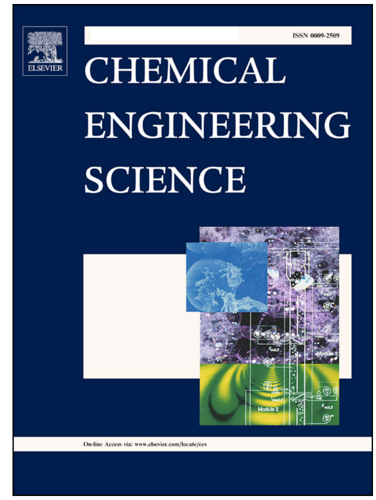
Lagrangian modeling of mass transfer from a single bubble rising in stagnant liquid

Jannike Solsvik



PII: S0009-2509(18)30363-4
DOI: https://doi.org/10.1016/j.ces.2018.06.002
Reference: CES 14276

To appear in: *Chemical Engineering Science*

Received Date: 5 February 2018
Revised Date: 25 May 2018
Accepted Date: 1 June 2018

Please cite this article as: J. Solsvik, Lagrangian modeling of mass transfer from a single bubble rising in stagnant liquid, *Chemical Engineering Science* (2018), doi: https://doi.org/10.1016/j.ces.2018.06.002

Lagrangian modeling of mass transfer from a single bubble rising in stagnant liquid

Jannike Solsvik

Department of Chemical Engineering, NTNU - Norwegian University of Science and Technology, Trondheim, Norway

E-mail address: jannike.solsvik@chemeng.ntnu.no

Abstract

A Lagrangian model has been derived that describes the size, species composition and velocity of an individual gas bubble as it ascends through a vertical column with stagnant liquid and exchanges mass with the other phase. Various correlations for the liquid-side mass transfer coefficient for laminar flow have been implemented in the Lagrangian model and the predictions are compared with available experimental data in the literature. The predictability of the Lagrangian model is in general not acceptable due to the limitations of the available theoretical framework employed for deriving the existing correlations for the mass transfer coefficient. The various mass transfer coefficients give very different simulation results, and furthermore, the experimental data show a transient behavior in the change of bubble size due to mass transfer which is not captured by the Lagrangian model. An over- or underestimation of the interface mass transfer flux will give an erroneous change of bubble size, which may have significant influence on the predicted bubble rise velocity - in particular if the drag coefficient is very sensitive to the size of the bubble. It is emphasized that the cause of discrepancy between the simulation results and experimental data is not due to the Lagrangian model but mainly caused by the lack of good models for the mass transfer coefficient.

Keywords:

Lagrangian model; mass transfer coefficient; bubbles; interface mass transfer

1 Introduction

Many industrial processes depend on interface gas–liquid mass transfer to or from gas bubbles rising in liquids. Distillation, fermentation, sewage treatment, and chemical reactors such as the bubble column and slurry column are examples. Much research on gas–liquid mass transfer has been performed in bubble swarms and concentrated on the establishment of correlations for the volumetric mass transfer coefficient, $k_L a$. Many physical and mechanical factors contribute to the mass transfer coefficient k_L and the specific bubble surface area a, and their combined effect in the volumetric mass transfer coefficient cannot be easily predicted. To better understand the phenomena involved, researchers have thus suggested to perform the mass transfer experiments of bubble swarms by measuring changes in bulk liquid concentration during which also the average bubble size is determined (Alves et al., 2004; Calderbank and Moo-Yong, 1961; Sardeing et al., 2006). As an alternative to