Hydrodynamics and Conjugate Mass Transfer from aTranslating Spherical Droplet in a Continuous Phase

A. Rachih, S. Charton, D. Legendre, E. Climent

Hydrodynamics and Conjugate Mass Transfer from a Translating Spherical Droplet in a Continuous Phase

Azeddine RACHIH[*‡1,2], Sophie CHARTON[1], Dominique LEGENDRE[2], Eric CLIMENT[2]

[1] CEA, DEN, DMRC, SA2I, F-30207 Bagnols-sur-Cèze, France
[2] IMFT, Université de Toulouse, CNRS, INP, UPS, Toulouse - France

Mass Transfer, Droplet hydrodynamics, Multiphase flow, Sherwood number, Interfacial phenomena

The optimization of separation processes, like liquid-liquid extraction, and improvement of separation apparatus design start most importantly with a good understanding of the hydrodynamic coupling between the two phases and the mass transfer across the interface. This task becomes challenging for complex polydisperse systems. Population of droplets or bubbles is often considered in these processes. Given the complexity of a global study of the system, the study of mass transfer at the scale of a single droplet moving in the surrounding immiscible phase is of prime importance. This study represents a major step towards derivation of reliable mass transfer resistance correlations.

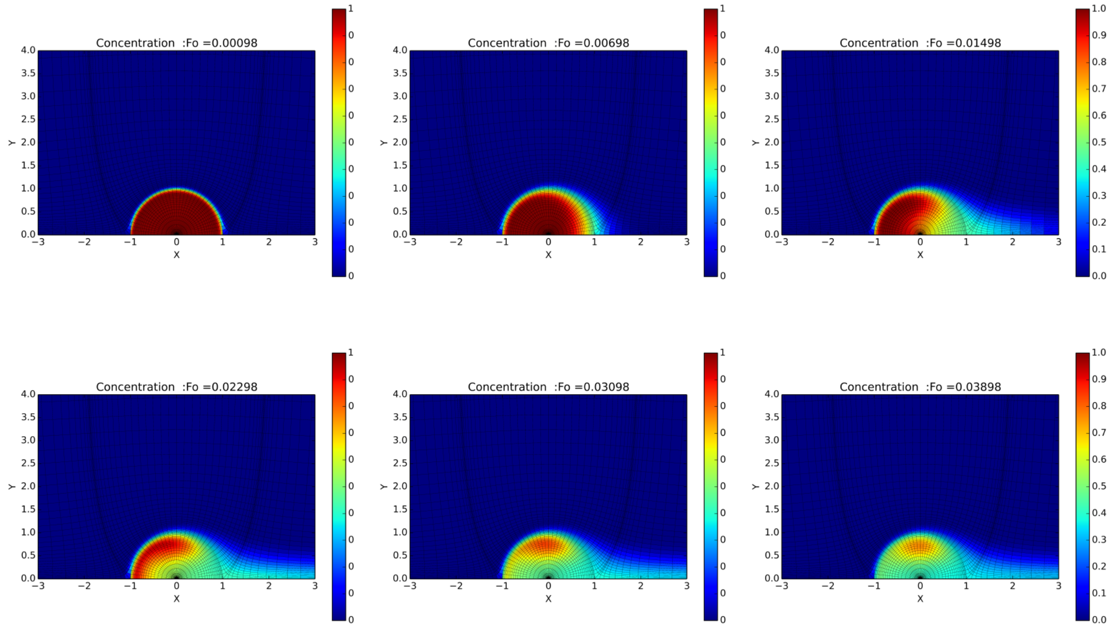
Many key physical parameters (such as the viscosity ratio, diffusivity ratio, flow configuration, etc.) may impact directly both hydrodynamics of a moving droplet in a continuous phase and extraction efficiency as well [1]. In this study, efforts have been made to investigate the interaction between the internal and the external flows in a single droplet on the one hand, and on the other hand, the influence of the main key parameters on the evolution of the Sherwood number. The temporal evolution and the spatial concentration distribution have been studied, analyzed and then validated on reference test cases.

Since under the hydrodynamic conditions typical of solvent extraction columns, the droplet usually achieves a spherical shape [2], a fixed (i.e. non deformable) mesh is considered in this study. A numerical investigation has been conducted by DNS to investigate the coupling between the internal and the external flows and their respective effects on mass transfer. JADIM, the CFD code developed at IMFT, was used and adapted in this aim. The finite volume scheme implemented, together with the use of an orthogonal curvilinear mesh, was shown to enable good description of interfacial phenomena [3]. A specific jump condition has been implemented in order to accurately represent the convection/diffusion and mass transfer coupling at the interface between the droplet and the surrounding liquid.

In this contribution, the numerical model was used to study the sensitivity of the rate of transfer of a non reactive solute to the various hydrodynamical and chemical parameters, accounted

‡Corresponding Author: Azeddine RACHIH (azeddine.rachih@cea.fr)

thanks to the Reynolds, Peclet, Fourier, Henri numbers. The results revealed good agreement with available experimental and numerical data [4,5]. The model predicts correctly the effect of relevant physical parameters on the transfer process. Moreover the respective effect of internal flow circulation and external convection was evidenced and drastic changes of the internal and external resistances to mass transfer with increasing values of the Peclet number were predicted.



REFERENCES

[1] Michaelides, E. E. (2003). Hydrodynamic force and heat/mass transfer from particles, bubbles, and drops—the Freeman scholar lecture. *Journal of Fluids Engineering*, *125*(2), 209-238.

[2] Grace, J.R., T. Wairegi. and T. H. Nguyen (1967). Shapes And Velocities Of Single Drops And Bubbles Moving Freely Through Immiscible Liquids. Trans. Instn Chem. Engrs, 54

[3] Legendre, D. and Magnaudet, J., 1998. The lift force on a spherical bubble in a viscous linear shear flow. Journal of Fluid Mechanics, 368, pp.81-126.

[4] Oliver, D. L., & Chung, J. N. (1986). Conjugate unsteady heat transfer from a spherical droplet at low Reynolds numbers. *International journal of heat and mass transfer*, *29*(6), 879-887.

[5] Juncu, G. (2010). A numerical study of the unsteady heat/mass transfer inside a circulating sphere. *International Journal of Heat and Mass Transfer*, *53*(15), 3006-3012.