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Unsteady Conjugate Mass Transfer between a Deformable Droplet and a Creeping Extensional Flow in a Cross-shaped Microchannel

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With developments and applications of micro-reactors in the food, chemical and pharmaceutical industry, hydrodynamics and transport processes of drops in shear and extensional flows in micro-channels have attracted much attention from both academics and practitioners. Such systems specifically demonstrate potentials to enhance transport in micro-channels. The objective of this work is to investigate the unsteady conjugate mass transfer process between a deformable drop and an extensional flow in a cross-shaped microchannel. The droplet may be trapped in the center of the cross-shaped microchannel and deformed by the extensional flow field. In such a system, it is very difficult to experimentally measure concentration variations precisely and in detail. Therefore, we established a mathematical model on the basis of the Stokes equation solved by a spectral boundary element method, which can describe the deformable interface and its disturbances on the flow field. The convection-diffusion equation is solved by a finite difference method to determine the unsteady conjugate interphase mass transfer. Simulation results show that the mass transfer rate, characterized by mean concentration variation and Sherwood number Sh, was significantly affected by Capillary number Ca, Peclet number Pe, viscosity ratio λ , interior-to-exterior diffusivity ratio K and distribution coefficient m.

References

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