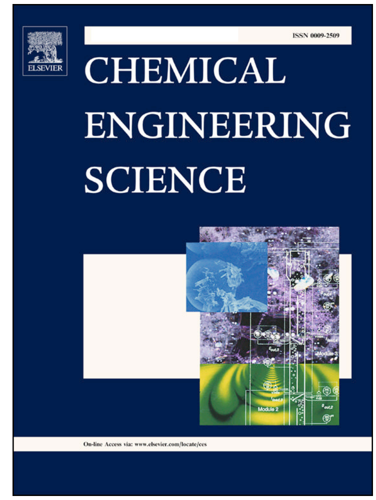

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Abstract

Though having been studied for more than four decades, photocatalysis is still hardly applied in large-scale water and wastewater treatment. This is mainly due to the low energy efficiency of conventional photocatalytic reactors. A recently introduced reactor concept, the fixed-bed photocatalytic membrane reactor (FPMR), can potentially overcome this shortcoming. Its performance for the degradation of organic compounds is examined for different modes of operation. For this purpose, FPMRs based on commercial submerged ceramic membranes were used, which are covered by a photocatalytic layer of pyrogenic titania. The FPMRs were performed in two operational modes: closed-loop reactor and continuous-flow reactor. Oxalic acid was used as a model organic compound to conduct photocatalysis. The influence of light intensity and catalyst layer thickness as well as mass transfer inside the layer were thoroughly studied. The evaluation of the reactors was based on the apparent quantum yield, the photocatalytic space-time yield and specific energy consumption. The results demonstrate that the FPMRs are considerably more efficient than other reported reactor concepts. Its apparent quantum yield can reach up to 11.1 %. Furthermore, its specific light energy consumption is merely around 0.1 kWh/g (TOC). The results also reveal that closed-loop FPMRs achieve higher efficiencies than continuous-flow FPMRs. Last but not least, a quantitative model for calculating the reaction rate constant of a photocatalytic membrane from observed reaction rate constant of a photocatalytic membrane reactor was developed and experimentally verified.

Keywords: photocatalytic membrane reactor, microreactor, apparent quantum yield, oxalic acid, mass transfer, light energy consumption

1 Introduction

Recent developments in photocatalysis have refreshed the interest of applying photocatalysis to water and wastewater treatment. For this purpose, photocatalytic membrane reactors (PMRs) are considered as the best technical solution because they combine the advantages of membrane processes and photocatalysis, allow continuous operation at low capital and operational costs, ensure compact apparatuses and simplify up-scaling (Leong et al., 2014; Molinari et al., 2017).