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Influence of salt valence on the rectification behavior of nanochannels

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Abstract

Taking account of the influence of electroosmotic flow, the behavior of the ion current rectification of a charged conical nanochannel is studied theoretically focusing on the effect of ionic valence. A continuum-based model comprising coupled Poisson-Nernst-Planck (PNP) equations for the ionic mass transport and Navier-Stokes equations for the hydrodynamic field is adopted. We show that if the bulk salt concentration is fixed, the behavior of the current-voltage curve depends highly on the ionic valence, which arises from the difference in ionic strength and ion diffusivity. As the bulk salt concentration varies, the rectification factor shows a local maximum, and the bulk salt concentration at which it occurs depends upon the salt valence: the higher the valence the lower that concentration. However, regardless of the salt valence, the ionic strength at which that local maximum occurs is essentially the same, implying that the thickness of electric double layer is the key factor. Due to the difference in ionic diffusivity, the magnitude of the rectification factor depends upon the type of salt. For example, the rectification factor of KCl is larger than that of KNO₃. The qualitative behavior of the ion current rectification of a positively charged

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