Aggregation Rates of Charged Colloidal Particles in a Couette Flow: Trajectory Analysis with Non-linear Poisson-Boltzmann Solution

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Abstract

Shear-induced aggregation, which coincides with the velocity gradient of fluid, extensively occurs in environmental and industrial processes. Thus, understanding of shear-induced aggregation is still important in many fields. However, although the aggregation kinetic theory in a shear flow provides fundamental aspects in practical situations, the verifications of the theory are not sufficient due to the lack of quantitative comparisons with experimental data. In particular, the experimental aggregation rates in the presence of electrostatic repulsion,[1] which diminishes the rates, have not been compared with theoretical calculations, since the previous calculation can not be applied to the experimental data because of using the expression for electrostatic repulsion which assumes the linearized Poisson-Boltzmann(PB) equation that is only valid in the low surface potential case. Therefore, we examined the comparison between theoretical calculations and experimental data by Sato *et al.* for the aggregation rates in a Couette flow as a function of KCl concentration at different shear rates. To calculate the theoretical rates, we employed the trajectory analysis[2] with the repulsion calculated using the non-linear PB solution.[3]

We plotted the capture efficiencies, which are defined as the ratio of the rate with and without particle interactions, for the polystyrene latex particles with a diameter of $2R = 1.96\ \mu$m against KCl concentration at different shear rates G in **Fig. 1**. Symbols are experimental values[1] at $G = 23(\triangle), 46(\bigcirc), 92(\bigtriangledown)\ \mathrm{s}^{-1}$, respectively. Lines indicate the theoretical values based on trajectory analysis with Non-linear PB solution,[3] assuming $\sigma = -60\ \mathrm{mC/m^2}$,[1] and Hamaker constant $A_\mathrm{H} = 2.0\times10^{-21}$ J which characterizes the magnitude of van der Waals attraction. We can see that the capture efficiencies decrease with decreasing KCl concentration and increasing electrostatic repulsion, and the present calculation can qualitatively describe the experimental data as shown in **Fig. 1**. However, we observed the quantitative discrepancies between the experimental and theoretical values. These discrepancies might be caused by Non-DLVO forces which are not included in the present trajectory analysis.

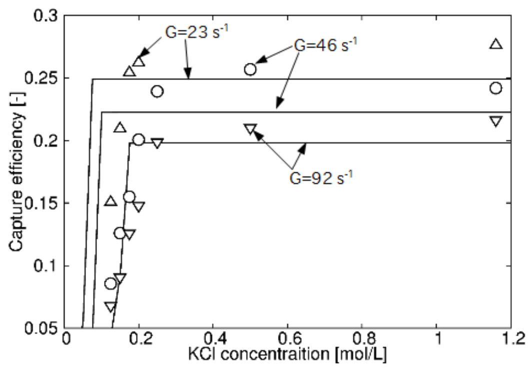

Fig. 1 Capture efficiency vs. KCl concentration for $2R = 1.96\ \mu$m: Symbols and lines are experimental values taken from Sato *et al.*[1] and theoretical ones based on trajectory analysis.

References

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