



ZnO-BiOCl Nanocomposite for Photocatalytic Degradation of Organic Dye†

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ZnO-BiOCl nanocomposite was synthesized *via* a two-step process where the precursor was first prepared by a facile coprecipitation method and then was calcined at 500 °C under air atmosphere. The nanocomposite is composed of porous ZnO nanoplates and BiOCl nanoparticles. For photodegradation of rhodamine B under the simulated sunlight irradiation, the ZnO-BiOCl nanocomposite exhibited higher photocatalytic efficiency than pure ZnO.

Key Words: ZnO-BiOCl, Nanocomposite, Synthesis, Microstructure, Photocatalysis.

INTRODUCTION

Photocatalytic degradation of organic pollutants has attracted great interest over the last decades¹. Zinc oxide, a direct wide band gap (3.37 eV) semiconductor, has been known as one of the most efficient photocatalysts with its outstanding photocatalytic activity and stability². Bismuth oxychloride with a high band gap is a potential photocatalyst under UV light irradiation because of its unique layered structure and high chemical stability³. However, the fast recombination rate of the photogenerated electron-hole pairs in the monocomponent semiconductors restricts their photocatalytic efficiency. It has been demonstrated that coupling of different nanostructured semiconductors to form nanocomposites can increase the photocatalytic efficiency by increasing the charge separation⁴. This paper presents the study on the facile synthesis and photocatalytic activity of a novel ZnO-BiOCl nanocomposite for photocatalytic degradation of organic dye.

EXPERIMENTAL

All reagents were of analytical grade, purchased from Shanghai Sinopharm Chemical Reagent Co. Ltd. and used without further purification. Zinc chloride (2 mmol), Bi(NO₃)₃·5H₂O (0.5 mmol) and CO(NH₂)₂ (10 mmol) were dissolved in 40 mL of distilled water under stirring. The mixed solution was sealed in a glass bottle (60 mL), kept static at 80 °C for 24 h and then cooled to room temperature. The precipitate was separated by centrifuge, washed with distilled water and

absolute alcohol several times and dried at 80 °C for 12 h. The as-obtained precursor was placed in a crucible and heated at 500 °C for 3 h in air. After cooling to room temperature, the final product was collected. For comparison, monocomponent ZnO sample were also prepared using the similar method and calcination process.

The X-ray diffraction pattern was recorded on a Japan Rigaku D/max- χ A X-ray diffractometer equipped with graphite monochromatized high-intensity CuK α radiation ($\lambda = 1.54178$ Å). The field emission scanning electron microscopy (FESEM) was performed on JEOLJSM-6700F. The UV-vis diffuse reflectance spectra (DRS) were recorded on a DUV-3700 DUV-VIS-NIR recording spectrophotometer from Shimadzu Corporation.

The photocatalytic activity was evaluated by the photodegradation of rhodamine-B under the simulated sunlight from a 300 W Xe lamp. The system containing 100 mL of rhodamine-B solution with an initial concentration of 5×10^{-5} M and 30 mg of photocatalyst was magnetically stirred in the dark for 5 h to reach adsorption equilibrium. After a given irradiation time, a small amount of the solution was withdrawn for analysis. The photocatalytic degradation process was monitored using a UV-VIS spectrophotometer (Shimadzu UV2550) measuring the absorption of rhodamine-B at 553 nm.

RESULTS AND DISCUSSION

X-ray diffraction pattern of the nanocomposite is shown in Fig. 1. The diffraction peaks can be indexed to two sets of

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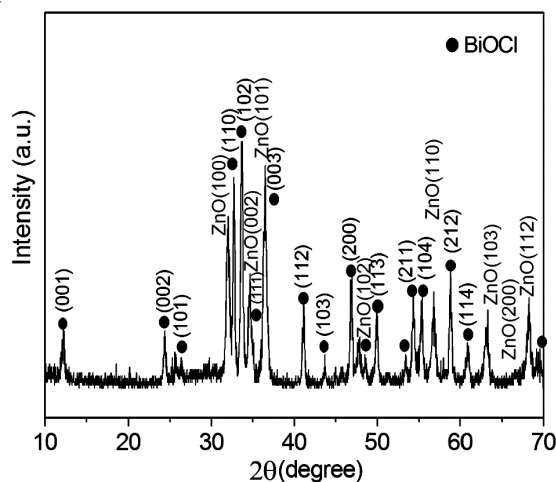


Fig. 1. XRD pattern of ZnO-BiOCl nanocomposite

XRD patterns which are corresponding to monoclinic BiOCl (JCPDS 06-0249) and hexagonal wurtzite ZnO (JCPDS 36-1451), respectively, indicating that the compositions of the sample are mainly BiOCl crystallite and ZnO crystallite.

Fig. 2 shows SEM images of the ZnO-BiOCl nanocomposite. From Fig. 2a, it is observed that the composite is composed of numerous nanoplates and some irregular nanoparticles. The magnified SEM image in Fig. 2b further reveals that these nanoplates present obvious porosity, which resulted from the thermal decomposition of carbonate and hydroxide of the precursor. Thus, it can be inferred that the porous nanoplates are ZnO from the thermal decomposition of basic zinc carbonate precursor⁵ and the irregular nanoparticles are BiOCl.

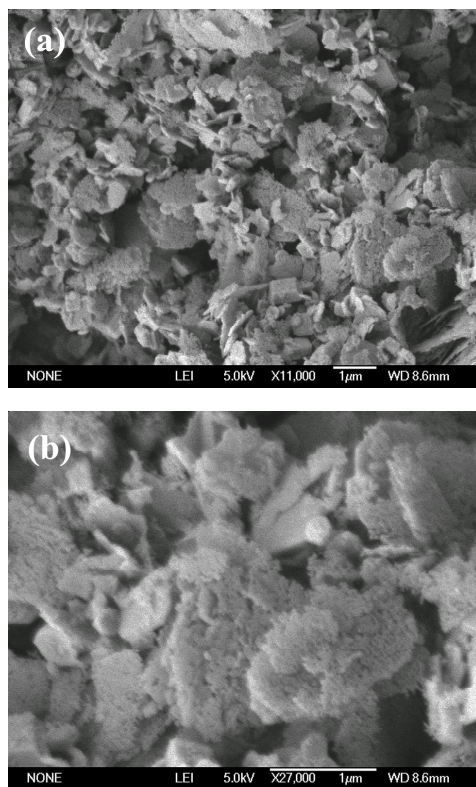


Fig. 2. (a, b) SEM images with high and low magnification of BiOCl-ZnO nanocomposite

To evaluate the photocatalytic activity of the BiOCl-ZnO nanocomposite, the photodegradation of the organic dye rhodamine-B was investigated under the simulated sunlight from a 300 W Xe lamp. Fig. 3a shows the UV-VIS absorption spectra of rhodamine-B aqueous solution with BiOCl-ZnO nanocomposite as photocatalyst and exposure to the light irradiation for various durations. The characteristic absorption of rhodamine-B at 553 nm decreased rapidly with extension of the exposure time and completely disappeared after 2 h. Fig. 3b shows the results of the rhodamine-B degradation using different photocatalysts, where C_0 and C_t are the initial concentration after the equilibrium adsorption and the reaction concentration of rhodamine-B, respectively. A blank test (rhodamine-B without any catalyst) under irradiation exhibited little decrease in the concentration of rhodamine-B. For pure ZnO photocatalyst, the rhodamine-B degradation is about 38 % at 2 h. For ZnO-BiOCl nanocomposite as a photocatalyst, the photodegradation of rhodamine-B reached nearly 100 % after 2 h of the light irradiation. ZnO-BiOCl nanocomposite exhibited a superior photocatalytic activity in the photodegradation of rhodamine-B under the simulated sunlight.

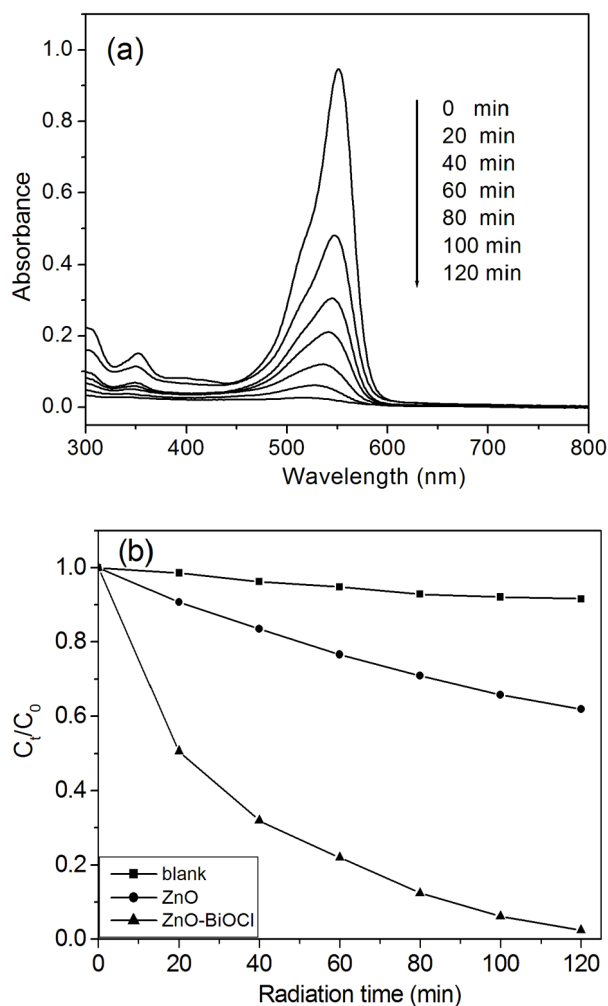


Fig. 3. (a) Time-dependent absorption spectra of the rhodamine-B solution during the simulated sunlight irradiation and using BiOCl-ZnO nanocomposite as a photocatalyst, (b) the rhodamine-B concentration changes under the simulated sunlight irradiation over different conditions

Conclusion

BiOCl-ZnO nanocomposite is prepared by a facile two-step process. The as-prepared BiOCl-ZnO nanocomposite is composed of porous ZnO nanoplates and BiOCl nanoparticles. For the photodegradation of rhodamine-B under the simulated sunlight, the BiOCl-ZnO nanocomposite shows a higher photocatalytic activity than the pure ZnO photocatalyst, which was mainly attributed to the extended photo-responding range towards visible light and the increased charge separation rate in nanocomposite.

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