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Dual Lattice Boltzmann method for electrokinetic coupling : behavior at high and low salinities in rough channels.

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We study the coupling between hydraulic and electric flows in a porous medium at small scale using the Lattice Boltzmann method. This method is a computational fluid dynamics technique that is used for advection and diffusion modeling. We implement a coupled Lattice Boltzmann algorithm that solves both the mass transport and the electric field arising from charges displacements.
The streaming potential and electroosmosis phenomena occur in a variety of situations and derive from this coupling. We focus on the streaming potential which is described using the ratio between the created potential difference and the applied pressure gradient. The streaming potential is assumed to be a linear function of the fluid conductivity, but experimental results highlight anomalous behaviors at low and high salinity. We try to account for them by setting extreme conditions that are likely to generate non-linearities.
Several pore radii are tested so as to determine what is the effect of a radius that is comparable to the Debye length, the screening length of the electric potential, due to the ions in the electrolyte. The volumetric integral of the electrical current is calculated for comparison with the 2D simulations. High values of zeta potential are tested to verify if the discrepancy regarding the theoretical result is concentration-dependent. We try to include a surface conductivity term in the coefficient formulation. Some tests including a rugosity on the channel walls are performed. All of these attempts show a normal behaviour of the streaming potential at high salinity. We observe a decrease of the ratio at low conductivity, showing that this ratio is modified when the pore radius becomes negligible compared with the Debye length, which is physically meaningful in little pores at low concentrations.

References :
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