

PROCEEDINGS

Self-swimming of a Droplet Induced by Combined Diffusiophoresis and Marangoni Effects

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ABSTRACT

The chemically active droplets, which converts the chemical energy into a localized fluid flow at the interfaces by generating a concentration gradients of surfactant, can realize self-propulsion with complex trajectories and have been widely studied to mimic the swimming behavior of micro-organisms. In reality, the motion of chemically active droplets is influenced by a combination of diffusiophoresis and Marangoni effect under concentration gradients of surfactant. However, the interaction between these two effects has been only studied for a drop under the constraint of the axial-symmetric motion. To understand the hydrodynamics of the unconstraint motion, we consider a two-dimensional drop model to investigate the locomotion of an active droplet characterized by three dimensionless parameters, the Péclet number (Pe), viscosity ratio (η) and the mobility ratio (m) between the two effects, which can be either positive or negative depending on the direction of the induced slip velocity influenced by the interaction state. Through a linear stability analysis, we find that the drop of a negative mobility ratio is more stable than the ones of positive mobility ratio of the same magnitude under the same Péclet number and viscosity ratio. Our numerical results show that the droplet state exhibits stationary, steady, periodic, and chaotic regimes with the growth of Péclet number. The speed of droplet decays as the absolute value of the mobility ratio increase for the same Péclet number, and this happens more significantly when mobility ratio is a negative value. The transition from periodic to chaotic regions contains a very narrow zone for Péclet number where the drop moves in circular and semi-circular motions, and this zone becomes narrower with increasing mobility ratio. In the periodic regime, the shapes of the trajectories at a fixed Péclet number and different mobility ratios are closely related to the high-order modes of the drop, including source dipole and force quadrupole, etc. The strong advection may induce a symmetric extensile flow and causes the droplet spontaneously to stop between the spontaneous motions. Our results also indicate that the velocity distribution approximately satisfies the Gaussian distribution law as Péclet number is large enough in chaotic regime.

KEYWORDS

Self-propulsion; droplet; diffusiophoresis; Marangoni effect

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