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New predictive correlation for mass transfer coefficient in structured packed extraction columns

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ABSTRACT

Developments in the area of packed columns, particularly structured packed columns, are ongoing, specifically in the area of liquid–liquid extractions in different industries. In the present study, mass transfer coefficients have been obtained experimentally in a structured packed extraction column to develop a new correlation for prediction of continuous phase Sherwood number. The experiments were carried out for toluene/acetic acid/water and n-butyl acetate/acetic acid/water systems with counter current flow in different heights of column. A new dimensionless parameter, d_{32}/h, is introduced in proposed equation. This number considers the effect of column height (h) and mean drop diameter (d_{32}) jointly. The main advantage of this approach is that the principal effect of column height is considered in correlation without which the experimental data could not be fitted with a acceptable accuracy.

Keywords: Liquid–liquid extraction; Packed column; Mass transfer coefficient; Sherwood number

1. Introduction

Packed columns have found increasingly wide use in separation processes such as distillation and absorption due to lower pressure drop and lower liquid hold-up than tray columns. However, the design, analysis and scale up of packed columns today are still based mainly on empirical or semi-empirical correlation. The main reason for this is that some of the performance characteristics such as mass transfer efficiency cannot be predicted reliably in packed columns (Sun et al., 2000). Liquid extraction consists of separating one or several substances (solute) present in a solid or a liquid phase by the addition of another liquid phase in which these substances transferred preferentially. This mass transfer is often operated in counter-current extractors. The efficiency of liquid–liquid contactors is primarily dependent on the degree of turbulence imparted to the system and the interfacial area available for mass transfer. Although many researchers consider that extraction is a fully mature technology lacking in potential for further improvement, there are still many questions that need to be solved urgently. One of them is to design commercial extractors safely with low costs. Nowadays, the scale-up of extractors still depends on large quantities of pilot experiments, which is expensive and time-consuming. Introduction of Sherwood number by measuring mass transfer coefficients is a promising method to solve the above problem (Jie and Weiyang, 2005).

The fundamental process for the rate of mass transfer in extraction columns is still not sufficiently well understood nor adequately modeled (Korchinsky, 1994). The accurate specification of the mass transfer coefficient plays an important role in packed columns precise design. Therefore understanding of relevant fluid dynamics and the mass transfer coefficients in these columns is of paramount importance for the precise design. These parameters can be presented in the form of Sherwood number. Packing cause internal circulation of drops and increase mass transfer coefficient. The transfer of a solute between a rising drop and a continuous liquid phase has been widely studied, both theoretically and experimentally. The importance of this area is reflected in the vast number of works published over the years and is of interest in a variety of industrial processes, such as liquid extraction (Kumar and Hartland, 1999).

2. Theoretical predictions of mass transfer coefficients

The mass transfer coefficient of dispersed or continuous phase is one of the fundamental and essential parameters

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