Asian Journal of Chemistry; Vol. 25, No. 10 (2013), 5827-5829

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2013.OH102

Degradation of Malachite Green on MoS_2/TiO_2 Nanocomposite†

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AJC-13345

The catalytic activity of a MoS_2/TiO_2 nanocomposite was evaluated using the degradation reaction of malachite green. The MoS_2/TiO_2 nanocomposite revealed excellent photocatalytic activity in the degradation reaction of malachite green. The good catalytic activity of the MoS_2/TiO_2 nanocomposite was ascribed to the large BET surface area. The degradation rate of malachite green was affected by reaction conditions, such as initial concentration of malachite green, repeatedly used cycles and dosage of MoS_2/TiO_2 nanocomposite. It is suggested that the MoS_2/TiO_2 nanocomposite was a promising catalyst for the removal of malachite green.

Key Words: Nanocomposite, Malachite green, Nanocomposite, Degradation.

INTRODUCTION

In order to improve the photocatalytic activity of TiO_2 in the visible light region, nanosized MoS_2 was used to modify TiO_2[1]. The size of MoS_2 has remarkable effect on its photo absorption[2-4]. When the size is very small (several nanometers), the strong quantum confinement effect leads to high photocatalytic activity of nano-MoS_2[5,6].

Nano-MoS_2 with a small band gap can be applied to sensitize TiO_2[1,7], producing an excellent photocatalyst. Forming nanocomposite decreases the size of nano-MoS_2 and increases the photocatalytic activity[8]. The present work investigated the photocatalytic degradation of malachite green on a MoS_2/TiO_2 nanocomposite.

EXPERIMENTAL

MoS_2/TiO_2 nanocomposites were synthesized by a chemical method reported by Hu *et al.*[9]. Anatase nano-TiO_2 was purchased from Zixilai Environmental Protection Technology Company, China. The prepared MoS_2/TiO_2 nanocomposite was characterized using a JEOL model 2010 high-resolution transmission electron microscopy (HRTEM) with an energy-dispersive spectrometry (EDS). The catalytic activity of MoS_2/TiO_2 nanocomposite was evaluated using the degradation of malachite green under the indoor sunlight with a 30 W daylight lamp. The absorbance (A) of malachite green solution was measured on a 721 spectrophotometer.

RESULTS AND DISCUSSION

Characterization of MoS_2/TiO_2 nanocomposite: The anatase nano-TiO_2 was corroded and activated by strong HCl because it contains -Ti-O- bonds[9]. The corrosion on surface of nano-TiO_2 provided nucleation sites for MoS_3 deposition. The as-prepared MoS_3/TiO_2 precursor is unstable and can be degraded at a high temperature, producing MoS_2/TiO_2 nanocomposite. Peaks of Cu, Cr and C elements in Fig. 1a results from the copper net and carbon film used in the EDS characterization. Thus, the nanocomposite is composed of elements Mo, S, Ti and O. The HRTEM image in Fig. 1b confirms that nano-MoS_2 particles with a typical layered structure were synthesized. The layer distance of nano-MoS_2 is ~0.62 nm, which is similar to that of bulk 2H-MoS_2. The average length of nano-MoS_2 particles is about 10-20 nm while the average thickness of about 3 nm (4-5 layers of MoS_2).

Degradation of malachite green on MoS_2/TiO_2 nanocomposite: Fig. 2 showed the influence of reaction conditions on the degradation of malachite green on MoS_2/TiO_2 nanocomposite. The pure nano-MoS_2 or nano-TiO_2 shows relatively weak catalytic activity for the removal of malachite green from water. However, the MoS_2/TiO_2 nanocomposites reveal high catalytic activity. The best mass proportion of MoS_2 and TiO_2 is 2:1 in the nanocomposite for the degradation reaction. Fig. 2b and c indicates that the decolouration per cent increases with the increased dosage of MoS_2/TiO_2 or the decreased initial concentration of malachite green. The

†Presented to the 6th China-Korea International Conference on Multi-functional Materials and Application, 22-24 November 2012, Daejeon, Korea

decolouration percent of malachite green on the nanocomposite in the 4th cycle was decreased to about 85 %, which indicates that the nanocomposite can be reused for at least 4 cycles.

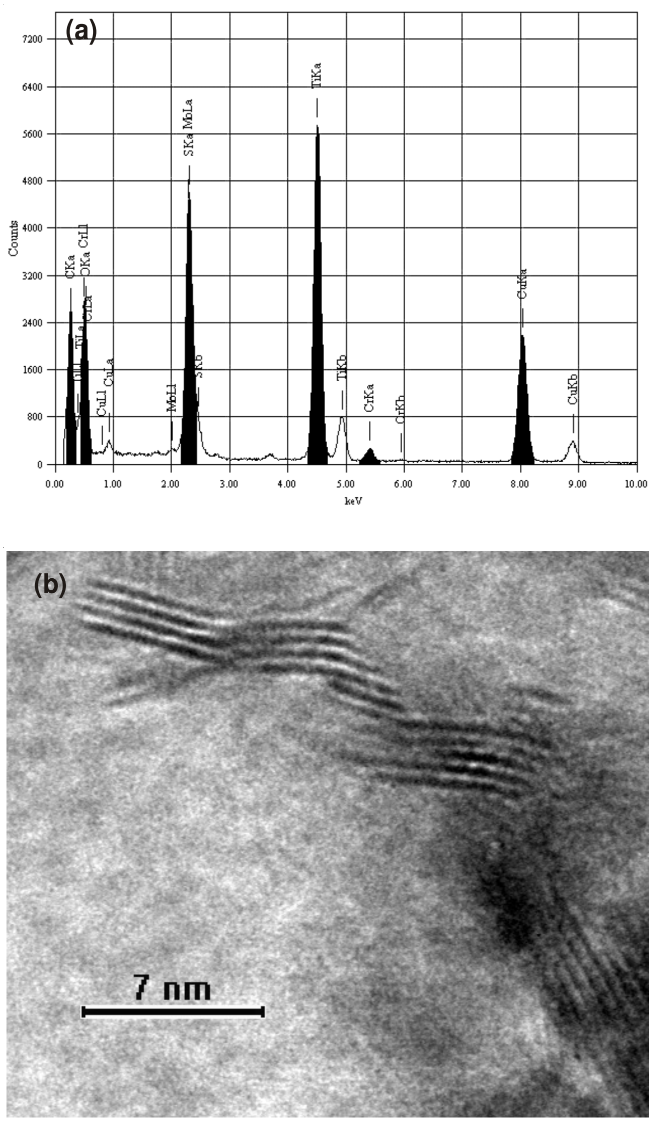
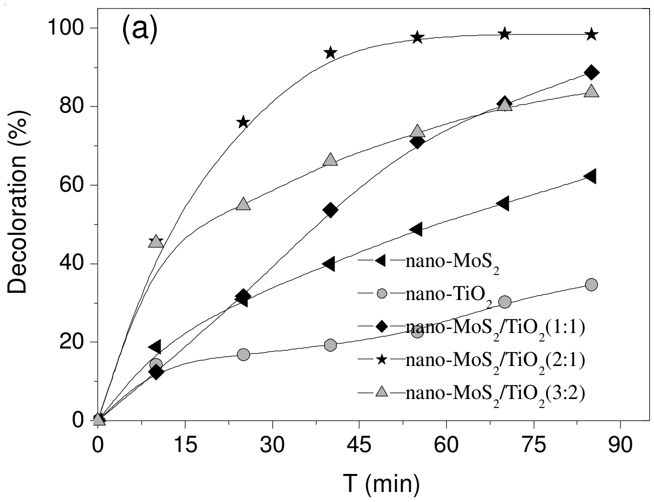


Fig. 1. EDS spectrum (a) and HRTEM image (b) of MoS_2/TiO_2 nanocomposite



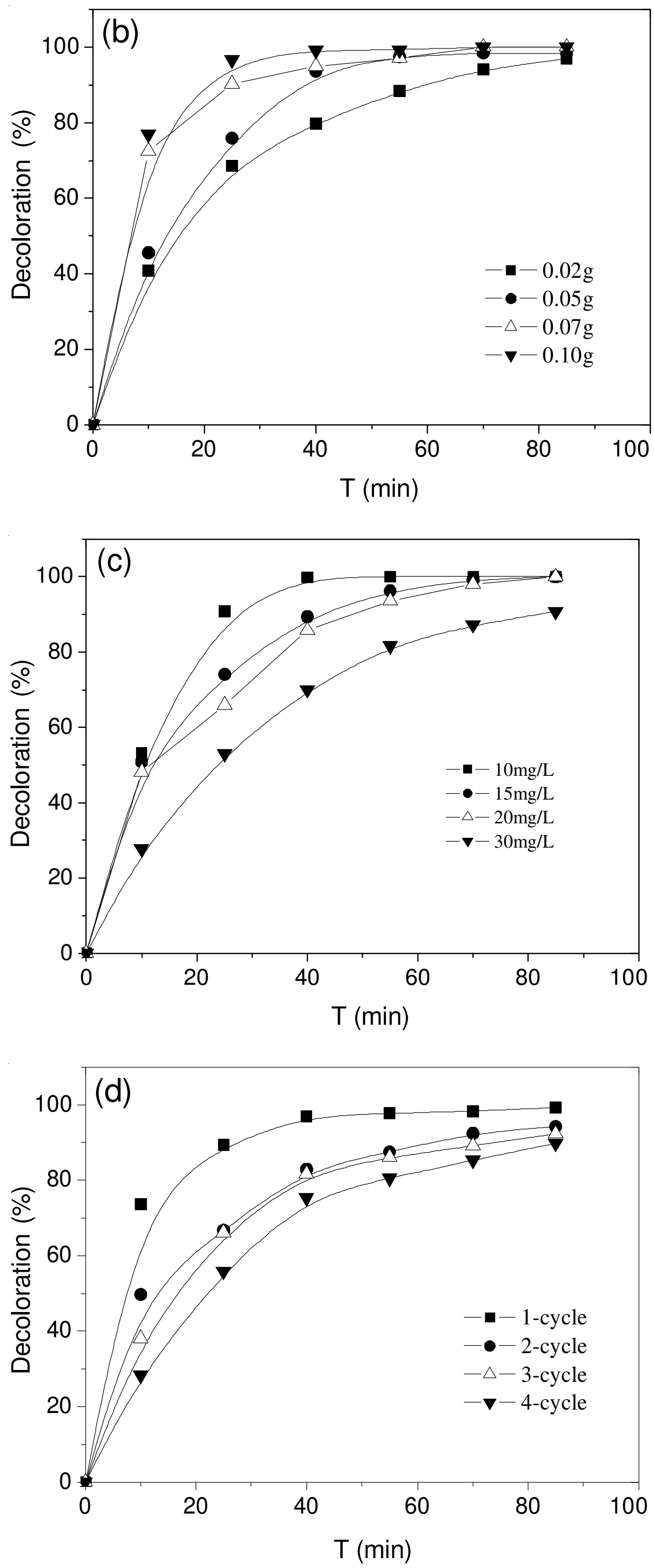


Fig. 2. Influences of conditions on the degradation of malachite green: (a) proportion of MoS_2 and TiO_2, (b) dosage of nanocomposite, (c) initial concentration of malachite green and (d) reusing cycles of the nanocomposite

Fig. 3 shows the adsorption isotherm plot of MoS_2/TiO_2 and pure nano-MoS_2 synthesized at 450 ºC. The results in Fig. 3 confirm that similar adsorption behaviours between the two kinds of nanoparticles. However, the adsorbed quantity of N_2 on the nanocomposite is remarkably more than that on the pure nano-MoS_2. As shown in Fig. 4, the saturated adsorption is at about 7.1 cm^3/g on the pure nano-MoS_2 while 21.0 cm^3/g on the nanocomposite. The nanocomposite has a BET area of about 91 m^2/g, whereas that of the pure nano-MoS_2 is only at about 31 m^2/g. The liner correlation coefficients exceed 0.9999, indicating the BET characterization is reasonable. The high BET area of the nanocomposite offered more active sites for the catalytic degradation of malachite green. Compared with the pure nano-MoS_2, the MoS_2 nano-platelets have smaller sizes in the nanocomposite. This implies that more active sites are provided to degrade malachite green when the MoS_2/TiO_2 nanocomposite was used as a catalyst.

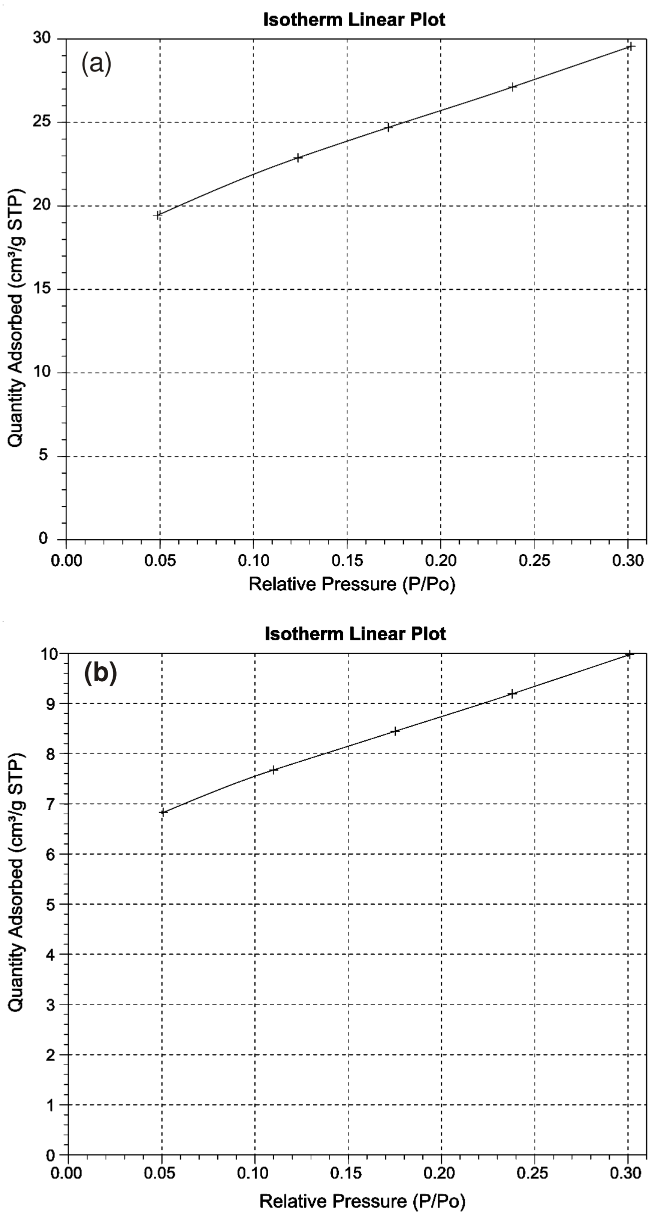


Fig. 3. Adsorption isotherm plot of: (a) MoS_2/TiO_2 and (b) pure nano-MoS_2

Conclusion

The MoS_2/TiO_2 nanocomposite has high catalytic activity in the degradation reaction of malachite green. The nanocomposite can be reused for at least 4 cycles and is a potential photo catalyst for the removal of malachite green from wastewater.

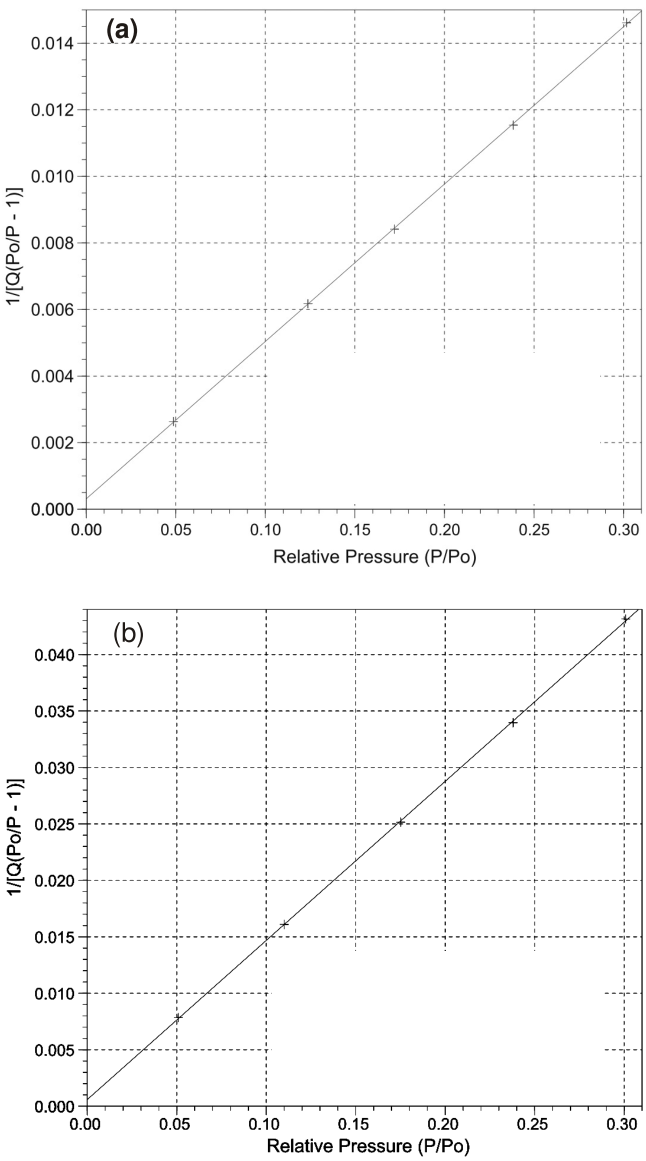


Fig. 4. BET surface area plot: (a) MoS_2/TiO_2 and (b) pure nano-MoS_2

ACKNOWLEDGEMENTS

This work is supported by the China Postdoctoral Science Foundation funded project (Grant No. 2011M500110) and the Hefei University Foundation (Grant no. 12RC03).

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