Photo Catalytic Activity of Coated Pet Fabrics with Synthesised Nano TiO_2 & ZnO : A Comparative Study

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ABSTRACT

The coated PET fabric with atomic ratios of Ti/(Ti+Zn) of 100%, 75%, 50%, 25%, and 0% was successfully prepared via sol–gel process from directly mixing TiO_2/ZnO sol. The scanning electron microscopy (SEM) observation, energy dispersive spectroscopy (EDS) and the X-ray diffraction method (XRD) measurements revealed that the microstructural morphology and the crystallization behavior of the composite film were essentially related to the atomic ratio of Ti/(Ti+Zn). The UV irradiated degradation of Methylen blue (MB) solution using the coated fabrics as catalyst showed a tendency of the photocatalytic activity of the film against the value of Ti/(Ti+Zn). Photocatalytic activity was observed for the film with Ti/(Ti+Zn) 25% , which has been attributed to the high degredation of MB.

Keywords: TiO_2/ZnO, Sol-gel, Polyester, Photocatalysis

1 INTRODUCTION

Over the past few decades, semiconductor photocatalysis is becoming more and more attractive due to its great potential to solve environmental problems [1]. Among the various semiconductors employed, titanium dioxide (TiO_2) is known to be a unique photocatalyst for the degradation of environmental contaminants due to its high photocatalytic activity, absence of toxicity, relatively low cost, and excellent chemical stability under various conditions [2]. Besides the wide applications in recent years as electronic devices due to its very attractive electrical properties, zinc oxide (ZnO) is also an important semiconductor for photocatalytic degradation of environmental pollutants because its photodegradation mechanism has been proven to be similar to that of TiO_2. Since photocatalytic process is based on the generation of electron/hole pairs by means of band-gap radiation, the coupling of different semiconductor oxides seems useful to achieve a more efficient electron/hole pair separation under irradiation and, consequently, a higher photocatalytic activity [3]. Therefore, in the present study we would like to present a detailed investigation on the preparation, characterization, and photocatalysis evaluation of TiO_2/ZnO nano particles on PET fabric.

2 EXPERIMENTAL

In the present study the TiO_2/ZnO nano composite film was prepared via sol–gel process and applying polyester fabric as substrate. Titanium Tetra Iso Propoxide (Merck, 99.99%, TTIP) was used to prepare TiO_2 sol at room temperature as follows. Firstly the TTIP was dissolved in 2-propanol and stirred to get a precursor solution then dropped into the mixture of distilled water and 2-propanol at a speed of one drop per second under a strong stirring. After that, the solution refluxed continuously for 24 h at 70˚C to achieve a TiO_2 sol. Zinc acetate (Aldrich, 99.99%) was used as a precursor to prepare ZnO sol. It was firstly dissolved in ethanol and stirred for 5min at 70 °C in water bath to get a precursor solution. A mixture of distilled water, diethanolamine, and ethanol was then dropped into the precursor solution at a speed of one drop per second under a strong stirring. After that, the solution was continuously stirred for 2 h to achieve a transparent ZnO sol. The prepared ZnO sol was then directly incorporated into the TiO_2 sol to get TiO_2/ZnO composite sol. By applying different amounts of TiO_2 sol and ZnO sol, the TiO_2/ZnO sol with different atomic ratios of Ti/(Ti+ Zn) of 100%, 75%, 50%, 25%, and 0% was achieved.

2.1 Characterization of the nano composite film

The crystalline phase of the film was identified through X-ray diffraction method (XRD, Philips, Netherlands). The surface morphology of the coated fabric was observed using scanning electron microscopy (SEM, Philips, Netherlands). The elemental analysis of the coated fabric was performed using energy dispersive spectroscopy (EDS).

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2.2 Photocatalytic activity evaluation

Raw and treated samples placed separately in methylene blue solutions (10 ppm), and placed in a labratoray UV cabinet (15W UVC lamp, Philips Co) for up to 3 hrs with 0.5 h steps and for 6 h continuously. Absorbance of the solution samples investigated by UV-Vis spectrophotometer (Varian), at λmax= 594 nm. The discoloring strength of solution (decreasing the concentration of methylene blue)used for the photocatalytic activities of different samples.

3 RESULTS AND CONCLUSIONS

The XRD measurement on this powder was conducted and the results were shown in Fig. 1. As seen from Fig. 1a, anatase TiO_2 was obtained after heat treatment at 500 °C for 2 h. The sharp peaks in Fig. 1a revealed good crystallization of TiO_2 under such condition (500 °C for 2 h). With a Ti/(Ti+Zn) of 75%, Only traceable peaks of anatase TiO_2 were appeared in Fig. 1b. As the Ti/(Ti+Zn) decreased to be 50%, diffraction peaks not for TiO_2 but for ZnO were observed (Fig. 1c). For a Ti/(Ti+Zn) of 25% the composite powder was crystallized well (Fig. 1d). The pure ZnO (Ti/(Ti+Zn) of 0%) was completely crystallized to be zinc oxide in Fig. 1e. Such results revealed that the crystallization behavior of the TiO_2/ZnO composite powder was essentially related to the incorporation of ZnO component and its amount.

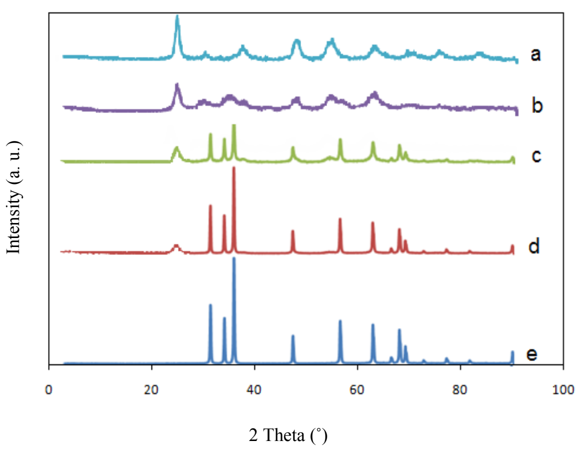

Fig 1. XRDpatterns of TiO_2/ZnO nano composite powder. a:0%, b:25%, c:50%, d:75%, e:100%

The SEM observation on the TiO_2/ZnO nano composite film with different Ti/(Ti+Zn) confirms the uniform coating of fiber surface by TiO_2 and ZnO nanoparticles Fig.2, and there is no evidence for noticeable agglomeration of nanoparticles existence on the fiber surface. The EDS confirms the existence of both particles on the surface of fiber Fig 2.

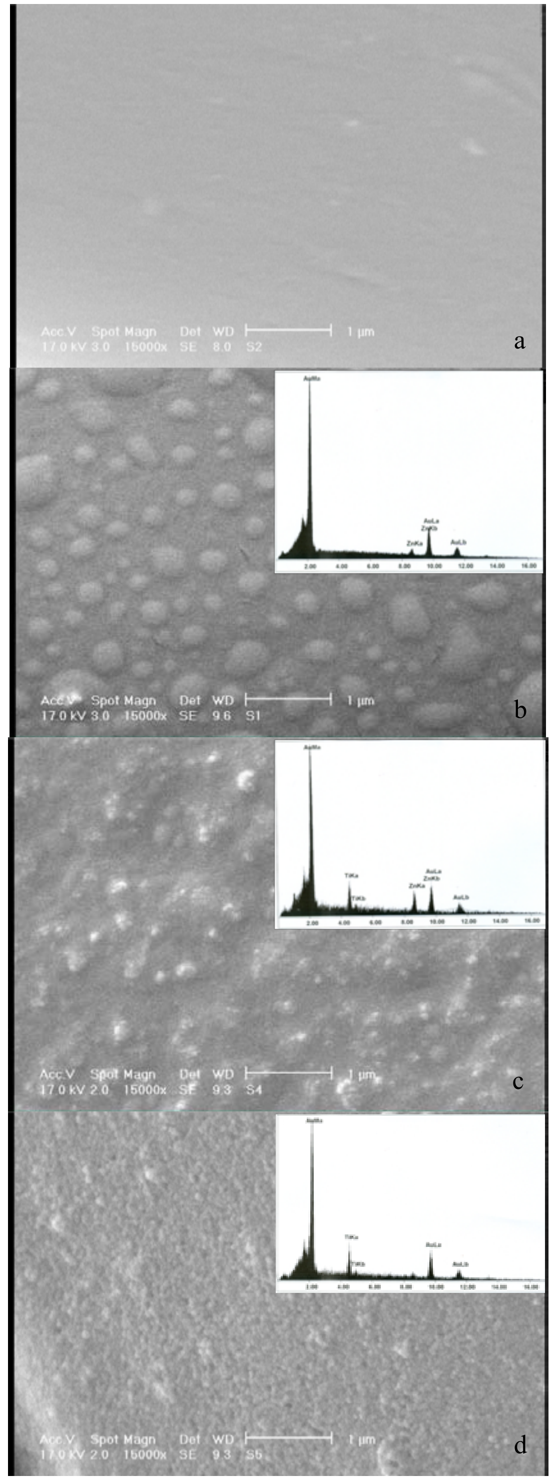

Figure 4 (a-c). SEM & EDS images of the surface distribution of a:unfinished, b:ZnO, c:TiO_2/ZnO and d:TiO_2 polyester fabrics

3.1 Photocatalytic activity of the nano composite film

The UV–vis adsorption spectra in Table 1 gave concentration maximum values at a wavelength of 594 nm. These maximum values, however, were noticeably different from each other, indicating different photocatalytic activity of the film employed. The concentration of MB solution catalyzed with pure TiO_2 film was almost the lowest while in the case of the TiO_2/ZnO film with Ti/(Ti+Zn) of 25% was the highest. By using the nano TiO_2/ZnO composite film as catalysts under UV irradiation, the MB solution was photodecomposed to be nearly transparent after 9 h. As seen from Table 1, the TiO_2/ZnO composite films with Ti/(Ti+Zn) of 25% had highest photocatalytic activity.The photocatalytic activity of the pure ZnO was rather low. The TiO_2/ZnO composite films with Ti/(Ti+Zn) of 75% and 100% were moderate. It is interesting to note that the photocatalytic activity of the composite film with Ti/(Ti+Zn) of 50% was considerably as close as that of 25%.

Table 1. Percentage of MB degradation after different time of UVC exposuring time (hr)

	Percentage of MB degradation after Different Time of UVC exposuring time (hr)							
Sample	0	0.5	1	1.5	2	2.5	3	9
0%	30.7	33.1	38.1	39.8	45.7	48.6	53.9	79.3
25%	32.4	37.2	42.5	48.5	52.6	57.9	61.5	91.1
50%	30.3	36.2	40.1	47.2	51.7	57.8	61.1	91
75%	31.7	34.2	40.7	42.7	47.2	53.8	57.9	85.7
100%	20.5	24.4	26.4	30.8	34.3	42.4	47.1	83.4

4 CONCLUSIONS

In the present study the PET fabric with Ti/(Ti+Zn) of 100%, 75%, 50%, 25%, and 0% was successfully prepared via sol–gel process from directly mixing TiO_2/ZnO sol. For pure TiO_2 and ZnO powder good crystallizations were achieved. The photocatalytic activity of the coated PET fabrics, as evaluated by photodegradation of MB solution, was clearly related to the molar ratio of TiO_2/ZnO. The TiO_2/ZnO composite films with Ti/(Ti+Zn) of 25% film showed highest photocatalytic activity while for pure ZnO film it was quite low.

ACKNOWLEDGMENT

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