

SHORT ABSTRACT

The current investigations are aimed at the analyses of fluid flow configurations consisting of two immiscible and miscible fluids by performing extensive numerical simulations. Firstly, the dynamics of formation, growth and breakup of liquid drops and jets emanating from orifices are investigated by performing direct numerical simulations. In the dripping regime, the viscosity of the drop liquid is fundamentally related to the phenomenon of interface overturning. A critical value of Ohnesorge number is identified beyond which overturning ceases. Two different modes of transition from dripping to jetting regime are observed, which can be clearly explained in terms of the relative importance of inertia and viscous effects on the dynamics of the processes. Secondly, the formation and breakup of a liquid jet in air with gravity acting normal to the direction of the liquid injection has been studied employing three-dimensional numerical simulations. It is observed that asymmetric perturbations develop on the liquid surface when liquid is injected perpendicular to gravity. The liquid jet follows a parabolic path due to the influence of gravity, which curves the jet trajectory. Thirdly, the influence of an external electric field on the dynamics of drop formation from submerged orifices is analyzed by solving axisymmetric electro-hydrodynamic numerical simulations. The simulations reveal that under the influence of an electric field, prolate shaped drops are formed at the orifice in the case of perfect dielectric fluids. In contrast, for leaky dielectric fluids, both prolate and oblate shaped drops can be formed depending on the combination of the fluid conductivity and permittivity ratios. The breakup time and detached drop volume can be suitably tuned by varying the strength of the applied electric field. Fourthly, the spatio-temporal deformation and pinch-off of compound droplets migrating inside a capillary tube have been investigated in detail. The outer drop deforms to a prolate shape whereas the inner drop attains an oblate shape at steady state. The inner drop migrates away from the initial concentric configuration and finally settles at a constant eccentricity. Furthermore, the migrating compound droplet can undergo an uncommon breakup stimulated by the thinning of the outer shell leading to pinch-off. Lastly, the influence of an applied electric field on the separation of water-ethanol solution inside a carbon nanotube (CNT) is explored using a series of molecular dynamics simulations. The study depicts that the direction of the electric field exerts a contrasting influence on the behavior of the water and ethanol molecules. The separation efficiency is found to improve with the increase in intensity of the externally applied electric field.