Contribution ID: **787** Type: **Poster + 3 Minute Pitch**

Electrokinetic Transport at Micro/Nanoscale Coupled with Surface Chemistry

Wednesday, 16 May 2018 16:58 (2 minutes)

Surface charge at solid-electrolyte interface is generally affected by the local physical and chemical properties in the solution such as ionic strength, pH and so on. In a system with concentration or pH variation, rather than the prevailing assumption of homogeneous surface change, it leads to a spontaneous inhomogeneous distribution of surface charge, which has been observed in geotechnical engineering, membrane science and microfluidics, but never been well understood. Further complexity comes from the multiscale feature of the electrical double layer (EDL) and its overlapping at micro/nano scale. Here, to tackle this coupled electrokinetic transport process, we present a general modeling strategy based on a classification using the ratio of the Debye length to the characteristic pore size. We show that this classification can be applied in modeling electro-osmosis (EOF) from a thin EDL to a fully overlapped EDL. The effect of inhomogeneous surface charge on electrokinetic velocity and permeability is discussed. This effect plays an important role in observed phenomena such as flow reversal in electroketic remediation and electro-osmotic hysteresis in EOF displacement.

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Session Classification: Parallel 8-A

Track Classification: MS 1.11: Conservative and Reactive Transport of Charged Species in Permeable and Impermeable Porous Media