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Effects of surface active agents on hydrodynamics and mass transfer characteristics in a split-cylinder airlift bioreactor with packed bed

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ABSTRACT

The effects of three types of surface active agents (containing SDS, HCTBr and Tween 40) with various concentrations (0–5 ppm) on the hydrodynamic and oxygen mass transfer characteristics in a split-cylinder airlift bioreactor with and without packing were investigated. It was observed that in the surfactant solutions, surface tension of the liquid decreased and smaller bubbles were produced in comparison with pure water. So, surfactants presence strongly enhanced mixing time and gas hold-up although oxygen mass transfer coefficient and the liquid circulation velocity reduced. Furthermore, the packing installation enhanced the overall gas–liquid volumetric mass transfer coefficient by increasing flow turbulency and Reynolds number compared to an unpacked column. The packing increased gas hold-up and decreased bubbles size and liquid circulation velocity.

Keywords: Airlift bioreactor; Gas–liquid; Surface active agents; Packed bed; Hydrodynamics; Mass transfer coefficient

1. Introduction

Airlift bioreactors are one of the important classes of modified bubble columns (Joshi et al., 1990) which are widely used in various industrial applications such as chemical, petrochemical, biochemical fermentation and biological wastewater treatment processes (Blenke, 1979; Chisti, 1989; Saez et al., 1998).

Surface active agents (such as surfactants) are containing hydrophobic and hydrophilic groups. These materials locate their hydrophilic head groups in the aqueous phase and allow the hydrophobic hydrocarbon chains to escape from water phase. They could reduce surface tensions by accumulating at the interface of immiscible fluids. Surfactants are commonly used in the petroleum, food, and pharmaceutical industries as detergents, emulsifiers, foaming and wetting agents (Porter, 1994). These materials as most important contaminates exist in many factories wastewater (Moraveji et al., 2010).

Kalekar and Bhagwat (2006) studied the adsorption of various surfactants at gas–liquid interface. Egan (1976) investigated the critical micelles concentration (CMC) for various surfactants in different solutions. Guo et al. (1997) observed that the gas hold-up (ε) in a packed bed column linearly increased with increasing the gas superficial velocity (U_G) (for $U_G < 0.011$ m/s) although it showed a power trend for high superficial velocities (for $U_G > 0.011$ m/s).

Chisti and Moo-Young (1993) studied liquid circulation velocity (U_{LC}) in an external loop airlift bioreactor (ELAB) using spherical bead and Raschig Ring packing in the riser section. According to this research, the airlift packed bed reactor generated enough liquid flow for successful operation with some cell culture and immobilized enzyme systems.

Further, the mass transfer coefficient increased with increasing the liquid superficial velocity in the gas–liquid packed bed columns (Yuan et al., 2004; Deront et al., 1998).

Nikakhtari and Hill (2005a) increased the overall volumetric mass transfer coefficient (k_La) by inserting a few nylon meshes as packing (with 96.3% porosity) in the riser section of an external loop airlift bioreactor. They also used stainless steel meshes as packing (with 99.0% porosity) in the riser of the same reactor to increase the volumetric mass coefficient (Nikakhtari and Hill, 2005b). However stainless steel meshes

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