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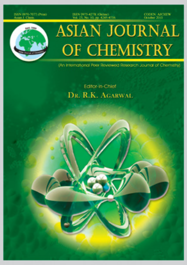

# Photocatalytic Properties of $MoS_2$ Deposited on Diatomite†

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A $MoS_2$/diatomite composite was synthesized by depositing $MoS_3$ on diatomite in a acidic solution and following calcination in $H_2$. The obtained composite presented excellent photocatalytic activity on the degradation of methyl orange. The photocatalytic properties was influenced by the composition of the composite, the initial concentration of methyl orange, the amount of the catalyst and the pH value. The $MoS_2$/diatomite composite is low-cost and can be reused for three cycles after filtration and drying. The $MoS_2$/diatomite composite presents potential applications in the wastewater treatment.

**Key Words: Molybdenum disulfide, Diatomite, Photocatalysis, Degradation.**

## INTRODUCTION

The photo absorption of $MoS_2$ is relative to its sizes. The small sizes of nano-$MoS_2$ lead to large blueshifts because of the strong quantum confinement effect[1,2], which allows nano-$MoS_2$ to be used as photocatalysts under visible light[3,4]. Recently, the photocatalytic activity of nano-$MoS_2$ was investigated on different supporters including kaolin[5] and $TiO_2$[1,3,6]. The present work studied the synthesis and photocatalytic properties of $MoS_2$/diatomite. The as-synthesized composite is very effective in the photocatalytic degradation of methyl orange and has potential applications in the wastewater treatment.

## EXPERIMENTAL

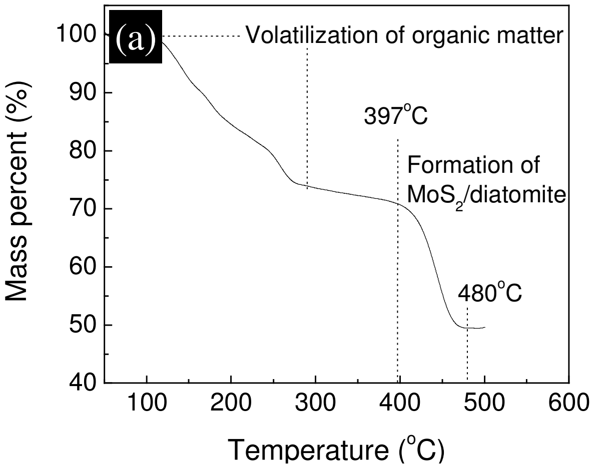
All reagents used were of analytical grade. 2.5 mmol $Na_2MoO_4$, 15 mmol $Na_2S$ and diatomite were dispersed in 100 mL de-ionized water. 4.0 mL of 12M HCl was added in the solution. The resultant precipitation was calcined at 480 ºC in $H_2$ for 0.5 h leading to the desired $MoS_2$/diatomite. The calcination reaction was studied on a Shimadzu model DTG-60H thermal analysis analyser. Micrographs were obtained using a FEI model Sirion 200 field emission scanning electron microscope (SEM). The photocatalytic properties of the $MoS_2$/diatomite were evaluated using the degradation of methyl orange under the indoor sunlight with a 30 W daylight lamp on a 721 spectrophotometer.

## RESULTS AND DISCUSSION

**Synthesis and characterization of $MoS_2$/diatomite composite:** The diatomite was activated by HCl because it contains -M-O- bonds (M = Ca, Al *etc.*), which provided nucleation sites for $MoS_3$ deposition on diatomite (eqn. 1).

$$4S^{2-} + MoO_4^{2-} + 10H^+ + \text{diatomite} \longrightarrow MoS_3/\text{diatomite}\downarrow + H_2S\uparrow + 4H_2O \quad (1)$$

As shown in Fig. 1a, the initial decomposing temperature of $MoS_3$/diatomite is at *ca.* 397 ºC. The $MoS_3$/diatomite can mostly be turned into $MoS_2$/diatomite at 480 ºC (eqn. 2).



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†Presented to The 5th Korea-China International Conference on Multi-Functional Materials and Application.

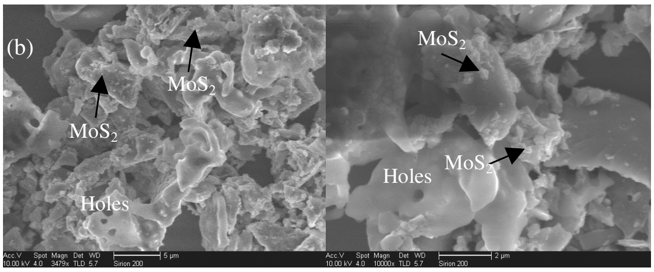
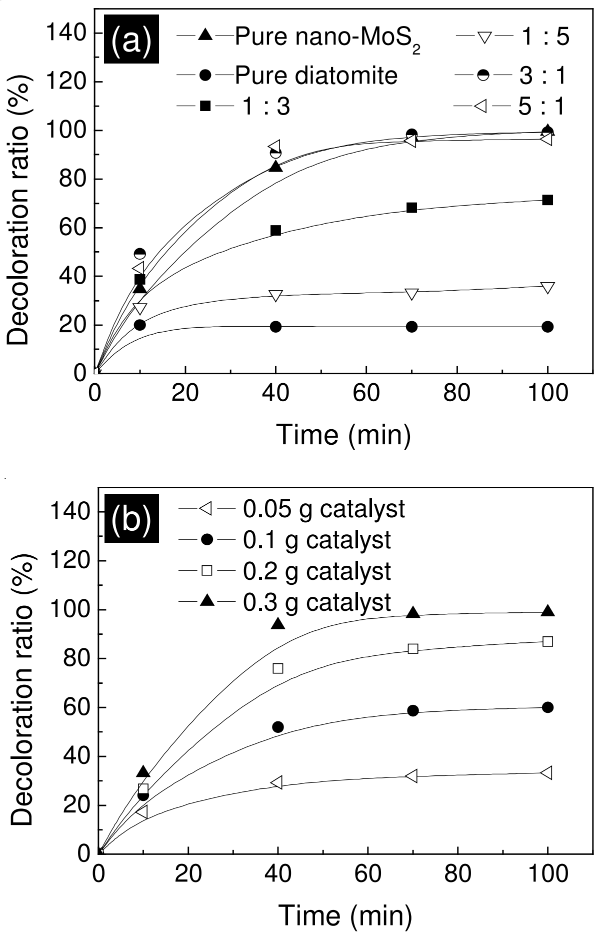


Fig. 1. Characterization of the $MoS_2$/diatomite composite: (a) TGA and (b) SEM

$$MoS_3\text{/diatomite} + H_2 \xrightarrow{480^{\circ}C} MoS_2\text{/diatomite} + H_2S \quad (2)$$

Fig. 1b indicates that the porous diatomite particles was split and became amorphous after acidification and calcination. A lot of $MoS_2$ particles were observed on the surface of diatomite without holes. However, $MoS_2$ was almost absent on the porous surface of diatomite, which indicates $MoS_3$ was difficult to deposit on the porous surface.

**Catalytic activity of $MoS_2$/diatomite composite:** The pure diatomite showed no activity for degrading methyl orange except for adsorption (Fig. 2a). The catalytic activity increased with the increasing contents of $MoS_2$ in the composite. A satisfactory decoloration ratio was observed in the composite with a weight ratio of 3:1 or 5:1 ($MoS_2$:diatomite), which is very close to that of the pure nano-$MoS_2$. The diatomite is easily obtained and low cost as compared to the pure nano-$MoS_2$. Thus, the application of $MoS_2$/diatomite is rather practical.



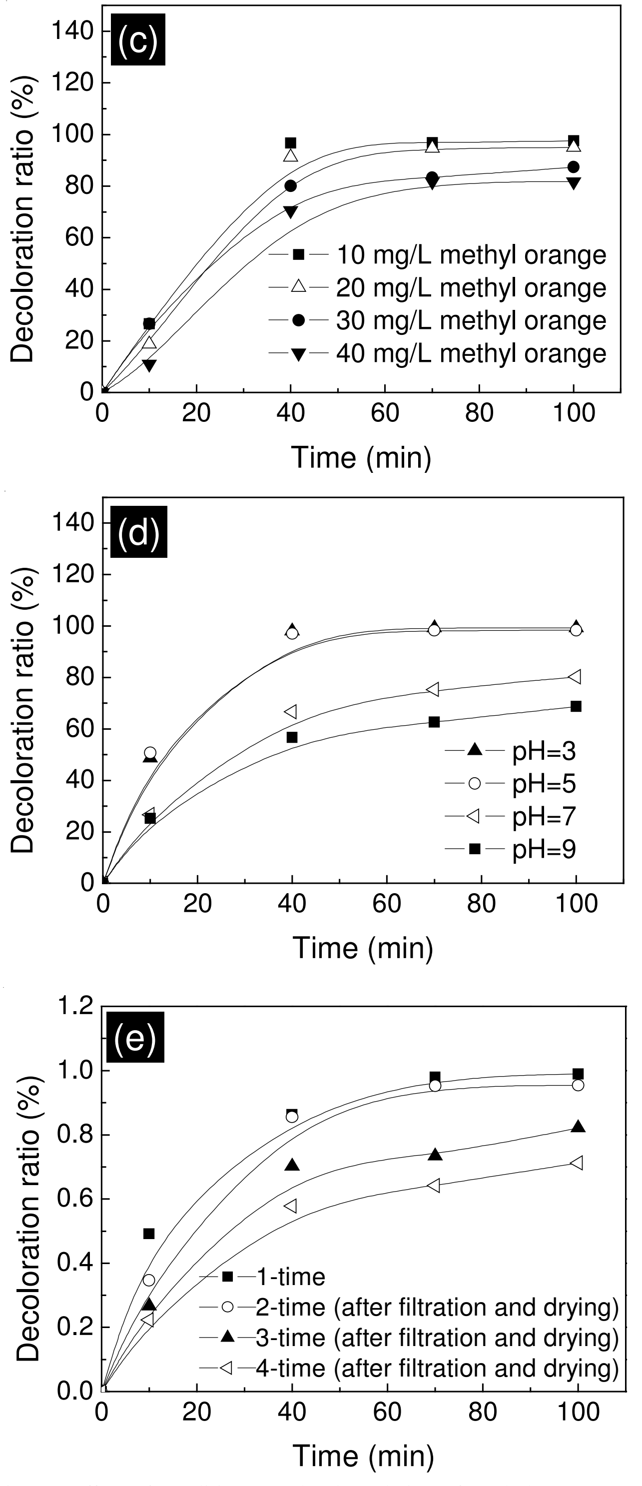


Fig. 2. Effect of conditions on the degradation of methyl orange: (a) composition of catalyst ($MoS_2$:diatomite), (b) amount of catalyst, (c) initial concentration of methyl orange, (d) initial pH value and (e) reusing cycles of catalyst

Fig. 2b provides the influence of the amount of $MoS_2$/diatomite on the decoloration ratio of methyl orange. The decoloration ratio can generally be improved with increasing amounts of the catalyst. The decoloration ratio of the methyl orange in this work also increased with the increasing amount of the catalysts. Satisfactory decoloration ratios occurred in 150 mL methyl orange solutions with no less than 0.2 g catalyst.

As is shown in Fig. 2c, the decoloration ratio decreased when the initial concentration was increased. The decoloration ratio was decreased to *ca.* 82 % when the initial concentration was increased to 40 mg/L. This indicates that the 0.2 g catalyst may used well work in < 40 mg/L methyl orange solution.

Methyl orange showed lower decoloration ratios under alkaline solutions than acidic ones (Fig. 2d). This implies that the degradation of methyl orange can be accelerated in acidic solution.

As shown in Fig. 2e, the decoloration ratio of the $MoS_2$/diatomite in the third cycle was decreased to about 82 %. A low decoloration ratio (71 %) was found in the 4th cycle, which indicates that the as-synthesized catalyst can be reused for 3 cycles.

**Proposed catalytic mechanism:** The degradation mechanism of methyl orange has been well studied by Baiocchi *et al.*[7]. The adsorbed water on $MoS_2$ may form active hydroxyl radicals ($\hat{}OH$) under visible light, which can degrade the organic chemicals[1]. The properties of $MoS_2$ are close relative to its size[8,9] and the use of a mineral can decrease the sizes of nano-$MoS_2$ [5]. The small sizes result in larger blueshifts and intense absorption of $MoS_2$/mineral under visible light. Thus, the composite $MoS_2$ deposited on diatomite showed high catalytic activity.

## Conclusion

A $MoS_2$/diatomite composite is prepared, which has high photocatalytic activity in the degradation of methyl orange. The composite can be reused for 3 cycles after filtration and drying. The composite is a promising photo catalyst for the removal of organic chemicals from wastewater.

## ACKNOWLEDGEMENTS

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