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The seeding effect on the microstructure and photocatalytic properties of ZnO nano powders

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ABSTRACT

Nano sized ZnO powders, with suitable amount of TiO_2 (P25), have been successfully synthesized via a novel modified hydrothermal method by using zinc acetate. Titania nano powder plays an important role in fabrication of ZnO nano structure. The structure and morphology of the product were characterized by X-ray diffraction and scanning electron microscopy, which show different morphologies and particle sizes. Photocatalytical properties of the product exhibit strong improvement in the reactivity of seeded powders. These powders have better properties because of coupling effect of semiconductors, small powder size and reduced recombination of electron-hole in the surface of a catalyst.

1. Introduction

Nanostructured ZnO is an attractive material for its unique performance in electronics, optics and photonics because of its wide band gap (3.37 eV) and high excitation binding energy (60 meV). Different morphology of that, such as nanowires [1], nanobelts [2] and nano powders [3] has been demonstrated by using a variety of methods [4].

The photocatalytic applications of various types of ZnO structures have been reported so far [5,6].

In photocatalysis and surface chemistry, charge trapping extends the lifetime of photogenerated electrons and holes and decreases their recombination rate. This is a desired effect because it enhances the quantum yield of the photocatalyst [7]. In the other way, surfaces and defects associated with the surface have a major impact on the physical properties of polycrystals, when they get a few nanometers in size since the surface-to-volume ratio is large [8].

The morphology of powders is another important factor which affects the surface-to-volume ratio. The preparation methods have an important effect on the microstructure, defects and photocatalytical properties of the semiconductors [9].

To increase the activity of photocatalysts, researchers used dye sensitized, metal or nonmetal doped catalyst nanoparticles and modificated semiconductor by addition of another semiconductor [10,11].

There are few publications about composite particles containing ZnO–TiO_2 and their photocatalytic properties. Titanium dioxide coated with zinc oxide was used as a recyclable photocatalyst by Gao et al. [12] or Korean researchers studied the effects of heterojunction on the photocatalytic properties of composite films [13]. The other group used the composite as a solar photocatalyst to degradate blue dye [14] and Liao et al. prepared nano sized TiO_2–ZnO composites to decolorize methyl orange [15].

In order to prepare composite photocatalyst with enhanced photocatalytic activity under UV–vis irradiation, in this paper, ZnO–TiO_2 powders were prepared by a seeded hydrothermal method under suitable condition. The effect of TiO_2 nanoparticle on the formation of ZnO powders was investigated, the photocatalytic activity of these samples was evaluated by degradation of azo dye in aqueous solution under artificial solar irradiation. Our results demonstrated that the TiO_2–ZnO heterostructure synthesized by hydrothermal method, shows a comparable photocatalytic property and controllable microstructure of ZnO–TiO_2 nano powders.

2. Experimental procedure

All the materials were of analytical grade and were purchased from Merck, Germany and Degussa. In a typical procedure, mixtures of 100 ml ethanol (C_2H_5OH) and 10 vol.% of triethanolamine (TEA, C6H15NO3) and 0–10 molar % of P25 (the commercial powder) were prepared. Zinc acetate dehydrate [$Zn(CH_3COO)_2 \cdot 2H_2O$] crystals were added to the initial solution under vigorous agitation until the desired pH of the mixture was reached to about 9. When the zinc acetate crystals were dissolved completely, sodium hydroxide (NaOH) pellets were added to the solution to increase the pH of the mixture to about 11. The resultant solution was then transferred into a Teflon-lined stainless steel autoclave which was sealed and

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