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RADIATION MODELING OF AIR PHASE CORRUGATED PLATE PHOTOCATALYTIC REACTOR

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Abstract The radiative energy absorption profiles on catalyst surfaces in an air phase corrugated plate photocatalytic reactor are mathematically modeled and numerically simulated based on the emission characteristics of a typical UV fluorescent lamp and solar radiation, the refraction indexes of the reactor materials, the spectral absorption characteristics of the catalyst, geometric optics, and analytical geometry. The effects of dimensions of the TiO_2-coated corrugated plates, multiple reflections, radiation sources, and refraction by the reaction medium were examined. Recapture of the reflected photons was found to result in higher photon absorption efficiency as well as more uniform local area-specific rate of energy absorption, which were shown to be dependent strongly on the dimensions of the corrugated plates. Compared to water phase systems, the radiation fields in air-phase corrugated plate reactors were predicted to be less uniform due to the lack of refraction by the reaction medium, especially when the light source is a UV-A lamp. However, the efficiency of photon capture is not significantly lower, and remains substantially higher than TiO_2 films on flat-plate geometries.

Key words: air, modeling, light, photoreactor, photocatalysis, radiation

1. Introduction

Photocatalysis is a series of heterogeneous photochemical reactions in which an oxide semiconductor, usually TiO_2, is photo-excited upon absorbing photons with appropriate energy levels. The photo-excited semiconductor produces electrons and holes (i.e., electron vacancies) which can migrate to the catalyst surface and initiate a series of oxidative and reductive reactions that may simultaneously oxidize toxic organic pollutants in water and in air [1]. In this and other photo-assisted processes, radiation absorption profiles in the system determine the process kinetics and specific products. Therefore, correct modeling of the emission, transfer, and absorption of photons is usually an indispensable step for the successful design, scale-up and optimization of photoreactors [2].

The kinetics of photocatalysis usually follow a low order (between 0 and 1) dependency on the rate at which the photons are absorbed on catalyst surface [3]. Among other requirements, an energy efficient photoreactor must possess a large illuminated catalyst surface. Based on this and other requirements, a corrugated plate photocatalytic reactor was designed, theoretically modeled [4], and experimentally tested using a water phase system. The photon absorption profiles

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