Chemical Engineering & Materials Science

University of Minnesota

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Professor

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Education
B.Ch.E., University of Minnesota, 1993
M.S., Ch.E., Stanford University, 1994
Ph.D., Ch.E., Stanford University, 1998

Research Areas
Applied & Computational Mathematics
Materials Processing
Transport & Fluid Mechanics

Research Interests

The processing of materials plays a central role in the disciplines of chemical engineering and materials science. Materials often are in a liquid or liquid-like state while being processed, and have interfaces with other media. Many such materials also contain complex structural elements like colloidal particles, polymer chains, and surfactant aggregates whose size is much larger than that of typical solvent molecules.

Our research involves integration of transport phenomena, colloid and interface science, rheology, applied and computational mathematics, and experiments to address fundamental issues motivated by problems in materials processing. These fundamental investigations are frequently inspired by industrial applications in areas such as coating and printing processes, polymer processing, nanofluidics/microfluidics, and energy. Topics of current interest include:

*Dynamic wetting*: Dynamic wetting is crucial to processes where liquid displaces another fluid along a solid surface, such as the deposition of a liquid coating onto a moving substrate or the displacement of oil in rock pores. Our efforts are aimed at improving fundamental understanding of dynamic wetting, and harnessing that understanding to address materials-processing-related issues such as the transfer of liquid between two separating surfaces and the entrainment of air in high-speed coating processes.

*Interfacial instabilities*: Instabilities at interfaces are usually undesirable in materials processing operations, but can sometimes be exploited for scientific and technological purposes (e.g., creating a topographically patterned surface). These instabilities can be driven by a variety of sources, including hydrodynamic, electrostatic, and intermolecular forces. We are interested in characterizing when and how interfacial instabilities occur, and in
developing ways to control them.

**Interfacial flows of suspensions:** The successful large-scale manufacture of emerging products in the energy and electronics industries requires that particulate suspensions be coated and printed at high speeds with minimal defects. By combining ideas from colloidal rheology and interfacial fluid mechanics, we are examining a number of model problems in this area.

**Polymer dynamics near surfaces:** The behavior of polymers near surfaces plays a key role in a variety of applications including biosensors, suspension rheology, and the development of novel nanostructured materials. In many cases, the surface may be patterned chemically and/or topographically, and fluid flows and electric fields may be present. We are applying Brownian dynamics simulations to study how fluid flow, electric fields, and surface patterning can be designed to manipulate the behavior of macromolecules near surfaces. Various molecular theories are leveraged to guide the simulations and to understand the results.

**Awards**

See CV

**Selected Publications**

Drying of Droplets of Colloidal Suspensions on Rough Substrates (with T. Pham), Langmuir 33, 10061-10076 (2017).


Stretching Liquid Bridges with Moving Contact Lines: Comparison of Model Predictions and Experiments (with C.-H. Huang and M. S. Carvalho), Soft Matter 12, 7457-7469 (2016).


Spreading of Thin Droplets of Perfect and Leaky Dielectric Liquids on Inclined Surfaces (with A. Corbett), Langmuir 32, 6606-6617 (2016).