Streaming potential of super-hydrophobic microchannels: existence of the saturation slip length and the optimal ratio of no shear-slots

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Recently there have been attempts of exploiting the streaming potential to convert the mechanical energy to the electrical energy. There are two kinds of super-hydrophobic surfaces, one having a smooth wall with a large Navier slip coefficient caused by the hydrophobicity of the wall material, and the other having a periodic array of no-shear slots of air pockets embedded in a no-slip wall as found in recently fabricated nano-structured surfaces. The electrokinetic flows over these two super-hydrophobic surfaces are modelled using the Navier-Stokes equation and convection-diffusion equations of the ionic species, together with the Poisson equation relating the ionic concentration to the electric potential. The numerical simulation reveals that the first kind surface has larger volumetric flow rate and larger streaming potential as the Navier slip coefficient increases for a given pressure gradient, and attains an asymptotic saturation volumetric flow rate and streaming potential at a large Navier slip coefficient. On the other hand, the second kind surface has monotonically increasing volumetric flow rate, while the streaming potential increases to a maximum value and, afterwards, decreases as the no-shear slot ratio increases.