Abstract

Sedimentation of a drop under its own weight in another immiscible medium has been extensively studied over the past decades. However, a relatively small number of studies have taken into account the presence of a bounding wall, which are ever-present in a settling problem, presumably because of the analytical difficulties associated with such considerations. In addition, the sedimenting drops almost always contain impurities in the form of surfactants, which tend to alter the inetrfacial properties, thereby changing the overall flow characteristics and the flow dynamics. Therefore, a more physically accurate description of settling should account for both the presence of a bounding wall as well as surfactants, a paradigm that has hitherto remained unaddressed in the literature. As such, here we attempt to study the effect of surfactants on the settling of a drop towards a solid wall, in the “insoluble surfactant limit". To this end only interfacial transport of the surface impurities are taken into account, while a bipolar coordinate system is used to represent the fluid motion. Approximate analytical solutions for the velocity field are derived using a uniform asymptotic expansion in terms of Capillary number (Ca_s, assumed to be small), wherein the surfactant transport is assumed to be diffusion dominated. The computed velocity fields are used to analyze the settling dynamics and deformation of the drop, as it moves downwards. It is found that the presence of surfactant generally slows down the drop and at the same time augments the deformation by changing the normal stress distribution across the interface. The effect of surfactant becomes most prominent near the wall, wherein the drop experiences the most rapid deceleration. Changes in the flow patterns caused by the presence of the wall also redistributes the surfactant around the interface, which leads asymmetric depletion and accumulation of the same near the poles. Our results might have potential significance in areas such as separation processes as well as droplet based microfluidic systems.