Ultrasound Contrast Agents: A problem in Fluid Mechanics

Kausik Sarkar
Department of Mechanical Engineering,
University of Delaware, Newark, DE 19716.

Micron-size gas bubbles are intravenously injected into patients' body to improve ultrasound blood flow images. These bubbles are encapsulated by a thin layer (~4-10nm) of protein, lipids and other surface active materials to prevent their premature dissolution in the blood. Strong ultrasound pulses can destroy these bubbles by rupturing the encapsulation. Destruction of microbubble agents can be used in real time blood flow velocity measurement, stimulating arteriogenesis (generation of new arteries) or targeted drug delivery. The encapsulation critically affects the performance of these agents in all applications. We have developed an interface model of the encapsulation that has an intrinsic surface rheology with surface viscosity and elasticity. In this talk, I will describe our approach that includes determination of rheological properties using one set of *in vitro* experiment, and then model validation using another set. Data on several contrast agents such as Sonazoid (Amersham Health, Oslo, Norway), Optison (GE Health Care, Princeton, NJ), Definity (Bristol Myers Squibb, N. Billerica, MA) will be presented. I will also present a model for the dissolution of microbubbles that accounts for the effects of encapsulation. The encapsulation hinders the permeability of the gas-liquid surface and its elasticity balances the surface tension induced stress. Both these effects will be explicitly modeled. The model behavior will be discussed for variations of the material parameters and conditions (encapsulation permeability and elasticity, mole fraction of the osmotic agent and liquid saturation).

If the time permits, in a second part, I will briefly discuss our computational research on deformation of a viscoelastic drop in a simple shear flow. We use the Oldroyd-B constitutive equation for the viscoelastic phase. In our investigation, we found that drop viscoelasticity results in an overshoot in drop deformation evolution due to the finite time it takes to develop the viscoelastic stress. This stress is inhibitive and leads to a decreased steady value. We provide an ordinary differential equation model for the observed scalings.