Study on enhanced photocatalytic performance of cerium doped TiO$_2$-based nanosheets

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Abstract

Cerium doped TiO$_2$-based nanosheets (Ce-TNSs) photocatalysts were prepared by a one-pot hydrothermal method using cerium nitrate as the cerium precursor. The photocatalysts were characterized by high-resolution transmission electron microscope (HRTEM), X-ray diffraction (XRD), Raman spectra, ultraviolet–visible light diffuse reflectance spectra (DRS), X-ray photoemission spectroscopy (XPS) and fluorescence spectra (FL). The results show that Ce$^{3+}$ and Ce$^{4+}$ co-exist in Ce-TNS. The doping leads to changes in binding energies of Ti and O. The concentration of Ti$^{3+}$ increases gradually when the cerium doping amount keep increasing. Appropriate amount of cerium doping can significantly inhibit the recombination of electron–hole pairs, which is proved by the decline in the intensity of the fluorescence spectra. Ce-TNS with doping ratio of 0.5% (molar ratio) possesses the highest photocatalytic activity when degrading Rhodamine B (RhB), which is 5 times and 1.6 times of that of P25 and the undoped TNS, respectively. It is suggested that cerium ions are efficient electron traps to improve the separation efficiency of electrons and holes.

1. Introduction

Photocatalytic technology is an important method of dealing with environmental pollution in recent years [1,2]. TiO$_2$-based photocatalysts are widely used for pollution control because they have many advantages such as high photocatalytic activity, high physical and chemical stability, low cost, and non-toxicity [3–5]. However, the traditional TiO$_2$ photocatalysts generally have two shortcomings: the low separation and migration efficiency of electron–hole pairs, and the narrow range of light absorbing. The insufficients are becoming bottlenecks restricting the large-scale applications of TiO$_2$-based photocatalysts.

Morphology control of TiO$_2$-based photocatalysts is usually one of the important research directions. The nanostructure of the photocatalyst has a great impact on the migration of the electrons and holes. Many new types of TiO$_2$-based photocatalysts have been reported in recent years, including nanorods [6], nanotubes [7], nanofibers [8], nanosheets (TNSs) [9,10], and nanoflowers [11]. The hydrothermal reaction of TiO$_2$ under high concentrated alkali