

Particle Deposition onto Solid Surfaces with Microscopic Charge Heterogeneity: The “Bump Effect”

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A stagnation point flow (SPF) setup was used to directly observe the deposition kinetics of colloidal particles onto micropatterned glass surfaces with well-defined surface charge heterogeneity features. The SPF system consists of a microscope focused on a small collector surface area, with an automated computer controlled image-capturing device comprising a CCD camera. Surface charge heterogeneity was microfabricated onto glass surfaces by chemically modifying well-controlled fractions of the glass surface with aminosilane using a soft lithographic technique. Particle deposition was observed for a wide range of flow rates (Peclet numbers) and solution ionic strengths. The observed experimental particle deposition rates at the various physicochemical conditions were compared to predictions based on a patchwise charge-heterogeneity model. Comparisons revealed that (1) deviation from the patch model occurs at high flow rates (or Peclet numbers), (2) the patch model approximates the deposition rate at lower Peclet numbers, and (3) deviation from the patch model predictions occurs at a lower flow velocity for the lower ionic strength runs. The particle deposition behavior and the breakdown of the patch model are attributed to the coupling between hydrodynamic and electrostatic double layer interactions. A mechanistic model which we term “the bump effect” is used to describe the deposition behavior on the micropatterned glass surfaces.