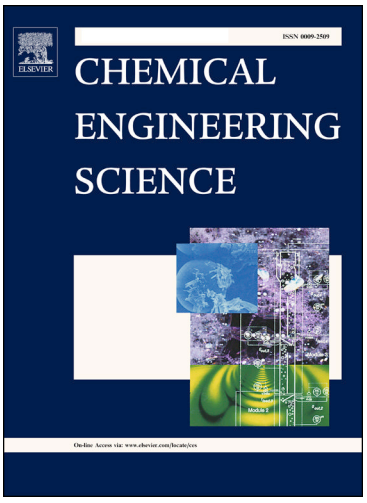

Prediction of concentration distribution in bubble columns with a rigorous turbulent mass diffusivity model Part II: Analogy between turbulent mass and momentum transfer in toluene emissions biodegradation process

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Prediction of concentration distribution in bubble columns with a rigorous turbulent mass diffusivity model Part II: Analogy between turbulent mass and momentum transfer in toluene emissions biodegradation process

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Abstract

Toluene is a kind of volatile organic compounds usually present in industrial emissions. In this work, the rigorous model for species concentration distribution prediction proposed in Part I was applied in simulating the biological degradation process of toluene in a bubble column (BC) reactor. We show in the present paper that the species concentration, turbulent mass diffusivity and velocity distributions along the bubble column bioreactor can be obtained simultaneously by applying the proposed model. On the basis of the simulations, the analogy between the turbulent mass diffusivity and turbulent viscosity for the bubble column reactor was investigated. The results showed that this analogy may depend on the rate of chemical or bio-chemical reaction in the bubble columns and remain for the case with a lower reaction rate.

Key words: Bubble column; Biodegradation of toluene; Analogy analysis; Turbulent mass transfer; Turbulent momentum transfer

1 Introduction

Toluene is a commonly encountered volatile organic pollutant in gaseous emissions from petrochemical, printing, and dyeing industries. Inadequate application and disposal may lead to accumulation of toluene in the environment, which is harmful to human health. For this reason the development of effective processes for reducing emissions of toluene and other pollutant has been increasingly interested by industries and the research community (Hecht et al., 1995; Wen et al., 2006). Industrial waste gases which contain toluene and other volatile organic compounds (VOCs) have been traditionally treated by physical and chemical methods, such as scrubbing, adsorption, condensation and oxidation processes (Kennes and Thalasso, 1998). In the past few decades bio-treatment of the waste gas has become a competitive alternative to the traditional methods. Compared to the physical or chemical treatment methods, biotreatment is more suitable to eliminate waste gas in low concentrations with the advantages of low cost, high efficiency and degrading the contaminants into innocuous substances, which can avoid the secondary pollution to the environment (Bailey and Ollis, 1986; Feng et al., 2006; Gavrilescu and Chisti, 2005; Jia et al., 2010).

The bioscrubber works usually for the treatment of highly water soluble compounds because the limitation of interphase mass transfer, but many VOCs like toluene have a low solubility in the water. The biofilter is often used in industries, but if it is operated for a long time, problems like, clogging, high pressure drop and dry zone formation may lead to significant decrease in the removal efficiencies of pollutant (Lo and Hwang, 2004a). Bubble column reactors have simple structure, but can provide close gas-liquid contact, high heat and mass transfer rates and low