Degradation of Malachite Green on MoS$_2$/TiO$_2$ Nanocomposite†

Kun-Hong Hu[1,2,*] and Mian Meng[2]

[1]Postdoctoral Working Station of Materials Science and Engineering, Hefei University of Technology, Hefei 230009, P.R. China
[2]Department of Chemical and Materials Engineering, Hefei University, Hefei 230601, P.R. China

*Corresponding author: E-mail: hukunhong@gmail.com

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

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.
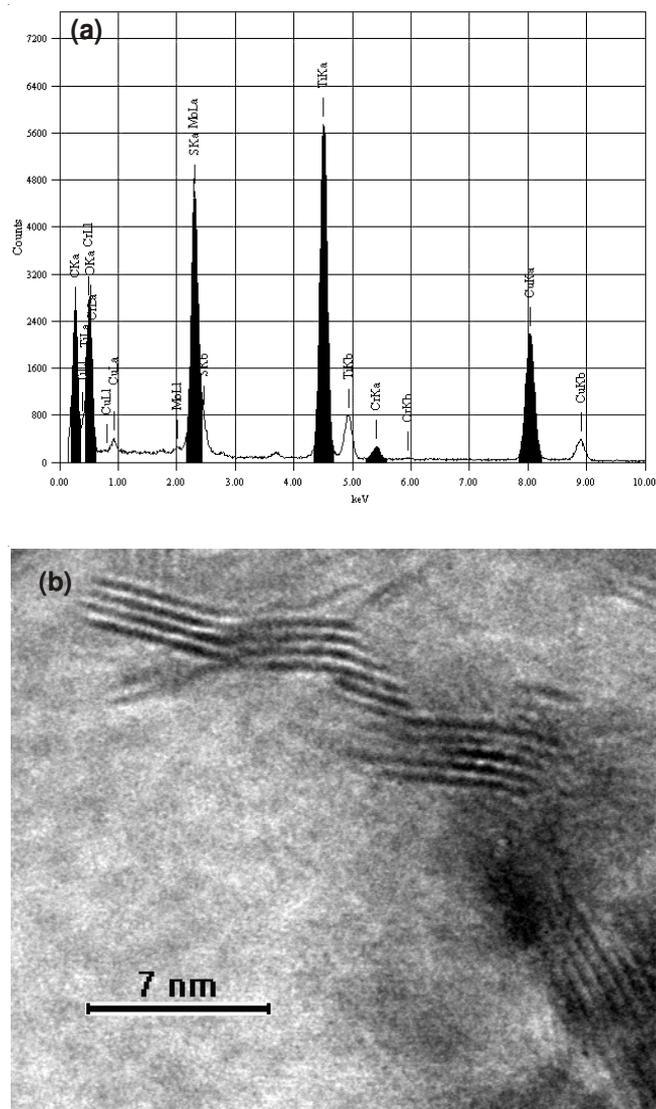

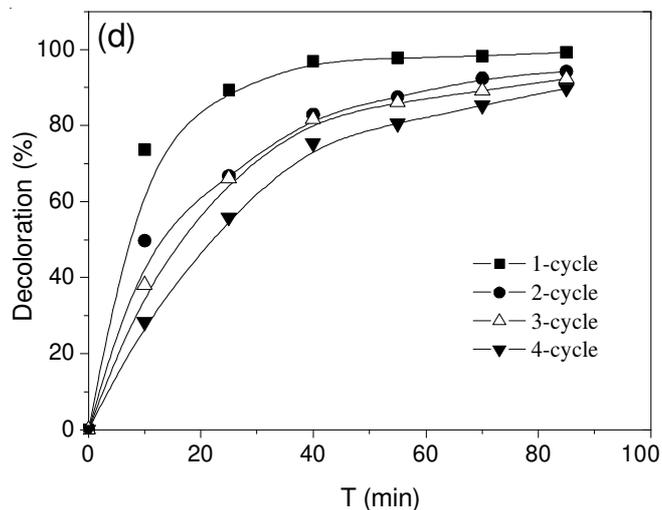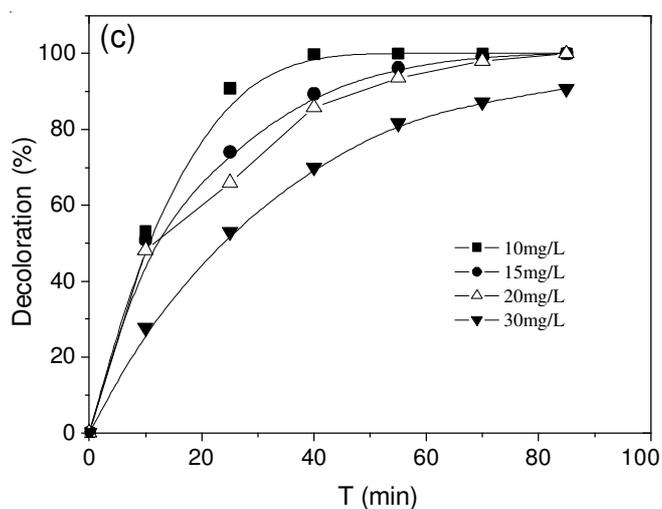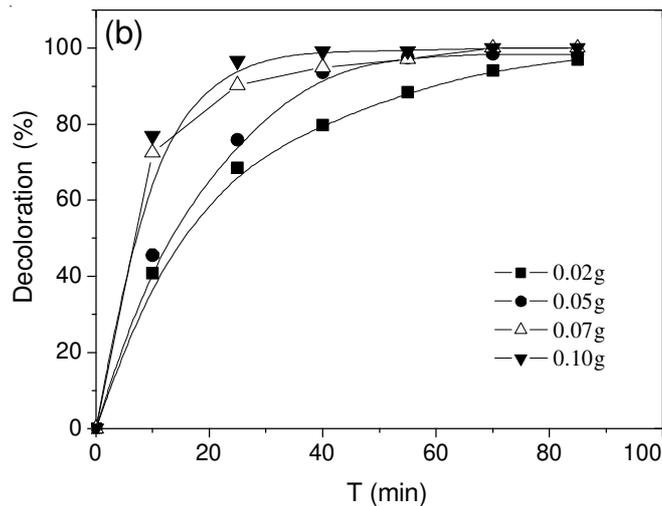Fig. 1. EDS spectrum (a) and HRTEM image (b) of MoS$_2$/TiO$_2$ nanocomposite
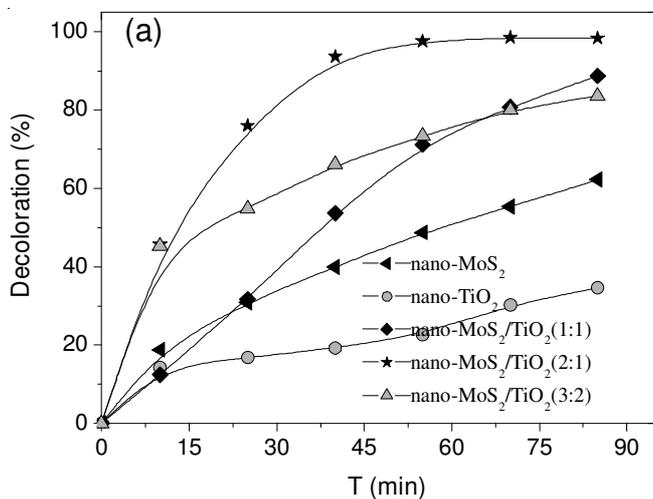

Fig. 2. Influences of conditions on the degradation of malachite green: (a) proportion of MoS$_2$ and TiO$_2$, (b) dosage of nanocomposite, (c) initial concentration of malachite green and (d) reusing cycles of the nanocomposite

Fig. 3 shows the adsorption isotherm plot of MoS$_2$/TiO$_2$ and pure nano-MoS$_2$ synthesized at 450 ℃. 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.
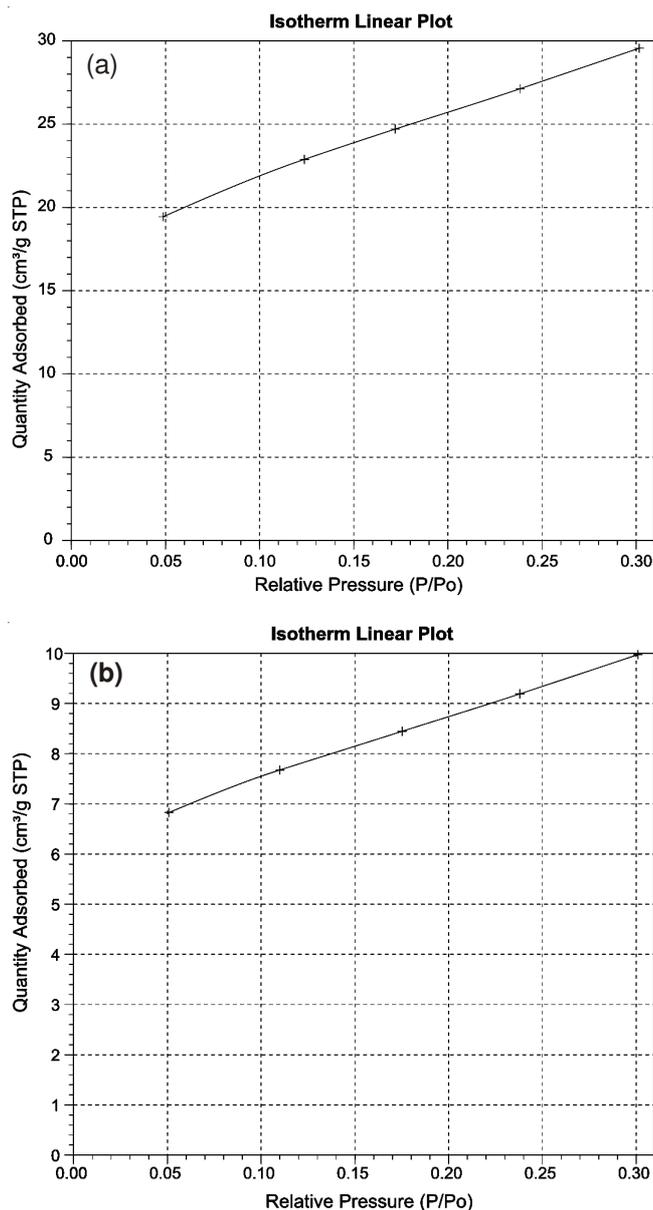

Fig. 3. Adsorption isotherm plot of: (a) MoS$_2$/TiO$_2$ and (b) pure nano-MoS$_2$

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.
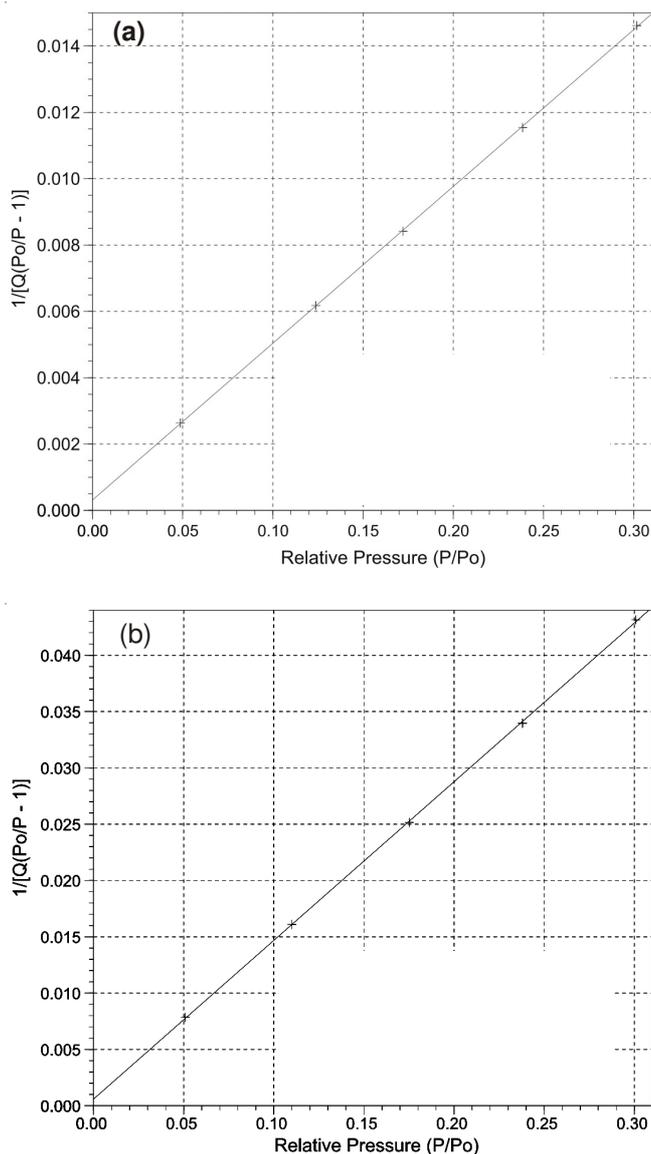

Fig. 4. BET surface area plot: (a) MoS$_2$/TiO$_2$ and (b) pure nano-MoS$_2$

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