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Studies on the photocatalytic performance of ZnO/PMMA composite activated by UV light

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Abstract: ZnO/PMMA composite thin films were prepared by simple solution cast method using THF as a solvent. X-ray diffraction studies explain the presence of ZnO and its hexagonal arrangement. Infrared spectroscopy studies indicate the functional group present in the composite. ZnO/PMMA composite thin films were irradiated by UV at 365nm, 312nm and 254nm. The photocatalytic activity of ZnO/PMMA was evaluated by photocatalytic decolorization of Congo red in aqueous solutions. The ZnO/PMMA composite film exhibited higher photocatalytic activity under UV irradiation at 365nm rather than 312nm and 254nm. After 2 hours of irradiation by UV light almost 90% of Congo red got decolorized.
Keywords: PMMA, ZnO, photodegradation, Congo red, UV irradiation.

1. Introduction

The dispersion of nano scaled inorganic fillers into an organic polymer to form polymer nanocomposites has drawn enormous attention in recent years [1]. Combining the properties of the polymer matrix and the inorganic filler creates a new, economic way to obtain desired high performance materials [2]. Recently, however, a number of studies [4, 5] have focused on the use of natural organic polymers as support materials for catalytic compounds, and more especially in the preparation of homogeneous and heterogeneous catalysts [6, 7 & 8]. In the present study, PMMA/ZnO nano composite thin film (NCF) was prepared by solution cast method and characterized by XRD, SEM and UV-Vis spectra. RhodamineB was selected as a model hazardous dye to evaluate the feasibility of the adsorption – photocatalytic decolorization by PMMA/ZnO under visible light irradiation.

1.1. Experimental Condition

1.2. PMMA/ZnO Preparation

0.5 g of PMMA was dissolved in THF, stirred vigorously to obtain the homogeneous gelatinous form. In a typical experiment, the controlled amount of ZnO was initially dispersed into the PMMA matrix by sonication.

The reaction mixture was stirred vigorously until it becomes a homogeneous mixture. Then the homogeneous mixture was poured into the petri dish and dried at room temperature. Then the films were dried in air oven at 105° C, the dry films were peeled off from the petri dish. For effective degradation of RhB dye, 50mg of catalyst was added to 75ml of the RhB dye solution in a 150ml reaction vessel. At given time intervals, 5ml of aliquots were collected.

2. Results and Discussion

Figure 1a shows the X-ray diffraction of the pure ZnO, chitosan and PMMA/ZnO composite films. For pure ZnO crystal, the typical diffraction peaks of hexagonal can be found, which can be indexed as the standard data (JCPDS No.89-0511). The diffraction peaks at 35.51 and 38.73 were related to the hexagonal structure with (002) orientation. The same characteristic peaks observed in the PMMA/ZnO composite confirm the formation of composite. The diffraction peak at 20.22 is characteristic diffraction peak for the PMMA and the peak is broad due to the amorphous nature of the polymer.

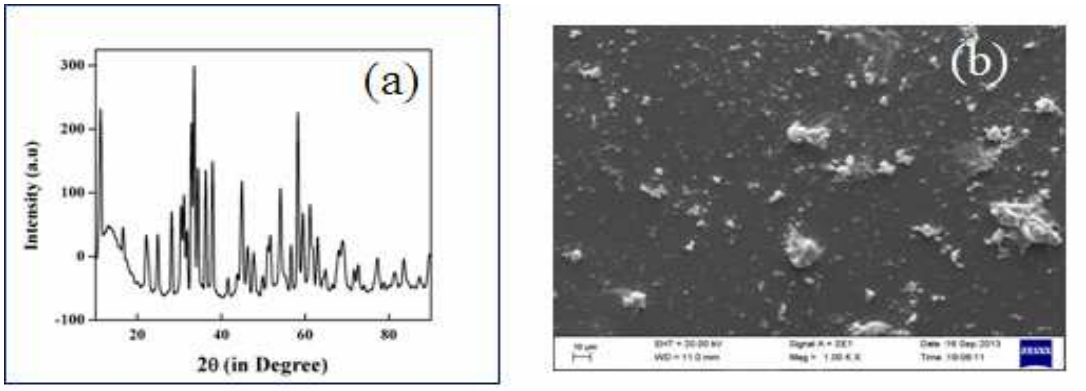

Figure 1: (a) XRD pattern of PMMA/ZnO (b) SEM micrograph of PMMA/ZnO composite

Figure 1 b shows the field emission scanning electron microscope images of the PMMA/ZnO. As shown in figure, the surface of the PMMA film was pretty smooth. However, the introduction of ZnO microspheres embedded over the PMMA matrix could provide larger surface area for the photocatalytic reaction and adsorption process. From these FESEM micrographs it is possible to confirm the formation of the PMMA/ZnO.

2.1. Photocatalytic Activity

The photocatalytic studies of PMMA/ZnO hybrid were carried out by degradation of RhB aqueous solutions under UV light irradiation. The photocatalytic degradation of RhB is shown in figure 2. The C/C_0 (where C was the main absorption peak intensity of RhB samples at each irradiated time interval at a wavelength of 554 nm, and C_0 was the absorption intensity of initial 10 ppm RhB solution) was plotted against the wavelength. There was almost no decolorization in the solution without catalyst and with catalyst in the dark. There is no adsorption of dye by the catalyst. The color of the dispersed solution disappeared after 75 minutes. From the figure 2, it is observed that after 75 minutes of irradiation the main absorption peak of RhB at (λ) 554 nm nearly disappeared, and the intensity of other small peaks decreased.

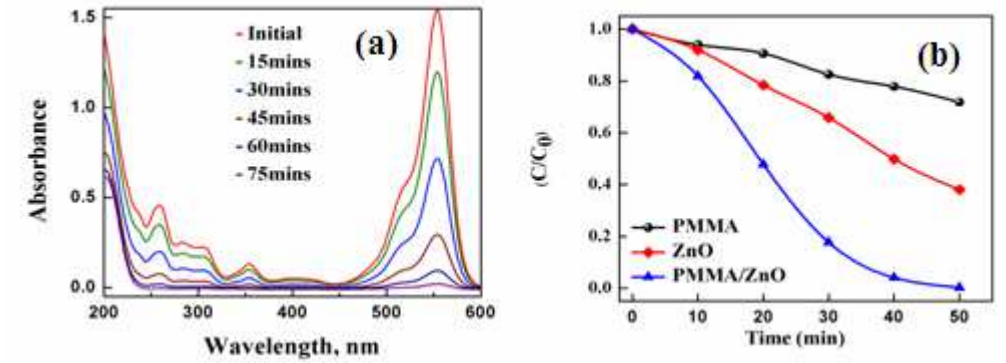

Figure 2: Photodegradation of RhB with different catalyst b) Comparisons study of photocatalytic activity.

Comparisons of photocatalytic activity among the pure PMMA film, pure ZnO and PMMA/ZnO are shown in figure 4b. The PMMA/ZnO shows the highest photocatalytic degradation rate of RhB.

3. Conclusions

PMMA/ZnO nano compounds was prepared via solution cast method. The structure, morphology and optical properties were investigated in detail. The PMMA/ZnO has significantly enhanced photocatalytic activity towards the degradation of RhB dye. This is attributed to the adsorption by PMMA and electron hole recombination rate by ZnO.

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