Abstract

A rigorous microscale electrokinetic model for hydrogel-colloid composites is adopted to compute macroscale profiles of electrolyte concentration, electrostatic potential, and hydrostatic pressure across membranes that separate electrolytes with different concentrations. The membranes are uncharged polymeric hydrogels in which charged spherical colloidal particles are immobilized and randomly dispersed with a low solid volume fraction. Bulk membrane characteristics and performance are calculated from a continuum microscale electrokinetic model (Hill 2006b, c). The computations undertaken in this paper quantify the streaming and membrane potentials. For the membrane potential, increasing the volume fraction of negatively charged inclusions decreases the differential electrostatic potential across the membrane under conditions where there is zero convective flow and zero electrical current. With low electrolyte concentration and highly charged nanoparticles, the membrane potential is very sensitive to the particle volume fraction. Accordingly, the membrane potential - and changes brought about by the inclusion size, charge and concentration - could be a useful experimental diagnostic to complement more recent applications of the microscale electrokinetic model for electrical microrheology and electroacoustics (Hill and Ostoja-Starzewski 2008, Wang and Hill 2008).

Keywords

Electrodiffusion, electrokinetic phenomena, hydrogel-colloid composites, membrane potential, microhydrodynamics, soft composite materials, streaming potential.