Data Article

MoO$_3$NPs/ZIF-8 composite material prepared via RCVD for photodegradation of dyes

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Abstract

Toxic wastewaters from the textile industry have made its way into rivers and other waterways, posing a serious health treat on both human and wildlife. Herein, this data set presents the potential use of MoO$_3$ nanoparticles supported on ZIF-8 in the photodegradation of a cationic dye molecule. The data presented in this article report a concise description of experimental conditions for the spray-dried ZIF-8 synthesis and subsequent deposition of MoO$_3$ nanoparticles via rotary chemical vapor deposition (RCVD). The photodegradation and analysis data reviled that the MoO$_3$-NPs@ZIF-8 3 wt% displayed the ability of degrading methylene blue up to 82% and 95% after 180 and 300 min, respectively.

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### Value of the data

- The use of the rotary chemical vapor deposition can encourage researchers to efficiently deposit other compounds on metal-organic frameworks.
- The as-synthesized MoO$_3$-NPs/ZIF-8 exhibits good photodegradation properties towards the removal of dye from polluted environment.
- To understand the relationship between an alternative nanoparticle deposition technique and the subsequent properties of the composite material.

### 1. Data

Nanoparticles deposition and coating of powders have been accomplished with numerous techniques including chemical vapor deposition (CVD) [2] and sol-gel [3]. The combination of a fluidized bed and CVD has been extensively used for coating powders. However, operational limits are imposed due to particle size and density of the powders. Rotary chemical vapor deposition (RCVD) is an alternative method that allows us to remove previous operational restrictions and achieve a uniform nanoparticle deposition [4]. A schematic representation and pictures of the apparatus are reported in Figs. 1 and 2.

Due to the harmful effects of industrial dye emission to the environment and human health [5,6], the following data set demonstrate the photocatalytic potential of the as-synthesized MoO$_3$-NPs/ZIF-8 on a
Fig. 1. Schematic of RCVD equipment.

diagram of RCVD equipment

Fig. 2. Pictures of the RCVD apparatus, (a) highlight the precursor chamber with the O₂ inlet, the tubular furnace and the rotating reactor (detail in c). In section (b) the rotating gear and the vacuum probe are displayed.
cationic dye molecule. In Fig. 2 is shown the structure of the methylene blue (MB). A change in maximum absorbance at 664 nm was used to monitor the dye’s degradation [7]. The UV–vis spectra for the methylene blue photodegradation are illustrated in Fig. 3 (Fig. 4).

In order to assess the structural stability of the MoO$_3$-NPs/ZIF-8 3 wt% after its use, the catalyst has been recycled multiple times. The PXRD spectra (Fig. 5) and FT-IR spectra (Fig. 6) reveal that the photocatalyst remains stable under the reaction condition showing negligible degradation. Furthermore, MoO$_3$-NPs/ZIF-8 3 wt% morphology was characterized after the 4th cycle by SEM (Fig. 7) and the metal content was assessed by ICP-AES (Table 1). The photocatalyst has been successfully recycled four times without evident decrease in performance, as shown in Fig. 8.
2. Materials, methods and experimental design

2.1. Materials

All reagents and solvents were purchased from commercial sources and used without further purification. The synthesis of the catalyst MoO$_3$-NPs/ZIF-8 is detailed in the original paper, [“Submitted to Microporous and Mesoporous Materials.”] and are briefly discussed below.

2.2. Spray-dried ZIF-8 synthesis

The synthesis of ZIF-8 was achieved following literature procedure with minor modification [1]. Zn(OAc)$_2$·2H$_2$O (16 mmol) and 2-methylimidazole (16 mmol) are solubilized in 50 mL of methanol. The reaction mixture was spray-dried with a feed rate of 11.5 mL min$^{-1}$, a flow rate of 4.6 $\times$ 10$^6$ mL min$^{-1}$ and an inlet temperature of 180 °C. The product is collected as a white powder and suspended in methanol overnight. After centrifugation the ZIF-8 is dried at 60 °C in vacuum oven.

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Fig. 5. PXRD pattern of MoO$_3$-NPs/ZIF-8 before and after photocatalytic reaction.

Fig. 6. FT-IR spectra of MoO$_3$-NPs/ZIF-8 before and after photocatalytic reaction.
2.3. ZIF-8 functionalization by rotary chemical vapor deposition

MoO$_3$ nanoparticles were deposited onto ZIF-8 with the use of a rotary chemical vapor deposition (RCVD) device (Figs. 1 and 2). In brief, the key feature of the RCVD is the rotary reactor chamber. Equipped with four inner blades, can ensure a sufficient contact time between the powder and the reactant gasses. A fixed amount of metal precursor [Mo(CO)$_6$] is placed in the evaporator chamber at 85 °C and carried into the rotary reactor by an oxygen flow of $8.3 \times 10^{-7}$ m$^3$ s$^{-1}$. The ZIF-8 was loaded into the rotary chamber and the deposition is set at 250 °C to prevent any degradation of the supporting material. The nanoparticle deposition process took place under reduced pressure ($1.0 \times 10^4$ Pa) and the deposition time ($0.6 > t > 1.8$ ks) was used to control the nanoparticles loading.

![Fig. 7. SEM pictures of MoO$_3$-NPs/ZIF-8 3 wt% after use.](image)

Table 1
ICP-AES results for fresh and recycled MoO$_3$-NPs/ZIF-8 3 wt%.

| MoO$_3$-NPs/ZIF-8 3 wt% | Metal loading (wt%) |
|------------------------|---------------------|
| Fresh                  | 3.01                |
| Recycled               | 2.63                |

![Fig. 8. Number of catalyst recycles.](image)

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2.4. Photodegradation experiments

The photodegradation of methylene blue by MoO$_3$-NPs/ZIF-8 was carried out as follows: 50 mg of as-synthesized catalyst were added into 200 mL dye aqueous solution (10 mg/L) and magnetically stirred for 30 minutes in a dark environment. Subsequently, the suspension is poured into a water-cooled jacket glass reactor to dissipate the intense heat sourcing from the solar lamp (PL-XQ 350 W Xenon). The solution aliquots were filtered through a 0.22 μm Millipore filter and analyzed by UV–vis absorption spectroscopy.

3. Data analysis

The MoO$_3$-NPs/ZIF-8 photocatalytic performance is calculated based on the methylene blue photodegradation kinetics according to Eq. (1):

\[
-\ln(C/C_0) = kt
\]

where C is the MB concentration at any given time (t), $C_0$ is the initial concentration and k is the rate constant.

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Transparency document. Supplementary material

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