Migration of polymer molecules near flowing fluid interfaces
HONGBO MA, University of Wisconsin-Madison, JUAN J. DE PABLO, MICHAEL D. GRAHAM — Migration of polymer molecules near flowing fluid interface is explored. First, a simplified system, a bead-spring dumbbell above a planar solid wall is considered. In shear flow, the dumbbell is stretched and aligned in the flow direction. The perturbation flow generated by the motion of beads can be calculated using the full hydrodynamic interaction tensor, and it is shown that the center of mass of the dumbbell is driven away from the wall by this perturbation flow. At the same time, Brownian diffusion always tries to smooth out the concentration gradient. As a direct result of balancing these two competing factors, a depletion layer appears. At steady state, the thickness of the depletion layer can be much larger than the size of the molecule, and depends on the normal stress differences and the molecular diffusivity, which in turn depend on the shear rate and molecular weight. Theoretical predictions are compared to detailed computer simulations for a more realistic system, a bead-spring chain model of a DNA molecule and good agreement is obtained. The migration near the interface between two fluids with different viscosities is also investigated. Finally, a novel separation mechanism based on the migration phenomena is proposed and a prototype device with wavy-shape channel is explored.

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