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The growth mechanism of titania/hydroxyapatite and its application in the photodegradation of methyl orange dye under UV irradiation

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ABSTRACT

In this work, titania/hydroxyapatite (TiO_2/HAP) composite materials were synthesized via a wet chemistry method. Morphological field emission scanning electron microscopy and electronic differential system field analysis revealed the growth mechanism that TiO_2 began to divorce from surface on HAP with the Ti content of 2.60% while separated from the surface of HAP with the Ti content of 4.83%. Furthermore, Fourier transform infrared spectroscopy verified that the crystal structure of TiO_2/HAP remained stable in the degradation process of MO. Especially, the TiO_2/HAP has a good photocatalytic activity and photostability with the Ti content of 2.55%.

Introduction

In recent years, the photocatalytic degradation technology used in environment and biological field is a hot spot [1–8]. Over these photocatalyst, Titania (TiO_2) was used frequently. TiO_2, a direct band gap semiconductor material with a band gap tuned in the range of 3.0–3.2 eV [8], has gotten much attention as a type of potent photocatalyst in the field of wastewater treatment. In the photocatalysis process, electron and hole pairs are produced by TiO_2 irradiated under UV light, and the electron and the hole can react with other groups (such as OH^-) and produced $\cdot O_2^-$ which have high oxidizable to degrade organic polluted compounds. To get a high photocatalytic activity, one method is to suppress the recombination of electron–hole pairs [9,10]. Electron hole pairs generated by ZnO under UV irradiation can be transferred to hydroxyapatite (HAP) as a medium which can prolong the existence time of the electron hole pairs [11] like TiO_2 [12]. Using different morphologies synthesized TiO_2 to apply for the degradation of methyl orange (MO) dye found that the photocatalytic activity of plate shape TiO_2 is better than P25 (the particle size of TiO_2 is 25 μm) [13]. That means morphology of TiO_2 is an important factor for the photocatalytic activity. According to Refs. [11,12,14], the activity (better charge separation, optimized surface reactivity) of photocatalysts can be improved by controlling the morphology of TiO_2 and using a suitable substrate material.

Clay minerals used as substrate materials were very popular in the past decades. Wang, et al. compared TiO_2/Skeleton, TiO_2/Dens and TiO_2/HAP to degrade Acid Red B dye, the results indicated that TiO_2/HAP owns the best effect [15]. Xie et al. and Ono et al used TiO_2/HAP to degrade the pentachlorophenol and methylene blue, and they found that the photocatalytic activity of TiO_2/HAP is 1.5 times higher than P25 [16,17]. Although the performance of TiO_2/HAP has been extensively studied [12,15–17], the growth mechanism of TiO_2/HAP has been less mentioned.

Herein, to understand the growth mechanism of TiO_2/HAP, a simple sol-gel method was used to synthesis TiO_2/HAP, and the photocatalytic activity was revealed through the MO degradation. The results indicated that the TiO_2/HAP under the Ti content of 2.55% is 10 times higher than HAP [18].

Experimental

Material

Tetrabutyl titanate (analytically purity) and absolute ethanol (analytically purity) were produced by sinopharm group (China). HAP was synthesized at a wet chemistry method according to our previous work

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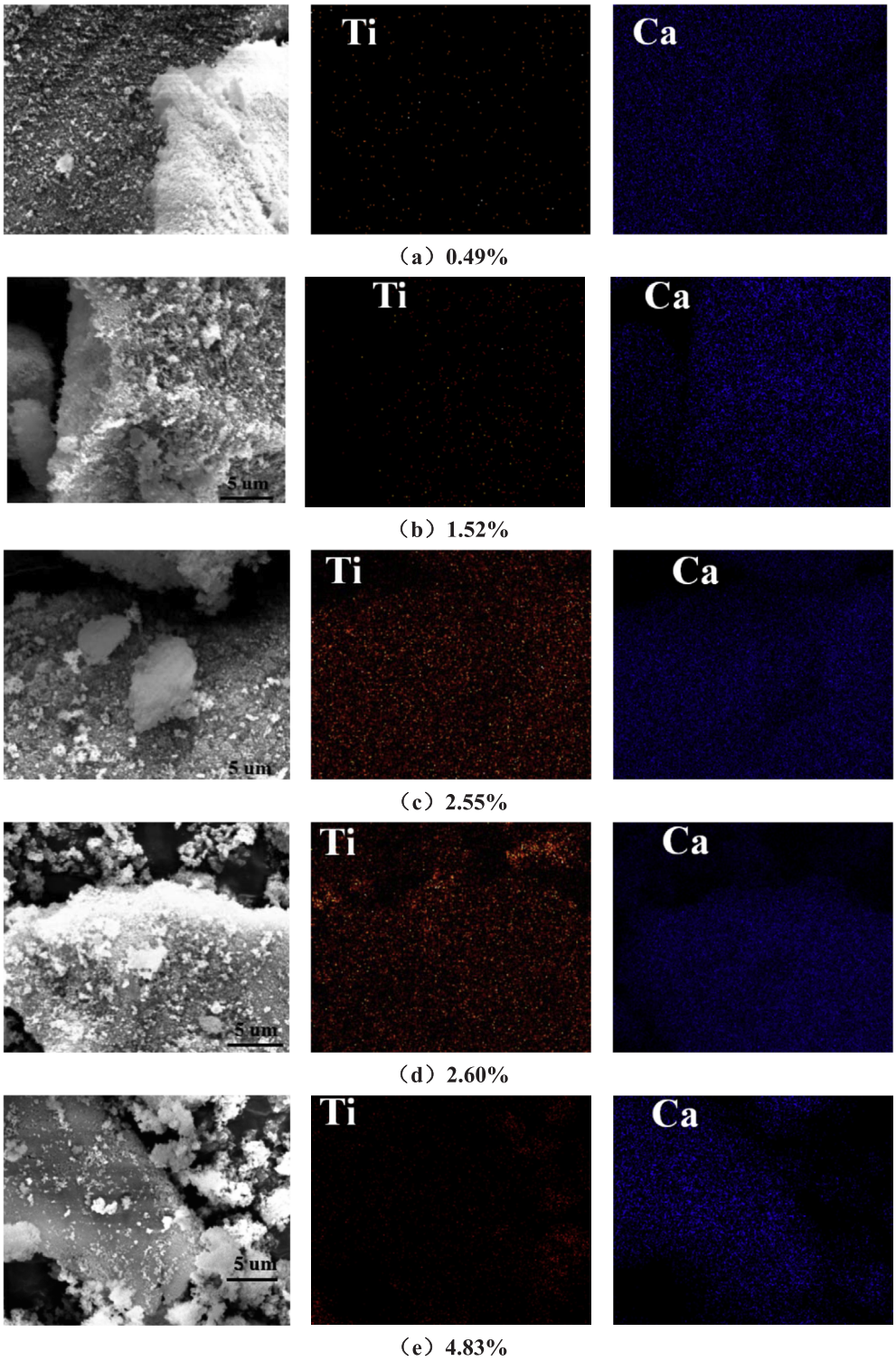

Fig. 1. FESEM and EDS of TiO_2/HAP samples.

[19]. Deionized water was used throughout the experiment.

Synthesis of TiO_2/HAP

In a simple synthesis of TiO_2/HAP, 20 ml absolute ethanol containing certain tetrabutyl titanate was added drop wise into 50 ml absolute ethanol dispersed 1 g HAP with stirring in a 250 ml beaker, and then added 40 ml absolute ethanol with 2 ml deionized water, stirring for 16 h. Then the reacted production was filtered to separate solid from liquid phase, followed by washed with deionized water, dried at 105 °C overnight and heated at 700 °C for 6 h.

Evaluation method for photocatalytic activity of TiO_2/HAP

MO was used to estimate the photocatalytic activity of TiO_2/HAP under UV irradiation (300 w). The TiO_2/HAP (the dosage is 1 g/L) was added in the simulated wastewater containing 5 mg/L MO dye and persists for 15 min in a 250 ml beaker. After the photocatalytic reaction,