Motion of Droplets under Shear Flow with Suction

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In Drug Delivery System (DDS), the drug is encapsulated in a liposome. The liposome passes through the epidermal cells in blood vessel and it is important whether the liposome arrives at inflamed region or not. In this study, we simulate the suction of the droplet from the simple shear flow region in blood vessel to the Poiseille flow region between endothelia as shown in FIG. 1.

The solutions are given by the boundary element method (BEM) assuming 2D geometry. The boundary of the droplet and the walls are composed of small line elements. The elements interact each other with Green function.

Snapshots of the system $l/a = 1.5, w/a = 1$ under a given shear rate are shown in FIG. 2 for several surface tensions σ and suction pressures p. In this case, the ratio between outer and inner viscosity is $\lambda = \eta^{in}/\eta = 1$. The snapshots show the particle behavior in the vicinity of the entrance of the Poiseille flow region. When the shear effects are stronger than the suction pressure, the droplets pass over the Poiseille region shown in (a)-(f) in Fig. 2. On the other hand, the droplet is sucked into the Poiseille region when the pressure is strong enough as shown in (i). We found that the suction of the droplets is dependent on the parameter

$$\alpha = \frac{\eta\dot{\gamma}l}{w^2 p_y},$$

which characterizes the ratio between the shear flow and the Poiseuille flow.

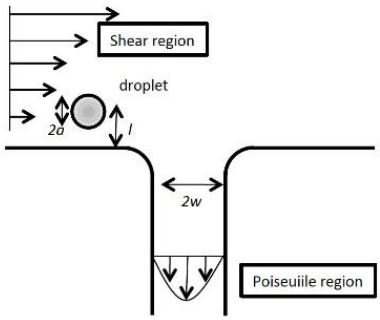

FIG. 1: Simulation system. The radius of the droplet is a and its initial position from the wall is l. The width of the Poiseuille region is $2w$.

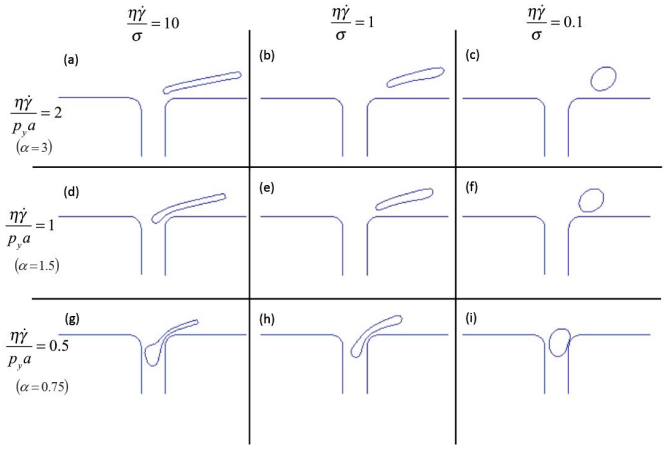

FIG. 2: Snapshots of the droplets of $\lambda = 1$ with $l/a = 1.5$ and $w/a = 1$. Here the shear rate $\dot{\gamma}$ is fixed, and the pressure gradient p_y and the surface tension σ are varied.