” Proceedings of the 27th Annual Meeting of the PPS, Morocco, May, 2011
- CF Jove-Colon, HK Moffat, RR Rao, “Thermodynamic modeling of liquid-liquid extraction for the system,” Proceeding of the International High-Level Radioactive Waste Management, Albuquerque, April, 2011
- M. B. Nemer, P. Santoro, X. Chen, J. B Blawzdziewicz, M. Loewenberg, “Coalescence of drops with mobile interfaces in a quiescent fluid,” to be submitted, Journal of Fluid Mechanics
- JB Lechman, MB Nemer, DR Noble, “Application of Conformal-Decomposition Finite Elements to Particle Suspensions,” to be submitted, IJNMF
- CR Roberts, MB Nemer, AM Grillet, “Monodisperse droplet generation in a thin flow-focusing μchannel,” Physics of Fluids, in preparation, 2011
- RR Rao, DR Noble, MB Nemer, “CDFEM for transient interfacial flows: A Verification Study, “ J Comp. Phys, in preparation 2011