Contribution ID: **357** Type: **Oral 20 Minutes**

Colloidal transport in a microfluidic porous medium with surface charge heterogeneity

Wednesday, 16 May 2018 11:53 (15 minutes)

Colloidal facilitated transport of contaminants is a major concern for transport of low solubility chemicals in ground water flows. Compared with themselves alone, contaminants travel much further after adsorbing to natural colloidal particles, as far as kilometers over years. Therefore, understanding the transport behavior of colloids would provide insightful knowledge for environmental protection and remedy. In the past most lab-scale experiments focused on studying the interactions between particles and homogeneous or physically heterogeneous porous media. In reality, porous media exhibit different chemical properties at the grain scale. To shed some light in this aspect, we built a family of pseudo-three-dimensional microfluidic porous media models packed by 10 μm polystyrene (PS) beads with opposite surface charges. Each porous medium contains more than 6000 beads and has a size of 1000 μm in length, 600 μm in width and 15 μm in height. An on-chip cross channel linked with an off-chip 4-way valve was applied to generate a step input of concentrated colloidal suspension, which also greatly reduced the influence of Taylor dispersion of colloidal particles. We further studied the effect of chemical heterogeneity on the transport and retention of colloidal particles. The breakthrough of the particles was recorded at the downstream of the porous medium. The colloidal retention profile was mapped using a confocal microscope. Beads with different surface properties are distinguished by their different fluorescent labels. Therefore we also obtained colloidal retention data for beads with different surface properties. With our platform, we developed a correlation between the overall collector efficiency and its constitutive collector efficiency under different salt conditions.

References

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Session Classification: Parallel 7-A

Track Classification: MS 4.10: Evaluation and Optimization of Non-Conservative Transport in Porous Media