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Methylene Blue Sensitization by Enriched Oxygen Vacancy ZnO

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Extended Abstract

Metal oxide photocatalysts have gained special attention as a green technology for environmental remediation. Zinc oxide is a popular semiconductor photocatalyst due to its electronic properties, low cost and toxicity, and the ability to mineralize organic pollutants completely. However, disadvantages such as a high rate of electron-hole recombination, and a wide bandgap for harvesting visible light, limit the application of ZnO [1].

One of the possible methods to overcome the metal oxide limitations is providing oxygen vacancies (OV) at the surface of the nanoparticles. OVs can trap the photo-generated electrons and they can act as an adsorption site, where the excited electron can transfer to the adsorbed compound. Hence, the presence of OVs will enhance photocatalytic degradation by reducing the electron-hole recombination [2].

In this study, the enriched OVs ZnO were provided by a temperature-programmed reduction (TPR) method. To this aim, commercial ZnO was heated by a ramp rate of 10°C/min to 500°C in a flow of 10% H_2/Ar. The formation of OVs was investigated by several characterization analyses such as TPR, TPO, PCO, XPS, XRD, PL, EPR, FE-SEM, TEM, BET, and Tauc plot. The adsorption capacity and photocatalytic activity of commercial ZnO (C-ZnO) and reduced ZnO (R-ZnO) were compared by photocatalytic degradation of methylene blue (MB) and methyl orange (MO). The experimental data of sequential adsorption in the dark and photocatalytic degradation under simulated sunlight were modelled by our recently developed kinetic model [3]. This model can simultaneously follow the concentration of the adsorbed dye on the surface of the catalyst and the aqueous dye in the solution. Furthermore, the model can identify the degradation that occurs by the electron-holes at the surface of the catalyst by the one that occurs by active radicals in the solution.

One interesting phenomenon that occurs in the photocatalytic degradation of dyes such as MB, is dye sensitization. In this phenomenon, an electron in the adsorbed MB molecule can be excited and transferred to the catalyst. In this way, the adsorbed MB acts as an antenna and the catalyst acts as an electron receiver to enhance the photocatalytic degradation of the process [4]. The experimental and the modelling results indicate that the photocatalytic degradation rate of MO is considerably lower than MB in both C-ZnO and R-ZnO catalysts. However, by application of MB and MO at the same time in the photocatalytic process, the MO degradation rate increases significantly. This can be a result of adsorbed MB sensitization at the surface of the catalyst, which can enhance the photo-generated electrons by transferring the excited electron of MB to the conduction band of ZnO.

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