Graduate Student Research Seminar

Spring 2024

Accelerated Transport of Highly Viscous Liquid through Microchannels by Multiphase Flow over Superhydrophobic Surface

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3:00 pm (EST) – 132 Fluor Daniel Building

Abstract

It is well-known that the flow resistance of a fluid moving through a cylindrical pipe increases rapidly with decreasing pipe diameter, i.e., inversely proportional to the diameter to the fourth power, which is determined by the Hagen-Poiseuille law. Consequently, it becomes a big challenge to transport liquid efficiently in small pipes, and it is more difficult for highly viscous fluids such as molten materials widely used in 3D printing. However, as a channel decreases in size, the surface area-to-volume ratio becomes large, wherein the surface forces dominate the fluid transport. By taking the advantage of interfacial forces in drop-based transport of liquid, the transport of highly viscous droplets moving through microchannels with superhydrophobic surface using many-body dissipative particle dynamics simulations was investigated. Two liquid droplets with similar surface tension but significant differences in viscosity are considered. By applying the same pressure gradient to drive the two different droplets, a faster motion of the more viscous droplet than the less viscous droplet is observed by a comparison of their center of mass velocities. This observation is opposite to traditional continuous fluid flow through microchannels but is consistent with recent experiments on viscosity-enhanced droplet motion. We quantify how viscosity, surface wettability, skin friction, and air-liquid surface tension affect the motion of viscous droplets as well as the internal flow field induced inside the moving droplets to improve our understanding on the mechanism of this anomalous flow phenomenon.

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