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Electrophoretically mediated partial coalescence of a charged microdrop

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Abstract

Coalescence of charged drops in the presence of an electric field has practical applications in microscale lab-on-a-chip devices. Existing studies have focused on macrodrops, but electrophoretic charge behaviour differs for microdrops due to the increased thickness of diffuse charge layers relative to drop dimensions. An electrokinetic model is used in this study to numerically investigate the charge transfer dynamics, for the problem of charged microdrop coalescence with an electroneutral bulk liquid. In particular, the focus is on the transition from complete to partial coalescence, and the study of residual droplet formation during partial coalescence. It is found that the increasing drop charge suppresses the formation of residual droplets. The size and charge of residual droplets is shown to vary with bulk ion concentration (represented by a dimensionless inverse Debye length) and initial separation distance, in difference to experimental results obtained for macrodrops. This behaviour originates from the unique charge dynamics of microdrops: the electrophoretic lift force at the drop summit varies throughout the coalescence process, affecting the convected charge in this region, which results in a charge-separation dependent residual droplet size. A scaling relation is obtained to relate the size and charge of residual droplets.

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