UNIVERSITY *of* NOTRE DAME

COLLEGE *of* ENGINEERING

Department of Aerospace and Mechanical Engineering

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The Mechanics of the Surfactant-Driven Fracture of Particle Rafts and the Influence of Surface Tension

Wednesday, September 27th, 2017, 3:30P.M.

136 DeBartolo Hall

Refreshments served 365C Fitzpatrick Hall at 3:00 p.m.

When a densely packed monolayer of hydrophobic particles is placed on a fluid surface, the particles interact through capillary bridges, leading to the formation of a particle raft or "praft". Densely packed monolayers exhibit a two-dimensional elastic response, and they are capable of supporting both tension and compression. The introduction of a controlled amount of surfactant generates a surface tension gradient, producing Marangoni forces and causing the surfactant to spread, fracturing the monolayer. These systems are of interest to materials scientists and engineers because they provide an idealized setting for investigating the interplay between fluid flow and fracture. Previous studies of the surfactant-induced fracture of prafts have examined the role of viscosity and the initial packing fraction on the temporal and spatial evolution of the fractures. The potentially important role of differences in surface tension between the surfactant and the underlying fluid has not been explored.

This seminar will describe a new continuum-based model and simulations that account for the interplay between the pressure exerted by a spreading surfactant and the elastic response of the praft, including the fracture toughness. This is effected through the use of a "surfactant damage" field that serves as both an indicator function for the surfactant concentration, as well as the damage to the monolayer. Stochastic aspects of the particle packing are incorporated into the model through a continuum mapping approach. The model gives rise to a coupled system of nonlinear partial differential equations, with an irreversibility constraint. We recast the model in variational form and discretize the system with an adaptive finite element method. A comparison between model-based simulations and existing experimental observations indicates a qualitative match in both the fracture patterns and temporal scaling of the fracture process. Based on the model, we determine a dimensionless parameter that characterizes the ratio between this driving force and the fracture resistance of the praft. Interestingly, while our results indicate that the stochastic aspects of the packing are important to the fracture process, we find that regimes of fracture are largely governed by differences in surface tension. Finally, we support our findings with newly designed experiments that validate the model and confirm the trends inferred from the simulations.

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If you are interested in meeting individually with Dr. Dolbow, please contact Carly at 631-5431.

Midwest Mechanics Seminar Series