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Using Mass Transport to Control Microscale Emulsion Formation

ABSTRACT

Droplet-based processing strategies in lab-on-a-chip devices hold great promise due to the ability to create precise volumes, to protect encapsulated materials, and to easily manipulate droplets. The microfluidic length scales in these devices also change the relative importance of various modes of mass transport like diffusion, kinetics, and convection. Knowledge of the relevant transport timescales for surface-active components like surfactants and particles has allowed us to control the formation of emulsions in ways not possible at the macroscale. For small molecule surfactants that diffuse rapidly, adsorption to interfaces in microfluidic geometries is kinetically limited. Here, the balance of kinetics and convection can be exploited in a microscale tipstreaming process to produce monodisperse, submicron emulsion droplets. For micron-sized surface-active particles that diffuse more slowly, adsorption to interfaces in microfluidic geometries is diffusion limited. Here, the balance of diffusion and convection can be exploited in a microfluidic bubble generator to produce stable, nonspherical Pickering foams. These two examples highlight the potential for developing microfluidic processes to synthesize novel multiphase materials.

BIOGRAPHY

Shelley L. Anna is Professor of Chemical Engineering and Mechanical Engineering at Carnegie Mellon University. She also holds an affiliated appointment in Physics. Prior to joining Carnegie Mellon in 2003, Dr. Anna received her B.S. in Physics from Carnegie Mellon, and an M.S. and Ph.D. in Engineering Science from Harvard University in 2000. She worked as Senior Research Engineer at Solutia Inc., and then completed a postdoctoral fellowship at Harvard University. At CMU, Dr. Anna's research interests are in multiphase microfluidics, interfacial rheology, and microscale transport phenomena. Dr. Anna is the recipient of a 2005 NSF CAREER award, the 2006 George Tallman Ladd Research Award from the College of Engineering at Carnegie Mellon, and a 2012 Honorable Mention for a Carnegie Science Award in the category of Emerging Female Scientist. Dr. Anna received the Russel V. Trader Career Faculty Fellowship in Mechanical Engineering in 2011.