Preparation of One-dimensional ZnO/Bi$_2$O$_3$ Heterostructures Nanomaterial for Visible Light Photocatalysis

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We use a simple route to prepare ZnO@Bi$_2$O$_3$ heterostructures at room temperature by the solid-state reaction method. The paper discussed morphology and photocatalytic properties of different content of ZnO@Bi$_2$O$_3$ composite nanomaterials. The as-prepared different content of ZnO@Bi$_2$O$_3$ composite with different content were characterized by SEM, TEM, XRD and Uv-vis spectrometry. We find that the Bi$_2$O$_3$ nanoparticles are well dispersed on the ZnO Nano rods. The result shows that we can the absorption of solar light can be enhanced by coating Bi$_2$O$_3$ and zinc oxide /bismuth oxide sample in sunlight irradiation shows the best photocatalytic activity under sunlight irradiation.

Keywords: Photocatalysis; ZnO@Bi$_2$O$_3$ Composite; Visible Light.

1. Introduction

Owing to the discharged toxic organic pollutants and colored wastewater, the water bodies in nature are seriously damaged, which is harmful to human health and the environment [1, 2]. Photocatalytic degradation of organic pollutants by photocatalysts has been the beneficial technology for water purification. In the field of photocatalysis, ZnO is believed to be an efficient photocatalytic material alternative to TiO$_2$ because both have similar band gap and photocatalytic mechanism. ZnO is an important semiconductor material with a band gap of 3.37eV at room temperature and its photocatalytic activity has been widely explored and reported [3]. Due to the wide band of ZnO, it only absorbs the UV light, which accounts for only 5% of the solar energy. Therefore, how to improve the photocatalytic activity is necessary to modify ZnO by enlarging the light absorption. Bismuth oxide (Bi$_2$O$_3$) is a kind of semiconductor with a band gap of 2.47eV, which is active under visible light irradiation [4]. It is expected that ZnO/Bi$_2$O$_3$ heterojunction could improve the photocatalytic properties of pure ZnO [5].

In this paper we intend to synthesize the ZnO/Bi$_2$O$_3$ heterojunction by the solid-state reaction at a room temperature and investigate the photocatalytic performance of ZnO/B$_3$ heterojunction under visible light irradiation.
2. Experimental

2.1. Fabriccation of ZnO/ Bi₂O₃ heterojunction

All chemicals reagents are analytical grade and directly used without further purification. Zn(CH₃COO)₂·2H₂O (0.438g, 2.0mmol) and different amount (0, 3%, 5%, 10%) of Bi₂O₃ were blended together in agate mortar and ground thoroughly for 30min at room temperature. Then, NaOH (0.64g, 16mmol) was added to the mixture and ground for further 2h. Finally, the products were washed several times with distilled water and absolute ethanol. Afterwards, we put the products in oven for drying at 100°C for 12h.

2.2. Characterization methods

The surface morphology of the samples was investigated using Field-emission scanning electron microscope (FESEM, Hitachi S-4800) equipped with an Energy-dispersive X-ray spectroscopy (EDS), and a transmission electron microscope (TEM, JEM 2100, 200 kV). The phase structures of the ZnO/Bi₂O₃ heterojunction nanocomposites were studied by powder X-ray diffraction (XRD, Bruker AXS D8-discover). The UV-visible spectroscopy measurement and Methylene blue (MB) UV absorbance was investigated by UV-vis absorption (Hitachi U-3900). In this experiment, 40mg ZnO/Bi₂O₃ heterojunction nanocomposites were added into 50 ml 10 mg/L MB solutions under visible light irradiation (PHILIPS, 662 nm) for photocatalytic examination under magnetic stirring. The UV absorbance spectra of MB solution were collected every 20 min.

2.3. Result and discussion

The SEM images of ZnO/Bi₂O₃ heterojunction and the TEM image of ZnO/Bi₂O₃ heterojunction were shown in Figure1. From Figure1a, the prepared ZnO without adding Bi₂O₃ shows flake or irregular Nano rods. While, the surface morphology was changed by adding Bi₂O₃, as shown in Figure1, we can see that some nanoparticles have attached on the surface of ZnO. As shown in Figure1c and Figure 1d shows a typical TEM image of ZnO/Bi₂O₃ heterojunction. It can be seen that Bi₂O₃ particles are anchored on the surface of ZnO.
Figure 1. The SEM images of (a) pure ZnO, (b) ZnO/ Bi$_2$O$_3$, (c), (d) TEM images of ZnO/ Bi$_2$O$_3$.

Figure 2 shows the XRD patterns of as-prepared samples. All the diffraction peaks of ZnO agree well with the wurtzite standard pattern (JCPDS No. 36-1451), while the diffraction peaks of α-Bi$_2$O$_3$ corresponds well to the standard pattern (JCPDS No. 71-2274).
Photocatalytic activities of the samples were evaluated by measuring the degradation of MB in aqueous solution under visible light irradiation. Figure 3 shows the UV-vis absorption spectrum of MB aqueous solution with ZnO/ Bi2O3 heterojunction as photocatalyst during different exposure time under the light irradiation. The maximum absorbance of MB diminishes gradually with time elapse. The absorption peak nearly disappeared in 50 min under visible light irradiation in the presence of ZnO/ Bi2O3 photocatalyst.
3. Conclusion

In summary, we have synthesized the zinc oxide /bismuth oxide heterostructures at room temperature. The result indicates the ZnO/Bi₂O₃ heterojunction has excellent photocatalytic efficient for MB solution under visible light irradiation.
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References