Abstract

The thesis presents a numerical investigation on hydrodynamics of a soft particle with heated hydrophobic core and electrophoresis of a soft particle. The mathematical model is based on the coupled Navies-Stokes, Energy, ion transport and electric potential equations. The Darcy-Brinkman model is used to formulate the flow through the porous layer and gel medium. Chapter 1 of the thesis is introductory. A pressure correction-based iterative algorithm, SIMPLE, is used to compute the governing equations in their full form. The study is made for a wide range of the flow parameters, occur in the governing equations.

In Chapter 2, the buoyancy induced mixed convection of a heated spherical particle with hydrophobic surface is studied. The influence of interfacial slip on the hydrodynamics of the particle and also on heat transfer is studied. The effect of favorable buoyancy effect is also analyzed. In Chapter 3, the hydrodynamics of a soft particle in which the surface of the rigid core is hydrophobic is investigated. The impact of the shell thickness and permeability on the hydrodynamics is analyzed. The presence of slip length on the surface of the rigid core is also studied. In Chapter 4, the mixed convection of a soft (or core-shell) particle consists of a rigid core coated with a fluid permeable shell is studied numerically. The effect of of presence of the permeable layer on hydrodynamics and heat transfer rate is studied. The rate of heat transfer is evaluated when the thermal conductivity of the porous layer is higher than the surrounding media. The effect of increase in surface temperature on flow separation and drag is also discussed. In Chapter 5, propulsion of a hydrophobic particle in gel medium is analyzed numerically. The hydrodynamics for micro-sized particles by considering the Reynolds number, based on the particle radius and translational velocity, as O(1) is considered. The effect of mixed convection on the hydrodynamics of the particle and heat transfer rate is studied. The presence of slip length on particle drag and heat transfer rate is also evaluated. Subsequently, a numerical study is made on the electrophoresis of a core-shell soft particle based on the first principle of electrophoresis in Chapter 6. The sustained solute release from the polymeric shell is also considered. No prior condition on particle charge density, Debye length or strength of the applied electric field is imposed in the present analysis. The impact of the double layer polarization and relaxation on the electrophoresis is highlighted by comparing with the existing analytical results. The mobility through the balance of electrical and hydrodynamical forces experienced by the particle is calculated. The hindrance created by the charge cloud on translation of the soft particle is discussed. The electrophoresis mediated sustained solute release from the soft particle is characterized . The influence of intrinsic parameters such as, surface potential of the core, volume charge entrapped within the polymer layer, softness of the polymer layer and bulk ionic concentration is also studied.

Keywords : Nusselt number; Drag force; Mixed convection; Hydrophobic; Electrophoresis; Double layer polarization; Electrophoretic mobility.