Kinetics on hetero-aggregation of unequal-sized particles in flow fields

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Mixtures of different types of colloidal particles such as clay minerals and humic substances are ubiquitous in water environments. These colloidal particles can adsorb substantial amounts of chemicals onto their surface due to their large specific surface area and surface charges. The transport of such particles facilitates the migration of adsorbed chemicals in the environments. The transport property of the particles is strongly affected by their aggregation. Therefore, understanding the aggregation process of colloidal particles is essential to control and predict the transport phenomena in water environments. The co-existence of different types of particles causes the aggregation of different particles called hetero-aggregation. Moreover, they are commonly subjected to flow fields. In this study, therefore, we have analyzed the experimental results of the turbulent hetero-aggregation by using the theoretical calculation for a simple shear and an axisymmetric extensional flows. The hetero-aggregation experiments for unequal-sized latex particles with three different size ratios were conducted. The hetero-aggregation rates were evaluated from the reduction of the number of free smaller particles due to the hetero-aggregation. Experimental capture efficiencies of hetero-aggregation rates show nearly constant irrespective of size ratio, which is defined as the smaller particle size divided by the larger one, while the theoretical rates in a simple shear flow drastically decrease with decreasing size ratio. In contrast, the capture efficiency in the extensional flow is less sensitive to the size ratio. Comparing the experiments with the theories, we found that the turbulent hetero-aggregation rates for unequal-sized particles can be more comparable with the calculation in the extensional flow than that in the simple shear flow. This infers that the flow in the microscale of turbulence is approximated as an axisymmetric extensional flow rather than a simple shear flow.

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