The Preparation of ZnO/AC Composite Photocatalytic Material for Coking Wastewater Treatment

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Abstract. A simple and low-temperature method was utilized to attach nanostructured ZnO to the surface of porous activated carbon (AC). The phase structure and surface morphology of the as-prepared sample were characterized. XRD analysis confirmed patterns for the wurtzite hexagonal phase of ZnO and AC from the sample. SEM demonstrated that the porous character and relatively larger surface area of ZnO/AC composite. In the photocatalytic degradation of coking wastewater, the ZnO/AC composite material showed effective photocatalytic activity. It could be attributed to highly efficient capture and transportation of photo-generated electrons from AC to ZnO.

Introduction

In recent years, nanostructured ZnO materials have attracted much attention due to their excellent qptical properties and facile synthesis methods, which can be applied in photovoltaic device applications. However, the wide band-gap energy of ZnO makes the photo-generated electron-hole pairs recombine fast [1]. In addition, its suspention system can easily generate catalyst condensation and is difficult to recycle, which will cause the waste of raw materials. So far, many methods have been used to efficiently generate electron-hole pairs through visible-light excitation, such as ion doping, noble metal loading and incorporation of electron-accepting materials.

As one of cheap carbon materials, activated carbon (AC) not only has great specific surface area and low cost, but also possesses large catalyst load and strong adsorption properties, which has become one of the first targets for photocatalyst carrier [2-4]. Thus, we report an easy one-step low-temperature chemical method to obtain a novel ZnO/AC composite photocatalytic material. At the same time, the photocatalytic efficiency of ZnO/AC composite photocatalytic material was characterized by the practical photocatalytic degradation effect of tail water from coking wastewater.

Experimental

The procedures were followed to fabricate ZnO/AC composite. First, NaOH (10mmol) and $ZnCl_2$ (0.2726 g) were adding into 50 mL of a suspension with activated carbon (50 wt%). Then, the mixing solution was stirred for 0.5 h and kept at 80 ℃ for 12 h in condition of seal. Finally, the resulting precipitate was separated with centrifuge, washed thoroughly with deionized water and dried at 60 ℃ for 4 h. The obtained sample was denoted as ZnO/AC.

The X-ray diffraction (XRD) were carried out on a Japan Rigaku D/max-χA X-ray diffractometer equipped with graphite monochromatized high-intensity $Cu_{K\alpha}$ source (λ=1.54178 Å). The scanning electron microscopy (SEM) was performed on JEOL JSM-6700F. The UV-vis diffuse absorption spectra was performed on a DUV-3700 DUV-vis-NIR recording spectrophotometer of Shimadzu Corporation.

Results and Discussion

XRD patterns of the as-prepared AC, ZnO and ZnO/AC samples were shown in Fig.1. There are two different kinds of diffraction peaks in ZnO/AC composite(Fig. 1b). The two broad peaks centered at ~25.21 and ~43.51 were indexed to the (002) planes and (100) planes of graphite in AC (Fig. 1c), respectively. The other diffraction peaks could be assigned to the hexagonal wurtzite structured ZnO (JCPDS card, 36-1451) in Fig. 1a. These results indicated that the obtained samples belong to a mixture of two phase containing hexagonal ZnO and graphite.

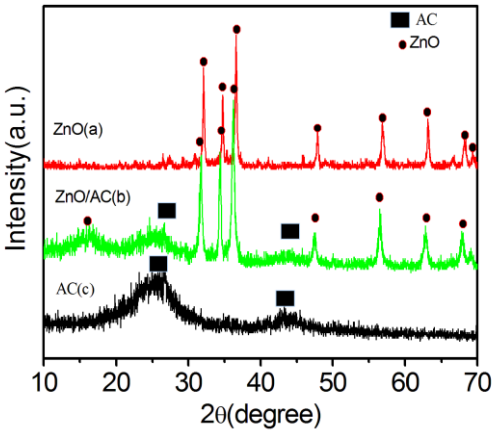

Fig. 1. XRD pattern of the as-prepared AC, ZnO and ZnO/AC samples

SEM studies provide useful information through the surface morphology of AC and ZnO/AC composite. As shown in Fig.2a, it was clearly revealed that multi-layer flake shapes of AC, which can provided larger surface for ZnO nanoparticles attached onto them. Fig. 2b depicted surface texture and porosity nature of ZnO/AC composite. ZnO nanoparticles were uniformly distributed over inside and outside surface of activated carbon. The immobilization of ZnO in the activated carbon revealed that ZnO/AC composites possess the porous character and relatively larger surface area, which will benefit capture and quickly transportation of photo-generated electrons.

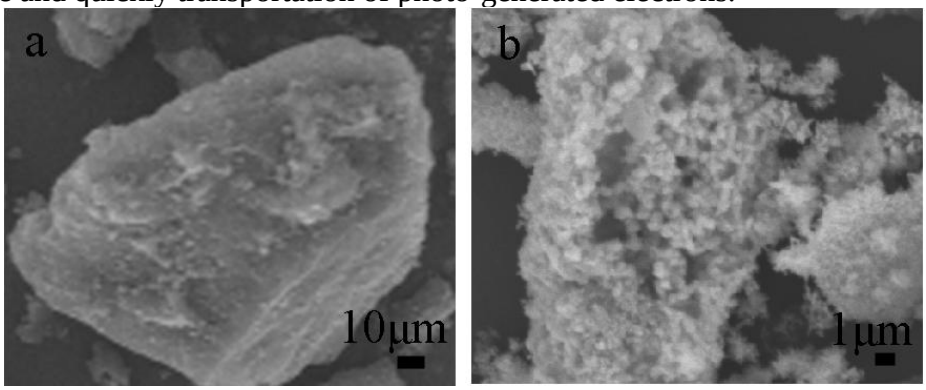

Fig.2. SEM images of the AC and ZnO/AC composite

To evaluate the photocatalytic activity of the as-prepared samples, the photodegradation of practical tail water from coking wastewater, a typical pollutant in the industry, was investigated under the UV-light from Xe lamp irradiation. Fig. 3 shows the UV-Vis absorption spectra of coking wastewater exposure to the light irradiation for various durations in the presence of ZnO/AC as photocatalyst, respectively. The characteristic absorption of coking wastewater at 229 nm decreased rapidly with extension of the exposure time. After irradiation of 120 min, the characteristic absorption of coking wastewater at 229 nm decreased of about 17 %. Though the photocatalytic result is unconspicuous, it indicated that the ZnO/AC composite has potential application prospect in the practical coking wastewater treatment.

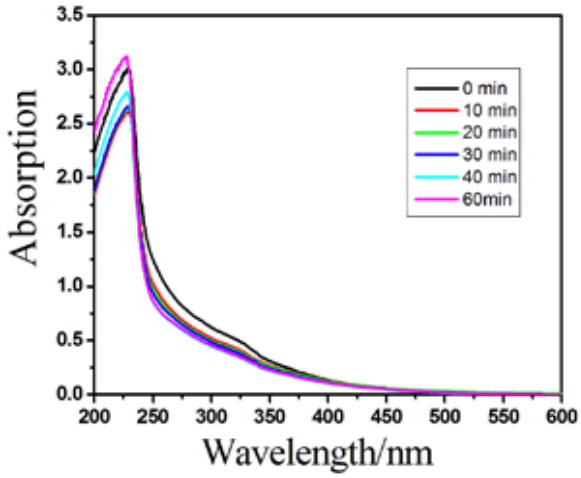

Fig.3.The UV-visible absorption spectra of the as-obtained ZnO/AC composite

Conclusions

A novel ZnO/AC composite is prepared by a facile one-step solution-based method under the low temperature. The obtained ZnO/AC composite is composed of activated carbon immobilized by ZnO nanoparticles. For the photodegradation of tail water under the UV-light irradiation, the ZnO/AC composite shows potential application prospect in the practical coking wastewater treatment.

Acknowledgments

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