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Local gas distribution and mass transfer characteristics in an annulus-rising airlift reactor with non-Newtonian fluid

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Abstract: Many chemical and biochemical processes operated in airlift reactors are limited by gas-liquid mass transfer of reactants. Therefore, it is essential to have a good understanding about the mass transfer characteristics and gas distribution in airlift reactors in order to design suitable reactors and to optimize aeration conditions. To accomplish this goal, experimental studies on the mass transfer characteristics, i.e. gas holdup, bubble size, interfacial area, volumetric mass transfer coefficient and liquid-side mass transfer coefficient were performed in an annulus-rising airlift reactor with Newtonian and non-Newtonian fluids. A 3D electrical impedance tomography (EIT) technique was used to measure local gas holdup and visualize gas distribution. The influences of aeration rate and liquid viscosity on local gas holdup and interfacial area were investigated at three axial positions along the riser. The EIT results show that the uniformity of gas distribution reduces by increasing liquid viscosity. Bubble size was observed to have a bimodal distribution in highly viscous liquids at high gas superficial velocities due to the intensified coalescence and breakup of bubbles. The maximum value of the local interfacial area is found at the fully developed flow zone in the riser. The liquid-side mass transfer coefficient was found to depend on liquid viscosity and bubble size for non-Newtonian liquids. Empirical correlations based on the experimental data obtained in this work are provided which predict well the local gas holdup and volumetric mass transfer coefficient.

Keywords: Airlift reactor, electrical impedance tomography, non-Newtonian fluid, mass transfer, gas holdup distribution, gas-liquid interfacial area

1. Introduction

Airlift loop reactors (ALRs) have attracted increased interest in chemical and biochemical processes, such as in acetophenone hydrogenation [1], in syngas fermentation to produce biofuels and chemicals from renewable raw materials [2], in wastewater bio-treatment [3] and so on. ALRs have good mixing and heat transfer efficiency as well as good suspension of particles with low energy consumption due to improved liquid circulation in comparison to bubble columns. Compared to mechanically stirred tanks, ALRs feature simplicity, low capital investment costs and easier scale-up [4]. The mild and uniform shear environment in ALRs is preferable for bioprocesses with fragile particles [5].

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