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Photocatalytic activity and photoelectrochemical properties of Ag/ZnO core/shell nanorods under low-intensity white light irradiation

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Abstract

Zinc oxide (ZnO) nanorod thin films were prepared by CBD onto glass and FTO/glass substrates. Silver (Ag) nanoparticles were synthesized on the surface of the prepared ZnO nanorod thin films using electrochemical methods. The scanning electron microscopy images of the Ag/ZnO/glass core/shell nanostructure confirmed that the average particles size is 20 nm while it was 41 nm for Ag NPs that synthesized onto ZnO/FTO NRs. The photocatalytic activity of the prepared Ag/ZnO core/shell nanostructure was studied by analyzing the degradation of methylene blue (MB) dye under visible light. Various pH values (6 and 10) and exposure time (30–240) min were controlled to investigate the photocatalytic activity of as-prepared Ag/ZnO core/shell nanostructure and that annealed at 200 °C and 300 °C for 1 h. It was observed that when the pH was 6, the degradation rate increased with the annealing temperature and irradiation time reaching 51% at the annealing temperature of 300 °C and exposure time of 240 min. In other hands, when the pH was 10, and the sample was annealed at 200 °C, it showed a good degradation rate of 100% at the irradiation time of 90 min. By contrast, the sample annealed at 300 °C required 180 min to degrade the MB dye completely. The photoelectrochemical cell measurement based on photocurrent density revealed a slight response to light. Cycle voltammetry (CV) measurement was conducted, and the CV curves of the Ag/ZnO core/shell electrodes indicated nonfaradaic and pseudocapacitance behavior. The electrodes showed nearly rectangular CV curves, which indicated the dominance of the nonfaradaic capacitance behavior. The specific capacitance of the electrodes remained at approximately 99%. Mott–Schottky analysis revealed that the semiconductor was an n-type with dependence on flat band potential V_{FB} deviation in the negative direction.

Keywords: ZnO, core/shell, photocatalyst, photoelectrochemical cell

(Some figures may appear in colour only in the online journal)

1. Introduction

Zinc oxide (ZnO) nanostructure is considered as a promising photocatalytic material due to its high catalytic activity, low cost, environmental friendliness, chemical stability, and easy synthesis in nanostructured forms. The main limitation of the ZnO nanostructure in achieving a high photocatalytic efficiency is the rabid recombination of charge carriers. Hence, the design and modification of ZnO photocatalysts with high sensitivity and reactivity has attracted increasing attention.

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