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Direct evaluation of the absorbed photon flow in a photocatalytic reactor by an actinometric method

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HIGHLIGHTS

- ▶ Role of light in a system with TiO_2 and uranyl is studied.
- ▶ A novel probabilistic model describes satisfactorily the system behaviour, including radiation.
- ▶ Probability that a photon is absorbed by a TiO_2 particle is presented.
- ▶ The absorption of light by TiO_2 is maximum around 300 nm and almost zero over 400 nm.

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ABSTRACT

One of the most important questions to be answered when designing a photocatalytic system is related to the role of light in the process and how to model it in an accurate, simple and generic way. In this paper, experiments with a TiO_2 suspension in an actinometric solution (uranyl nitrate + oxalic acid) have been carried out. A cylindrical reactor and a tubular reactor irradiated by a Xenon lamp were used to perform the experiments. Thus, it was possible to evaluate the absorbed light.

A probabilistic model is also presented. This model tries to explain and predict light behaviour when entering into the photocatalytic system. The experimental results obtained in the cylindrical reactor were fitted to the model and it was possible to estimate the probability of a photon to be absorbed by a TiO_2 particle after crashing it (P_{abs}). It is a TiO_2 pseudocharacteristic parameter. Thus, once it is determined and, if the same photocatalyst is used, P_{abs} would be able to be used in different systems. P_{abs} was estimated for different wavelengths ranges and was tested by applying the model to a tubular reactor for different catalyst concentrations, which means that the geometry of the system and the TiO_2 concentration were modified. Despite of the different conditions, the model was able to predict the system behaviour. The photon flow absorbed by TiO_2 is also presented.

1. Introduction

Heterogeneous photocatalysis is a promising technology for waste water treatment and it has been deeply studied during last decades [1–5]. It is stable, cheap and suitable for a wide amount of pollutants. But even if basic principles of photocatalysis are well established, there are still some remaining aspects which must be overcome to achieve the full development required for a wide commercialisation. Currently, several research lines are open in order to answer these pending questions. Some efforts have been focused on finding the best photocatalyst [6–9], although TiO_2 is still the most widely option chosen. Other groups are studying the role of active species [10,11], how to improve photocatalyst properties [12–15] or how to facilitate its recovery by working with supported photocatalyst [16,17]. Finally, several papers have been published studying how to improve photoreactors performance by means of new materials or designing reactors which minimises the radiation losses [18–21].

The differential aspect in heterogeneous photocatalysis is the involvement of light in the process. The study of the light effect and its links with the optical properties of the photocatalyst and the medium is an extremely complex issue. It depends on different parameters: photocatalyst aggregate size, pH and absorbance of the medium, spectrum and intensity of light, light scattering, geometry and material of the photoreactor, etc. Therefore, one of the most defiant challenges in photocatalysis is to understand the role of light and interconnect it with the rest of variables. The final goal is to obtain a general, reliable model, which describes such an intricate system. It would allow to characterise and design more efficient photoreactors and to facilitate their scaling up.

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