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Short Communication

Transfer Coefficients in Liquid-Solid by Using Microreactors

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DESCRIPTION

Micro reactors are useful tools for chemical reaction and kinetic studies. Because of reduced length, they undergo some advantages such as improved temperature control, accelerated heat and mass transfer, and enhanced mixing of reactants. Micro Packed Bed Reactors (MPBRs) or Micro Fixed Bed Reactors (MFBRs), which combine the benefits of micro reactors and fixed-bed reactors, have been demonstrated to be promising tools for multiphase catalytic reaction systems in investigating catalyst performance reaction kinetics, and chemical synthesis [1].

In multiphase reactors the packed beds of catalyst particles, in gaseous reactant are sparingly soluble in the liquid phase, and both liquid reactant and the dissolved gas reactant diffuses to catalyst surface where the reaction takes place [2]. The evaluation of liquid-to-solid mass transfer is essential for the modeling and designing of multiphase reactors. Generally, two main experimental techniques have been employed for determining Liquid–Solid (L-S) mass transfer coefficients:

(1) Dissolution of sparingly soluble solids into liquids

(2) Electrochemical techniques.

Other experimental techniques have also been reported such as chemical reactions with significant solid–liquid mass transfer resistance, ion exchange followed by an instantaneous irreversible reaction and dynamic absorption [3]. In gas–liquid two-phase flow in macro scale packed beds, low gas and liquid flow rates lead to a low interaction regime, where the gas does not affect the liquid textures and the particles may not be entirely wetted, resulting in poor mass transfer characteristics.

At higher gas and liquid flow rates, the high interaction regime is obtained where the bubble, dispersed, and pulse flow lead to improved mass transfer characteristics. Even though trickle flow is not obtained at the micro scale because of the dominance of capillary forces, low and high interaction regimes exist. Gas and liquid phases have a constant share of the bed void-age without perturbing to each other at low flow rates (low interaction), while at increased liquid superficial velocities are between the two phases which leads to fluctuations in both gas and liquid characteristic lengths (high interaction) [4].

Gas and liquid were introduced into the micro reactor through a T-junction and flowed through a section of empty channel before reaching the packed bed, producing either slug-flow or annular flow which depends on the ratio of gas to liquid flow rates [5]. They is a flow observation with high-speed which provides further information for flow patterns and the liquid pulses passing towards packed bed. The Liquid–Solid (L-S) mass transfer coefficient was first measured with liquid phase flowing through the copper particle packed bed to validate the experimental setup and procedures.

The correlations for larger scale packed bed reactors are not suitable for predicting the mass transfer in micro scale packed bed reactors [6]. The main reason for this comes from the fact that viscous and capillary forces are predominant in the Micro Packed Bed Reactors (MPBRs) in comparison with the large-scale packed bed reactors. Hydrodynamic behavior of a Micro Packed Bed Reactors (MPBR) differs from that of an industrial-scale trickle bed, due to the significant effect of capillary forces, and consequently there could be no real trickle flow in a micro scale packed bed. In literature, Liquid–Solid (L-S) mass transfer studies in Micro Packed Bed Reactors (MPBRs) are scarce [7].

In experimental studies of Liquid–Solid (L-S) mass transfer by using dissolution methods in macro scale packed beds, the volumetric mass transfer coefficient was commonly derived with an Ideal Plug Flow Reactor (PFR) model is under the steady flow conditions for both trickling and pulsing flow regimes.

It also involves liquid-to-particle mass transfer in micro packed beds with liquid-only flow using the copper dissolution method for different channel geometries, i.e., circular and rectangular, and channel hydraulic diameter to particle diameter ratio (N) [8]. They demonstrated the shape of the channel has no influence on the liquid-to-particle mass transfer as long as (N) is constant.

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CONCLUSION

These results show that pulsing flow was predominant in the Micro Packed Bed Reactors (MPBR) for the whole range of Gas-Liquid (G-L) flow rates investigated in this work. The characteristics of the pulsing structures are varied depending upon the flow pattern of upstream Gas-Liquid (G-L) flow. However, this flow pattern was sensitive and destabilized by disturbances from upstream or downstream pressure fluctuations, or non-uniform packing, which made the reaction measurement in higher gas velocities irreproducible. However, the mass-transfer was less affected during the sparse slug flow regime, which is possible due to the negligible presence of gas pockets, resulting in an increase of the effective interfacial area. While our studies have been performed with nonporous particles, at which the investigation of porous catalysts are required to improve the correlations for use in catalytic Micro Packed Bed Reactors (MPBR).

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