

STEM

Simulation of Oil Droplets Through Porous Media Using Dissipative Particle Dynamics

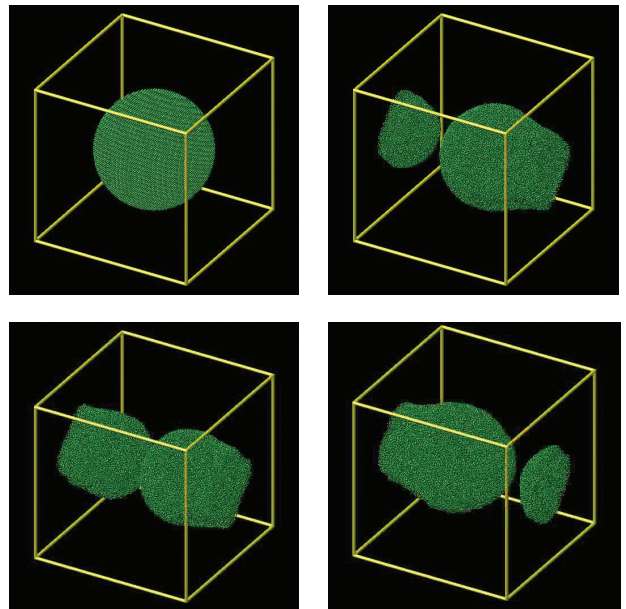
Student researcher: Yuchen Zhang, Senior

In oil industry, recovery of crude oil can be improved by injecting aqueous solutions containing surfactants, polymers, and mineral ions into an oil reservoir. This process is called enhanced oil recovery. Water and oil are immiscible, separated by an interface, and their motion through a capillary tube is governed by the surface tension. However, the physics can be more complex during an enhanced oil recovery process in the underground porous media, caused by micro-emulsion formation, role of salinity, and surfactant/polymer adsorption on the rock.

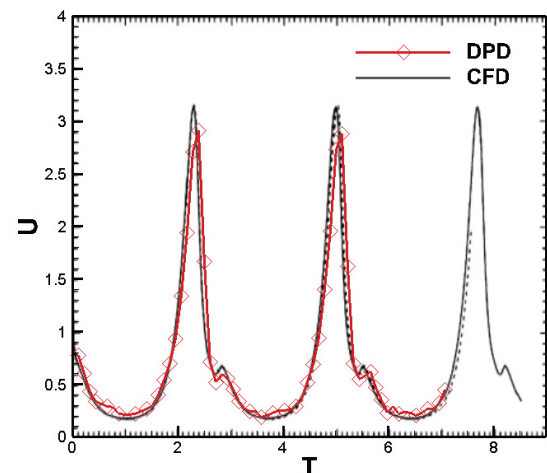
In this research, I use the dissipative particle dynamics (DPD) method to study the transport of an oil droplet passing through porous media. This method simulates the motion of particles, similar to a molecular dynamics method. However, the particles here are not single molecules, but clusters of molecules. Therefore, this method can handle a larger length and time scale compared to a molecular dynamics method.

The properties of the water and oil phases are quantified from separate DPD simulations. To obtain the viscosity of water or oil, I set up Couette flow simulations and evaluated the viscosity based on the ratio of shear stress and shear rate. The water-oil surface tension was measured using a DPD simulation of a flat interface in the presence of surfactants, and it was calculated based on the balance of normal forces across the interface. I then numerically simulated the motion of an oil droplet passing through a cubic lattice of fixed spherical particles to obtain the temporal evolution of the droplet's velocity. The number density and domain size was sufficiently large so as to obtain accurate results. Results from DPD agree well with computational results obtained using computational fluid dynamics tools in Alexander Z. Zinchenko and Robert H. Davis's 2008 article, "Squeezing of a Periodic Emulsion Through a Cubic Lattice of Spheres," from *Physics of Fluids*. I also observed the break-up of the droplet at high capillary numbers.

Research advisor Arezoo Ardekani writes: "One of the challenges with chemical enhanced oil recovery is to understand the role of surfactants/polymers on transport of multiphase flow through rocks. Pore scale computer simulations of Yuchen Zhang helps us understand these complex interactions."



Snapshots of an oil droplet passing through regular packing of identical spheres. The oil droplet is surrounded by water and there are fixed spherical particles at each corner of the cube, whose radius is 0.492 of the edge length.



Time evolution of the volume-averaged velocity of the oil droplet.