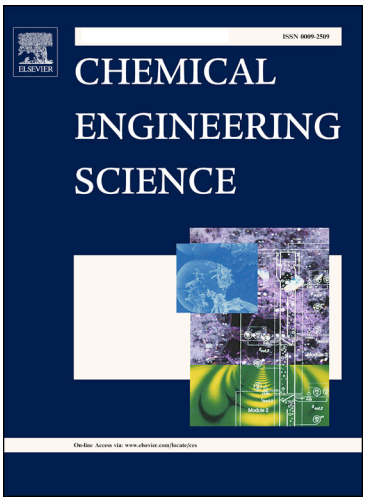

Streamline-averaged mass transfer in a circulating drop

Paul Grassia, Sebastián Ubal

PII: S0009-2509(18)30104-0
DOI: https://doi.org/10.1016/j.ces.2018.02.042
Reference: CES 14066

To appear in: *Chemical Engineering Science*

Received Date: 9 November 2017
Accepted Date: 25 February 2018

Please cite this article as: P. Grassia, S. Ubal, Streamline-averaged mass transfer in a circulating drop, *Chemical Engineering Science* (2018), doi: https://doi.org/10.1016/j.ces.2018.02.042

Streamline-averaged mass transfer in a circulating drop

Paul Grassia[a,*], Sebastián Ubal[b]

[a] *Department of Chemical and Process Engineering, University of Strathclyde, James Weir Building, 75 Montrose St, Glasgow G1 1XJ, UK*
[b] *UNL CONICET, INTEC, Güemes 3450, 3000 Santa Fe, Argentina*

Abstract

Solute mass transfer is considered from the outside to the inside of a circulating drop in the context of liquid-liquid extraction. Specifically an internal problem is treated with resistance to mass transfer dominated by the liquid inside the drop. The Peclet number of the circulation is large, on the order of tens of thousands. A model is proposed by which the mass transfer into the drop begins in a boundary layer regime, but subsequently switches into a so called streamline-averaged regime. Solutions are developed for each regime, and also for the switch between them. These solutions are far easier to obtain than those of the full advection-diffusion equations governing this high Peclet number system, which are very stiff. During the boundary layer regime, the rate at which solute mass within the drop grows with time depends on Peclet number, with increases in Peclet number implying faster growth. However larger Peclet numbers also imply that the switch to the streamline-averaged regime happens sooner in time, and with less solute mass having been transferred to date. In the streamline-averaged regime, solute concentration varies across streamlines but not along them. In spite of the very large Peclet number, the rate of mass transfer is controlled diffusively, specifically by the rate of diffusion from streamline-to-streamline: sensitivity to the Peclet number is thereby lost. The model predictions capture, at least qualitatively, findings reported in literature for the evolution of the solute concentration in the drop obtained via full numerical simulation.

Keywords: Liquid-liquid extraction; Circulating drop; Mass transfer; High Peclet number; Streamline-averaged model; Mathematical modelling

*Corresponding author
Email address: paul.grassia@strath.ac.uk (Paul Grassia)