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Styrene absorption in water/silicone oil mixtures

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HIGHLIGHTS

- The absorption of styrene in water/silicone oil systems was investigated.
- The mass transfer for air/oil systems is double those determined for air/water system.
- This result is valid whatever the silicone oil percentage (2, 10 or 20% v/v).
- This result is due to the high value of the partition coefficient ratio (m_R = 257).

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ABSTRACT

The absorption of styrene in water/silicone oil systems at a constant flow rate for emulsion compositions ranging from 0% to 20% was investigated using a dynamic absorption method. It was found that the mass transfer for air/water/silicone oil systems is roughly double than those determined for air/water systems whatever the silicone oil percentage (ϕ). This result, mainly due to the high value of the partition coefficient ratio ($m_R = H_{water}/H_{oil} = 257$), was in agreement with the enhancement factor models proposed in the literature. Considering the volumetric mass transfer coefficient, it was shown that change in K_La versus ϕ depended on the mass transfer model used for its determination. By using the "equivalent absorption capacity" concept developed by Dumont et al. [18] (CEJ 162 (2010) 927–934; doi:10.1016/j.cej.2010.06.045), a dramatic decrease in the K_La with increasing silicone oil volume fraction was observed in relation to the decrease in the value of the partition coefficient H_{mix}. Conversely, considering a styrene mass transfer pathway in series (gas → water → oil), the K_La values for gas/water/silicone oil systems were roughly double the K_La for gas/water systems and did not depend on the mixture composition. The styrene mass transfer performances were also analyzed using the modeling framework proposed by Hernandez et al. [17] (CEJ 172 (2011) 961–969; doi:10.1016/j.cej.2011.07.008). This model confirmed the ability of a water/silicone oil mixture to increase the styrene mass transfer by a factor of 2 and verified that the change in H_{mix} versus ϕ followed the trend predicted by the theory (although the H_{mix} values determined from this model were significantly lower than the theoretical values).

1. Introduction

Styrene is an important industrial chemical, which is mainly used as a starting material for the production of synthetic polymers and as a solvent in the polymer processing industry. Due to its volatility, styrene represents a major hazardous air pollutant (HAP) and volatile organic compound (VOC) emitted by industry. Styrene removal from air is a significant problem because it has proved difficult to find a useful method. Traditionally, industrial waste gases have been treated by physico-chemical methods: adsorption, scrubbing, condensation, and oxidation processes [1,2]. However, for low-concentration gas exhaust (in general, the concentration of styrene in industrial waste gas is less than 1 g m^{-3} [3]), VOC removal can be achieved by using degrading microorganisms as biocatalysts. In fact, microorganisms are able to attack chemical waste products and degrade them naturally before their release into the environment. Moreover, the use of microorganisms is an economical technique [4,5]. Styrene, however, is poorly soluble in water and usually toxic for microorganism growth, even at low concentrations. In order to overcome these problems, a water-immiscible, biocompatible and non-biodegradable organic solvent can be used to, on the one hand, improve the absorption of styrene and, on the other hand, act as a reservoir for the controlled delivery of styrene to the aqueous phase where biodegradation occurs [6]. The absorption ability of

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