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Preparation and Photocatalytic Activity of TiO_2 Tablets

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Abstract. TiO_2 tablets prepared by pressing mechanism and by planetary ball mill doped Fe, and they have been investigated by XRD, and SEM techniques. The results show that the pure TiO_2 tablets has the high photocatalytic degradation rate of Rhodamine B at 500˚C, and Fe/ TiO_2 0.25 mol.% higher than pure TiO_2 tablets, but the rate of doped TiO_2 tablets at the beginning is lower.

Introduction

In recent years, various kinds of volatile organic pollutants is increasing, these pollutants have poor biodegradability , high concentration of organic matter and biological toxicity, it is difficult to handle by traditional purification techniques, serious threat to human health.[1] There is an urgent need to develop high efficiency, low energy consumption, wide range of use, do not pollute the environment function material and the suitable technology.[2] Photocatalytic degradation technology can fully biodegrade various kinds of organic and inorganic pollutants in wastewater, and waste gas, so has attracted wide attention both at home and abroad, and the researching of nanometer photocatalytic materials has entered a new era, becomes a new technology may be widely applied.[3-5]

The nanometer TiO_2 as a catalyst with high stability and activity, safety, low cost and no secondary pollution, [6] so it in the environment pollution control and other fields has huge potential value. [7-10] However, it is difficult to separate and recycle TiO_2 powders, and its cost of post-processing is high, while TiO_2 thin films compared with powder is reusable, easy to recycle, and thus has a wider application prospect. [11] But degradation rate of TiO_2 thin films is relatively low and can be easily detached.

Experimental

Sample preparation. Take a certain amount of TiO_2(CP, was obtained from Sinopharm Chemical Reagent Co. , Ltd)in the planetary ball mill, added a tiny amount of Fe, 10ml ethanol and 100ml deionized water, mixed 5 hours. Then put the mixture in the electrothermal constant temperature drying oven, 120˚C, 6 hours. Then put the power into a quartz mortar, after several minutes, added a few drops of glue(purchased from Deli group co, Ltd), continue to grind until smooth. Take the same quantity of material in the tablet press, 3Mpa for 15 seconds.

Characterizations. X-ray diffraction (XRD, DX2700) patterns of all samples were collected in the range 20–70˚ with a step width of 0.03˚s^{-1} , operated at 40 kV and 30 mA. The surface morphologies and particle sizes were observed by scanning electron microscope (SEM, S-4800).

Evaluation of photocatalytic activity. The photocatalytic activity was evaluated by measuring the decomposition of 5 mg/L Rhodamine B (RhB) solution. A 25W UV lamp (was purchased from Guangzhou ,Cnlight) was used as the light source, stirred for 1h to ensure equilibration of RhB over the tablet surface. Then the RhB aqueous solutions were irradiated by the 254 nm UV light for 1h, 2h, 3h and 4h, respectively. The light absorption of RhB solution was quantified by UV-Vis Spectrophotometer (Shanghai Spectrum instruments CO, LTD). Degradation rate of the RhB was calculated by the equation:

$D = [(A_0 - A) / A_0] \times 100\%$,

(A_0 is the light absorption of RhB solution at 254 nm absorbancy, and A is the light absorption of RhB solution at the maximum absorption absorbancy measure by the UV-Vis Spectrophotometer).

Results and discussion

Fig. 1 shows XRD patterns of Fe doped TiO_2 tablet with contents from 0.0 mol.% to 1.0 mol.%. All the peaks in the XRD patterns were analysed by MDI Jade 5.0. The crystal lattice constants of the three samples are almost the same. TiO_2 has three different phase structures: anatase, rutile and brookite. A lot of researches have proved that among these phase structures, TiO_2 with anatase structure has the best photocatalytic properties. But many experimental results indicate that mixed crystal TiO_2 (by the synergistic effect of anatase and rutile phase) can greatly improve the photocatalytic activity.[12, 13] Diffraction peaks without Fe, indicating that Fe is uniform in the dispersion, no crystal precipitation.

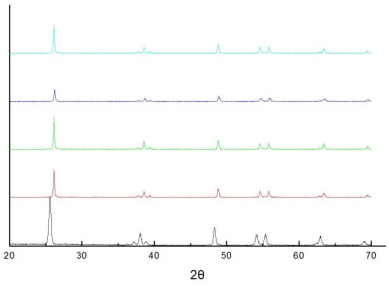
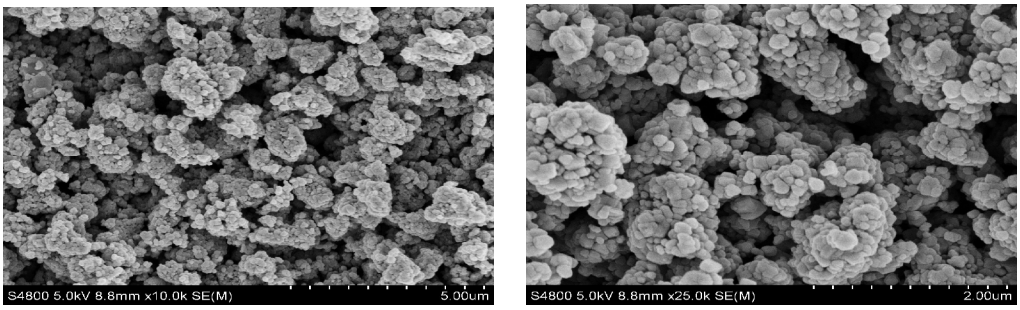
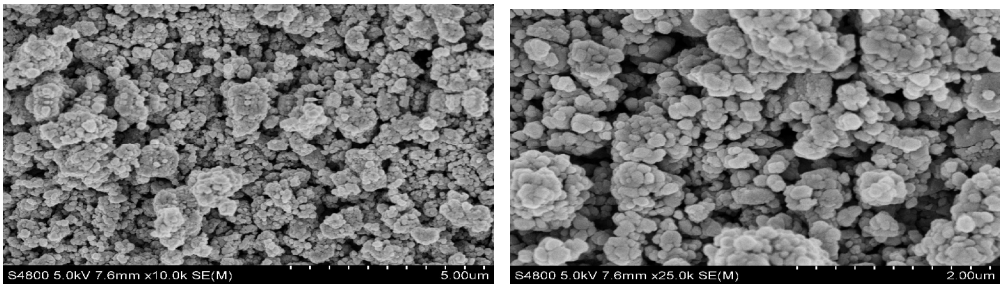


Fig. 1. XRD patterns of Fe doped TiO_2 tablets with different contents of Fe
the contents are (from bottom to top)：0.0mol.%, 0.25mol.%, 0. 5mol.%, 0.75mol.%, 1.0mol.% .



(a)

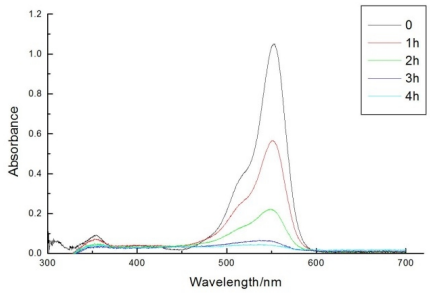


(b)

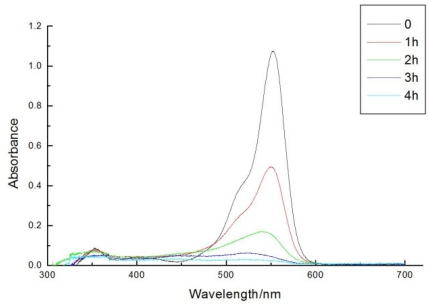
Fig. 2. SEM images of TiO_2 tablets: (a) pure TiO_2 tablet (b) 0.25mol.% Fe doped

Fig. 2 are SEM images of pure TiO_2 tablet and 0.25 mol.% Fe doped one. It shows that the average grain size of the tablets is about 40–50 nm. Other tablets have similar grain sizes known from SEM observation (SEM images for other tablets are not shown here).

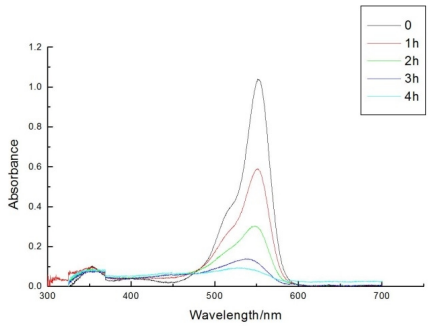
Fig. 3 (a), (b), (c), (d) and (e) are, respectively, UV-Vis absorption spectra of Rhodamine B photocatalyzed by TiO_2 tablet with doped Fe 0.0mol%, 0.25 mol.%, 0.5 mol.%, 0.75 mol.% and 1.0 mol.% for 1h,2h,3h and 4h. It can be seen that the photocatalytic performance of TiO_2 can be improved by doping 0.25 mol.% Fe. But with the increase of Fe, the photocatalytic efficiency decreases.



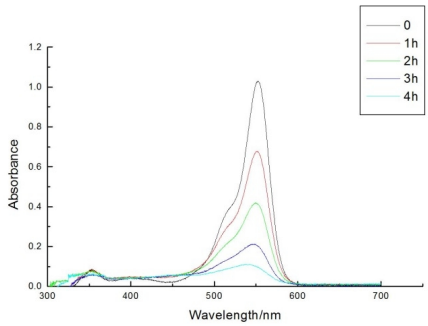
(a) Pure TiO_2 tablet



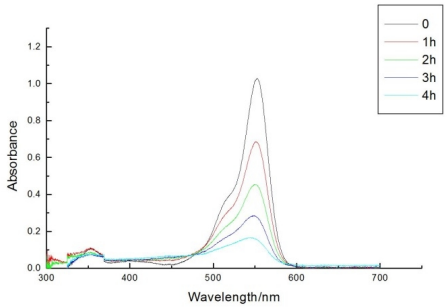
(b) 0.25mol.% Fe doped tablet



(c) 0. 5 mol.% Fe doped TiO_2 tablet



(d) 0.75 mol.% Fe doped TiO_2 tablet



(e) 1.0 mol.% Fe doped TiO_2 tablet

Fig. 3. UV-Vis absorption spectra of RhB

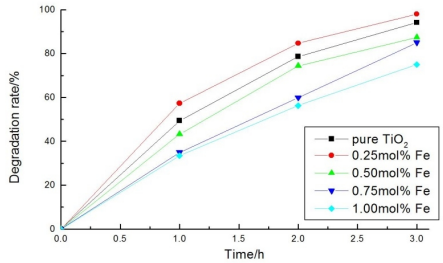


Fig. 4. Degradation rate of RhB catalyzed by TiO_2 doped with different amount of Fe

The influence of dopant concentration on degradation rate of Rhodamine B was evaluated and the results areshown in Fig. 4. It can be seen that doping concentration has a significant effect on the photocatalytic performance of TiO_2. There exists an optimum doping concentration at around 0.25 mol.% Fe.

Fe dopants enhance the efficiency of the photocatalytic may be due to Fe ions trap electrons and/or holes on the surface or during interface charge transfer, therefore increasing the lifetime of one or both of the generated charge carriers, or reduce the compound of electrons and holes. [14]

Conclusions

It is easy to get good photocatalytic performance of TiO_2 tablet by controlling sintering temperature. Photocatalytic performance investigation shows that lower doping concentration enhances the photocatalytic performance of TiO_2, while higher doping concentration decreases the performance. The optimum doping concentration is about 0.25 mol.% Fe. The 0.25 mol.% Fe doped TiO_2 tablets have better photocatalytic performance than 0.5 mol.% doped TiO_2 tablets.

Acknowledgements

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