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Research Article

Synergetic Enhancement of the Photocatalytic Activity of TiO_2 with Visible Light by Sensitization Using a Novel Push-Pull Zinc Phthalocyanine

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A new one-pot synthesis of a novel A_3B-type asymmetric zinc phthalocyanine (AZnPc) was developed. The phthalocyanine complex was characterized unambiguously and used to prepare a TiO_2 hybrid photocatalyst to enhance its photocatalytic activity in the visible range. Different compositions of the phthalocyanine dye were tested in order to find the optimum amount of sensitizer to get the highest activity during the photocatalytic tests. The hybrid photocatalyst was characterized by UV-Vis diffuse reflectance (DRS) and Fourier transform infrared spectroscopy (FT-IR) and its photocatalytic activity was compared with that of the individual components considering the effects of sensitization on their efficiency to degrade Rhodamine B as a model reaction. A synergic improvement of the photocatalytic activity for the hybrid system was explained in terms of an improved electron injection from the photo-activated phthalocyanine to the TiO_2. Considering the structural features of the phthalocyanine sensitizer and their effect on aggregation, some mechanistic aspects of its binding to TiO_2 are suggested to account for the photocatalytic activity enhancement. Finally, the inhibitory effect on the sprouting of chia seeds (*Salvia hispanica*) was evaluated in order to test the toxicity of the water effluent obtained after the photodegradation process. According to our growth inhibition assays, it was found that the Rh-B degradation by-products do not lead to an acute toxicity.

1. Introduction

Since the discovery of the photocatalysis process [1], several research areas have been developed to get an insight into its operation with the ultimate aim of implementing a practical application, particularly in the fields of energy conversion and water depuration which have been identified as the biggest problems facing humanity over the next decades. For the latter, photocatalysis has received lately a lot of attention and the endeavors have been aimed at three different research fronts: improving the efficiency of the charge transfer processes, widening the absorption spectrum to the visible range, and ensuring catalyst recovery. In addition, photocatalysis research has been focused on the depuration of water contaminated mainly with three kinds of recalcitrant organic compounds: dyes, pesticides, and pharmaceuticals, and in this field TiO_2 has established itself as the benchmark material [2]. However, the fact that it can only be activated with ultraviolet radiation due to its wide bandgap constitutes a drawback. Because of this, more recently, the scientific effort has been directed to broaden the visible light response band of TiO_2 using different approaches such as metal and nonmetal doping, coupling with other narrower bandgap semiconductors, and dye sensitization [3].

Dye sensitization is an inexpensive approach to extend the wavelength range of the incident radiation required to