KINETIC STUDIES OF THE PHOTOCATALYTIC DEGRADATION OF TARTRAZINE

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Abstract- Kinetic studies of the photocatalytic degradation of tartrazine are carried out in a batch stirred reactor built in quartz at laboratory scale using TiO₂ as catalyst and irradiating the photoreactor with ultraviolet light. An experimental design is performed using as independent variables or factors the catalyst concentration, the calcination temperature of the catalyst and the initial concentration of tartrazine. The obtained kinetic model indicates that the value of the kinetic constant, k, for a first order reaction is high, in the operating conditions studied. This is consistent with the low value of the adsorption constant, K. The experimental data fitted, with the Langmuir-Hinshelwood model, lead to an equation that, in the range of concentrations studied, allows the evaluation of photodegradation and describes well the photoreactivity results.

Keywords—tartrazine, photocatalysis, kinetics.

I. INTRODUCTION

Tartrazine is an artificial dye that is present in a wide variety of foods and drugs, having been reported to cause health problems at the level of bronchia and skin, in case of intensive ingest for the human (Colins-Wiliams, 1985; Dipalma, 1990; Giri et al., 1990; and Hess, 2002). It has been found as a contaminant of wastewaters that can not biodegrade quickly or easily. One of the processes that can be used to eliminate this contaminant is heterogeneous photocatalysis. This process is based on the direct or indirect absorption by a solid, usually a semiconductor, of photons of visible or UV light. When this semiconductor is illuminated, it can generate electron-hole pairs by promoting an electron from the valence band to the conduction band, thus leaving a gap in this band. These holes can absorb H₂O or hydroxyl groups from the reaction medium and produce highly reactive hydroxyl radical species.

On the other hand, the electrons promoted to the conduction band, can reduce the molecular oxygen to peroxide anion to form hydrogen peroxide or organic peroxides in presence of organic compounds (Akpan and Hameed, 2009).

Radical hydroxyls are strong oxidizing agents that can degrade organic compounds or their intermediaries to reach final products such as CO₂, H₂O, N₂. The photocatalysis process can be defined, then, as the acceleration of a chemical reaction by the presence of a catalyst which, when activated by absorption of light, accelerates the reaction process by interaction of the reactive with the electron-hole (e-, h+) pairs, being this a characteristic of semiconductor materials. In particular, for water recovery, the best catalyst is titanium oxide, TiO₂. Bekbolet et al. (2002) in their studies of humic acid photocatalytic degradation performed the kinetic analysis in terms of a pseudofirst order kinetics (at low substrate concentrations) and a Langmuir-Hinshelwood kinetics (at high substrate concentrations). They showed that the reaction rate does not depend on the specific surface of the catalyst and that the morphological and crystallographic properties of the TiO₂ can play an important role in the photocatalytic efficiency. Sobczynski et al. (2004) studied the photocatlytic decomposition of phenol by TiO₂. They recommend the use of the initial reaction rate for kinetic studies, due to the existence of many competing reactions in the suspensions of TiO₂ illuminated, and present a mechanism for the complete mineralization of phenol. Wu et al. (2006) studied basic dyes decomposition kinetics by nano-sized TiO₂ suspension, at a pH of 9.8, by varying the agitation speed, TiO₂ suspension concentration, initial dye concentration, temperature, and UV power intensity. They developed a kinetic model, based on the Langmuir-Hinshelwood model and the Lambert-Beer's law, to successfully correlate the initial rates. Furthermore, Gondal et al. (2007) applied the photocatalysis process to compare the catalytic activity of four photocatalysts for the phenol degradation in water, irradiating with laser: WO₃, NiO, Fe₂O₃ and TiO₂. They obtained the maximum degradation using a WO3 catalyst and showed that the degradation process follows a first order kinetics. Moreover, Sham et al. (2009) performed the kinetic study of the photocatalytic degradation of the 2chlorophenol, determining that the kinetics of the organic compound degradation fits satisfactorily with the Langmuir-Hinshelwood (L-H) model. Farias et al. (2009) focused their study on the kinetic modeling of the Fenton and photo-Fenton degradation of a pollutant (formic acid) in aqueous solution, for low iron concentrations. They derived a reaction rate expression from an accepted reaction mechanism by having explicitly into account the local volumetric rate of photon absorption. Friedmann et al. (2010) discussed the relevance of the parameters affecting the kinetics and mechanisms of photocatalysis for TiO₂ water treatment. They determined that there is a strong interplay between pollutant structure, reactivity, and mode of interaction with cata-