Gravity-driven motion of a drop or bubble near an inclined wall at low Reynolds number

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The creeping motion of a three-dimensional deformable drop or bubble in the vicinity of an inclined wall has been studied in this work by numerical simulation and experiment. The dynamic deformation and subsequent steady-state drop/bubble shape and velocity are examined as functions of the Bond number, drop-to-medium viscosity ratio, and the wall inclination angle. We have developed a novel algorithm that is a combination of boundary-integral and economical multipole techniques, which allows calculations with as many as 20000-40000 boundary elements and many thousand time steps to reach a steady state.

The steady drop-to-wall separation and drop velocity depend heavily on the Bond number and viscosity ratio for intermediate-to-large inclination angles (i.e. 30-75 degrees above horizontal). The drop/bubble is able to approach the wall very closely (to less than 1% of drop radius) in steady motion, even for moderate Bond numbers. Viscous drops maintain smaller separations and deform more than bubbles at fixed Bond number over a large range of inclination angles. The steady velocity for homoviscous drops increases with increasing Bond number for intermediate-to-large inclination angles. However, for smaller inclination angles, non-monotonic behavior for the steady velocity with increasing Bond number is observed. Experimentally measured velocities are compared with numerical simulations for an extensive portion of the parameter space.

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