Enhanced Sun Light Photocatalytic Activity of TiO_2 Prepared with the Assistance of Urea

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Abstract. In this paper, TiO_2 photocatalyst with enhanced photocatalytic activity was prepared by Sol-Gel method with the assistance of urea. The specific surface area, structure, and the hydroxyl content were characterized by Brunauer-Emmett- Teller (BET) measurements, X-ray diffraction (XRD), and FT-IR, respectively. The results show that adding urea into the synthetic system alters the specific surface parameters and hydroxyl content. The photocatalytic activity for decolorization of rhodamine B (RhB) aqueous solution was investigated. The results show that the photocatalytic decolorization of rhodamine B aqueous solution over TiO_2 prepared with the assistance of urea is more than four times of that over the reference TiO_2 and the underlying mechanisms are discussed.

Introduction

Titanium dioxide (TiO_2), as an important and promising photocatalyst, has been widely studied due to its low cost, light weight, eco-friendliness and long-term stability [1]. Photocatalytic property of TiO_2 has been intensely investigated and shows potential application [2,3]. However, the photocatalytic activity of α-Fe_2O_3 should be further boosted to meet the practical use. In order to promote the photocatalytic activity, continuous efforts have been developed to improve the photocatalytic performance of TiO_2. Among these approaches, doping with nonmetals ions is an effective way [4].

The primary goals of this work is to study the effect of urea on the surface texture, the hydroxyl content on the surface and its relation to the photocatalytic activity of the photocatalyst prepared. The photocatalytic activity was evaluated by decolorization of rhodamine B aqueous solution under sun light illumination.

Experimental

All chemicals are analytical grade reagents and were used as received. TiO_2 was prepared by a Sol-Gel routine. Tetrabutylorthotitanate (17.2mL), area and diethanolamine (4.8 mL) were dissolved in ethanol (67.28 mL), the molar ratio of N/Ti is 1%. After stirring vigorously for 2 h at room temperature, a mixed solution of water (0.9 mL) and ethanol (10 mL) was added dropwise to the above solution with a burette under stirring. The resultant alkoxide solution was kept standing at room temperature for hydrolysis reaction for 2 h, resulting in the TiO_2 sol. The composition ratio of $Ti(OC_4H_9)_4$, C_2H_5OH, H_2O and NH $(C_2H_4OH)_2$ in the starting alkoxide solution was 1:26.5:1:1 (in molar ratio). The power was prepared after calcination the TiO_2 gel at 823K. Pure TiO_2 was also prepared as the same procedure mentioned above without the presence of area. The samples were named as 1% and TiO_2, respectively. The specific surface area analysis of TiO_2 was carried out by the Brunauer-Emmet Teller (BET) method. X-ray diffraction (XRD) patterns were recorded on a DX -2600 X-ray diffractometer using Cu Kα (λ=0.15406 nm) radiation equipped with a graphite monochromator. The X-ray tube was operated at 40 kV and 25 mA. Catalyst samples were characterized by a FT-IR (NICOLET 6700) in KBr pellets. The photocatalytic activity of TiO_2 (50 mg) prepared was evaluated by decolorization of 50 mL rhodamine B (the concentration is 10 mgL^{-1}) under the illumination of sun light.

Results and Discussion

The surface parameters of the catalysts are shown in Table 1. It is clear that 1% sample holds the higher BET surface area, pore volume and the smaller pore size, while TiO_2 has the lower BET surface area, pore volume and the larger pore size. A high specific surface area can provide more reactive adsorption/desorption sites for photocatalytic reactions, which is beneficial to the photocatalytic performance, this result accords well with the results of photocatalytic activity measurements.

Tab. 1 Surface parameters of the prepared photocatalysts

Catalysts	S_{BET} (m^2/g)	Pore volumes (cc/g)	Pore size (nm)
TiO_2	15	0.0076	10.6
1%	26	0.0138	9.1

The XRD patterns of the TiO_2 and 1% are shown in Fig.1.

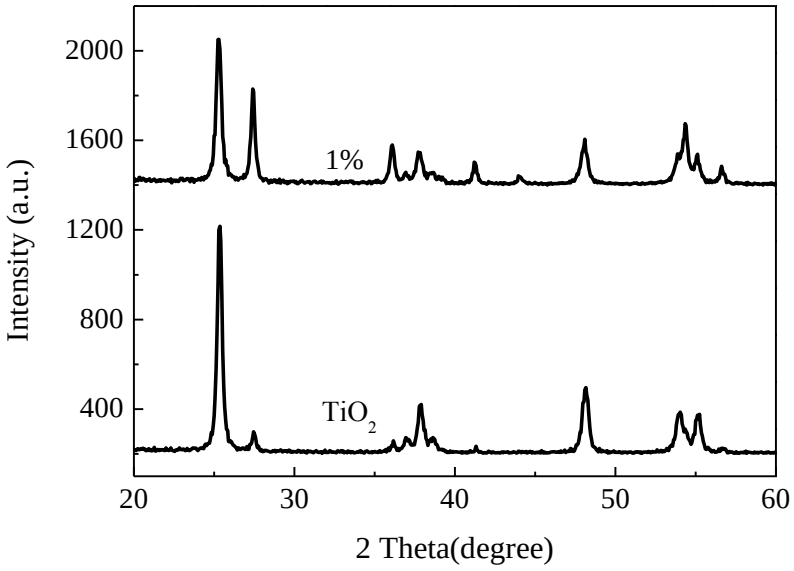

Fig.1. XRD patterns of TiO_2

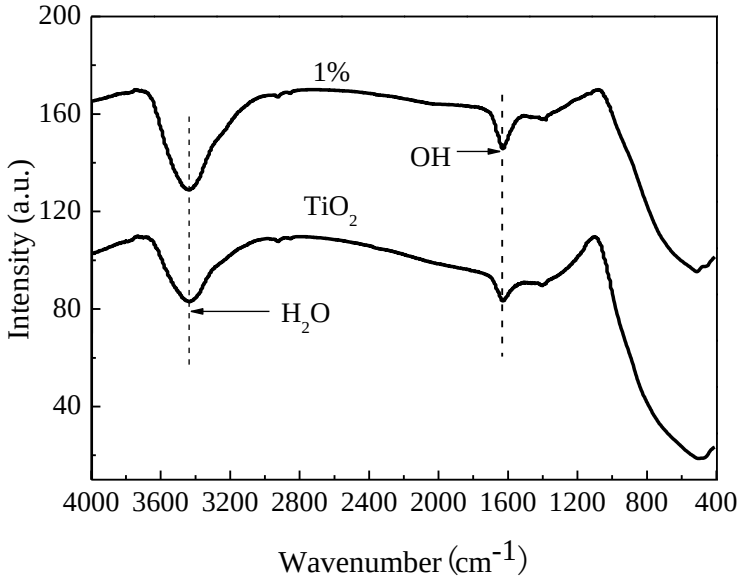

Fig. 2 FT-IR spectra of photocatalysts

The characteristic peaks two photocatalysts can be assigned to rutile and anatase phase. It is interesting that the full width at half maximum (FWHM) of 1% is wider than that of TiO_2. According to Scherrer equation, the wider the FWHM is, the smaller the crystal size of sample is. This result demonstrates that the increased crystal size leads to the BET surface area of TiO_2 decrease, which fits well with the result of BET surface area.

FT-IR spectra of photocatalysts are presented in Fig.2, two bands located at 3420 cm^{-1} and 1630 cm^{-1} are assigned to O-H bending modes of adsorbed water and hydroxyl groups. It is interesting to notice that the peak of H-O on 1% is stronger than that of pure TiO_2, which indicates that the hydroxyl content on 1% is greater than on TiO_2. Usually, promoted photocatalytic performance can be benefited from the enhancement of hydroxyl content on the surface of photocatalyst [5]. This result is in good consistent with the results of photocatalytic activity.

The photocatalytic activity of 1% and TiO_2 was compared and presented in Fig.3.

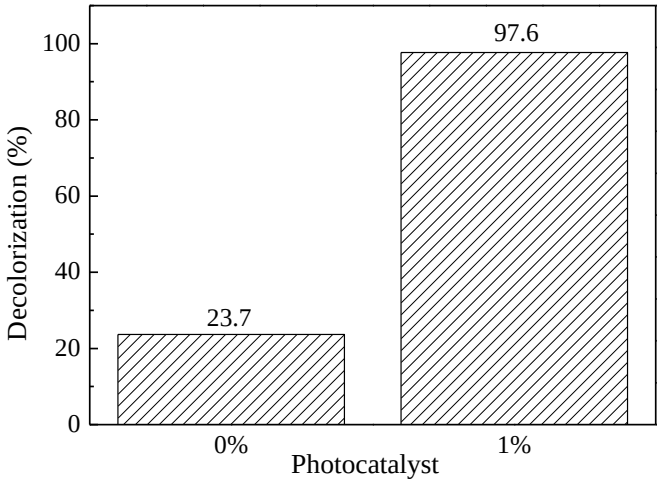

Fig.3 Removal of RhB over photocatalysts for 15h under sun light irradiation

It can be seen from Fig.3, the order of photocatalytic activity is 1%＞TiO_2. The decolorization for 1% and TiO_2 is 23.7% and 97.9%, respectively. In this paper, the enhanced photocatalytic activity of 1% may be attributed to high hydroxyl content on the surface and increased specific surface area.

Conclusions

In summary, Sol-Gel routine has been successfully applied to prepare TiO_2 with high photocatalytic performance. The results demonstrate that the photocatalytic decolorization of RhB aqueous solution is more than four times of that over the reference TiO_2. Adding urea into the synthesis system is an effective and simple way to promote the photocatalytic performance of TiO_2.

Acknowledgements

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