Comparison of Eulerian and Lagrangian Colloidal Deposition in Laminar Flow

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Abstract

Colloidal fouling involves particles depositing on a surface, often leading to adverse effects including: reduced heat transfer efficiency in heat exchangers and flow blockage in oil refineries. There exist two main approaches to model the deposition process: Eulerian and Lagrangian, but very few studies have investigated the quantitative difference between the two. This work aims to highlight key differences between the two modelling approaches in the context of the careful experimental work of [1, 2].

Initial deposition rates of polystyrene latex particles in laminar flow have been studied with parallel plate [1] and stagnation point [2] flows; with a range of ionic strength of the buffer solutions. These studies compare their experimental results with numerical calculations (from the convection-diffusion equation in the Eulerian reference frame) and the Smoluchowski-Levich solution of the convection-diffusion equation.

We have simulated both parallel plate and stagnation point flow cases and tracked colloidal particles in the Lagrangian reference frame. DLVO theory was used to describe the interaction between the particles and the depositing surface: including the electrostatic double layer (repulsive) and van der Waals (attractive) forces [3]. Particles must overcome an energy barrier to reach the surface and deposit; this energy barrier depends on the ionic strength of the buffer. Brownian motion effects have also been investigated. Results from the Lagrangian particle tracking simulation are a closer match to the experimental data than the Eulerian calculations, and Smoluchowski-Levich solution, of the convection-diffusion equation.

References

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