The effects of polymer molecular weight on filament thinning & drop breakup in microchannels

Paulo E. Arratia
Dept. Mechanical Engineering & Applied Mechanics
University of Pennsylvania

In this talk, the effects of fluid elasticity on the dynamics of filament thinning and drop breakup processes are investigated in a cross-slot microchannel. Elasticity effects are examined using dilute aqueous polymeric solutions of molecular weight (MW) ranging from 1.5×10^3 to 1.8×10^7. Results for polymeric fluids are compared to those for a viscous Newtonian fluid. The shearing or continuous phase that induces breakup is mineral oil. All fluids possess similar shear-viscosity (~0.2 Pa s) so that the viscosity ratio between the oil and aqueous phases is close to unity. Measurements of filament thickness as a function of time show different thinning behavior for the different aqueous fluids. For Newtonian fluids, the thinning process shows a single exponential decay of the filament thickness. For low MW fluids (10^3, 10^4, and 10^5), the thinning process also shows a single exponential decay, but with a decay rate that is slower than for the Newtonian fluid. The decay time increases with polymer MW. For high MW (10^6 and 10^7) fluids, the initial exponential decay crosses over to a second exponential decay in which elastic stresses are important. We show that the decay rate of the filament thickness in this exponential decay regime can be used to measure the steady extensional viscosity of the fluids. At late times, all fluids cross over to an algebraic decay which is driven mainly by surface tension.

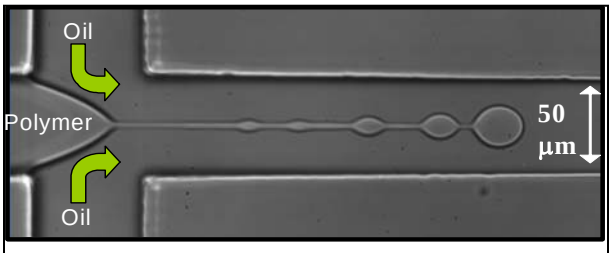

Figure 1: Polymer fluid filament being stretched by an immiscible oil fluid of same shear viscosity in a 50 μm cross-slot microchannel.