The Friction Coefficient of Fractal Aggregates in the Continuum and the Transition Regimes

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Abstract

Aerosol and colloid aggregates are complex fractal-like structures composed of primary spheres. The drag force exerted on a fractal-like object is usually determined by solving numerically the Stokes equation. In this study we calculate it by relating it to a molecule-aggregate collision rate. We create the fractal aggregates with a cluster-cluster aggregation algorithm using the software MATLAB® and then we insert the created structures into COMSOL Multiphysics with the tool LiveLink™ for MATLAB®. The collision rate is determined by calculating the steady-state molecular diffusive flux to the aggregate surface. Hence, the friction coefficient of an aggregate in the momentum transfer continuum regime can be calculated from the steady-state diffusion equation that we solve in COMSOL Multiphysics. The appropriate boundary conditions in the continuum regime are Dirichlet conditions with the fluid density being 0 on the surface of the fractal and unity far away from it on the outside sphere. We expand this method to the slip-flow regime. The approach remains the same but the boundary condition on the aggregate surface for the steady-state molecular diffusion equation is a Robin condition whereby the fluid density on the aggregate surface is related to its derivative. On the outside sphere Dirichlet condition remains. Finally we calculate the friction coefficient and the mobility radius.

Figures used in the abstract
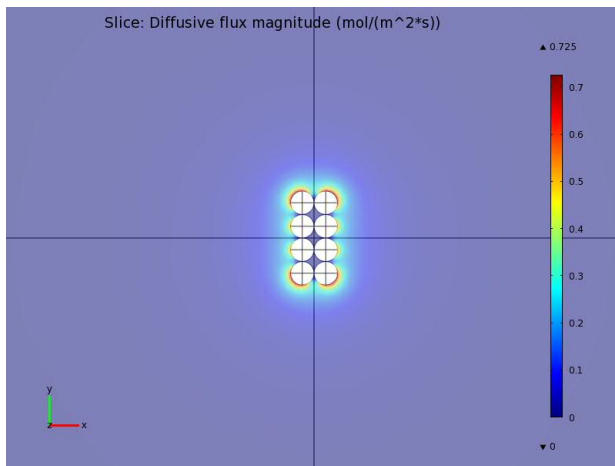
Figure 1: The diffusive flux change near the surface of a fractal aggregate using COMSOL.