

## Electronic Supplementary Information

### **A general one-step approach for in situ decoration of MoS<sub>2</sub> nanosheets with inorganic nanoparticles**

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#### **Experimental Section**

**Synthesis of noble metal nanoparticles decorated MoS<sub>2</sub> nanosheets (MoS<sub>2</sub>-Pt and MoS<sub>2</sub>-Au).** Typically, MoS<sub>2</sub>-COOH (20 mg) was dispersed in DEG (30 mL) and the mixture was treated with an ultrasonic bath (40 kHz) for 15 min. Then, K<sub>2</sub>PtCl<sub>4</sub> (20.8 mg, 0.05 mmol) or HAuCl<sub>4</sub>·3H<sub>2</sub>O (19.7 mg, 0.05 mmol) was added and stirred for 30 min. The above mixture was heated to 200 °C for 20 min under the protection of argon flow and constant stirring. 7.5 mg of NaBH<sub>4</sub> in 10 mL of DEG was injected rapidly into the above hot mixture. The resulting mixture was further heated at 200 °C for 1 h. The final product of MoS<sub>2</sub>-Au or MoS<sub>2</sub>-Pt was separated by centrifugation and washed with water.

For comparison, MoS<sub>2</sub>-Pt was also synthesized by using sodium citrate instead of NaBH<sub>4</sub> as reducing agent. In addition, graphene was also employed as substrate to

fabricate graphene-Pt nanohybrid with the same synthetic procedure as MoS<sub>2</sub>-Pt.

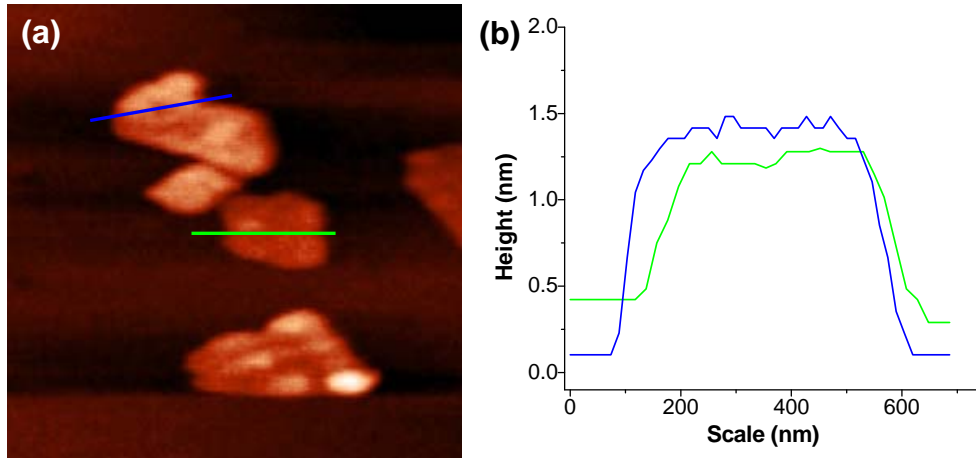
**Synthesis of Fe<sub>3</sub>O<sub>4</sub> nanoparticles decorated MoS<sub>2</sub> nanosheets (MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub>).**

Typically, NaOH (100 mg) was added into DEG (10 mL), heated at 120 °C for 1 h in a argon atmosphere, and cooled down to 70 °C to produce a NaOH/DEG stock solution. MoS<sub>2</sub>-COOH (20 mg) was dispersed in DEG (30 mL) and the mixture was treated with an ultrasonic bath (40 kHz) for 15 min. Then, FeCl<sub>3</sub> (80 mg, 0.49 mmol) was added and stirred for 30 min. The above mixture was heated to 200 °C for 20 min under the protection of argon flow and constant stirring. 3.5 mL of 70 °C NaOH/DEG stock solution was injected rapidly into the above hot mixture. The resulting mixture was further heated at 200 °C for 1 h. The final product of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub> was separated by centrifugation and washed with water.

**Synthesis of semiconductor nanoparticles decorated MoS<sub>2</sub> nanosheets**

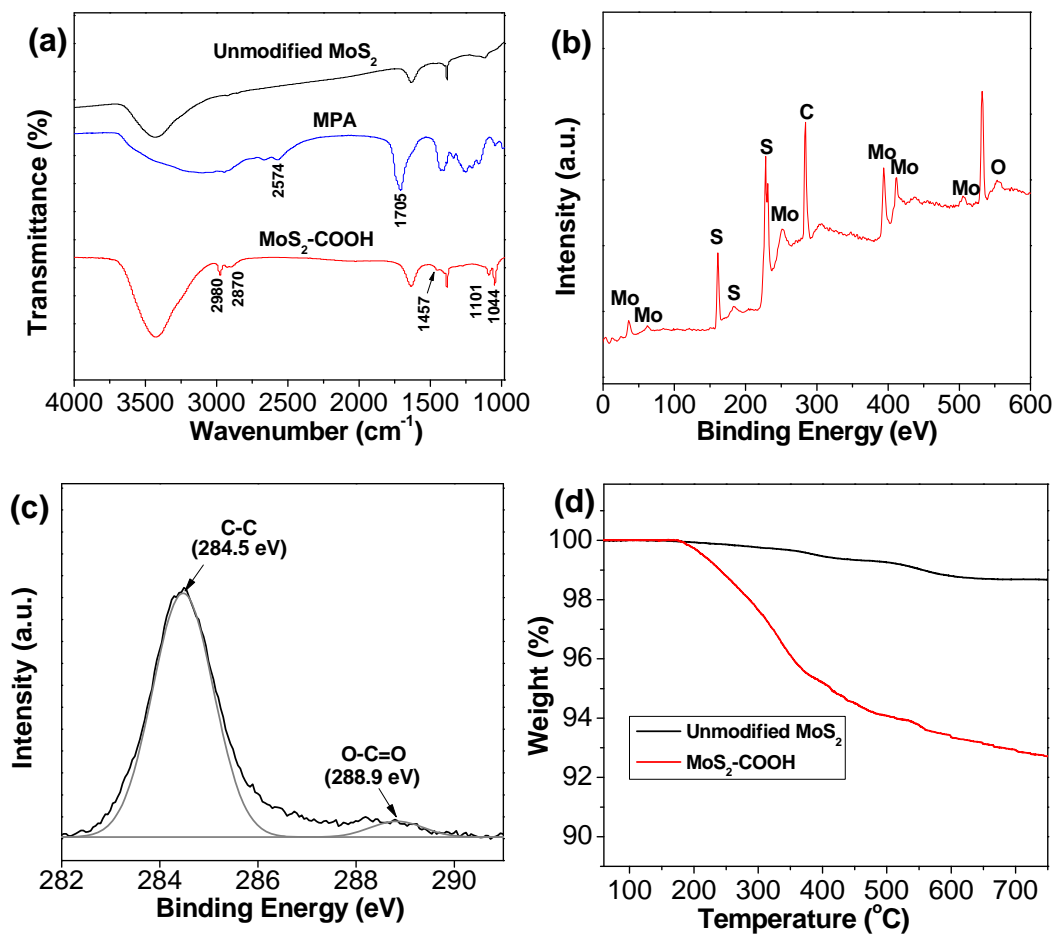
**(MoS<sub>2</sub>-CdS and MoS<sub>2</sub>-PbS).** Typically, MoS<sub>2</sub>-COOH (20 mg) was dispersed in DEG (30 mL) and the mixture was treated with an ultrasonic bath (40 kHz) for 15 min. Then, CdCl<sub>2</sub> (18.4 mg, 0.1 mmol) or Pb(CH<sub>3</sub>COO)<sub>2</sub>·3H<sub>2</sub>O (40 mg, 0.1 mmol) was added and stirred for 30 min. The above mixture was heated to 200 °C for 20 min under the protection of argon flow and constant stirring. 25 mg of Na<sub>2</sub>S·9H<sub>2</sub>O in 10 mL of DEG solution was injected rapidly into the above hot mixture. The resulting mixture was further heated at 200 °C for 1 h. The final product of MoS<sub>2</sub>-CdS and MoS<sub>2</sub>-PbS was separated by centrifugation and washed with water.

**Fig. S1**



**Fig. S1.** (a) Representative AFM image of MoS<sub>2</sub>-COOH nanosheets. (b) Height profile of corresponding planes along the lines in (a).

**Fig. S2**



**Fig. S2.** (a) FTIR spectra of MPA, MoS<sub>2</sub>-COOH and unmodified MoS<sub>2</sub> nanosheets. XPS survey spectrum (b) and C1s spectrum (c) of MoS<sub>2</sub>-COOH. (d) TGA curves of MoS<sub>2</sub>-COOH and unmodified MoS<sub>2</sub> nanosheets.

The successful introduction of carboxylic groups was elucidated by FTIR and XPS. For comparison, we also synthesized MoS<sub>2</sub> nanosheets using the same procedure as MoS<sub>2</sub>-COOH except the addition of mercaptopropionic acid (MPA) ligand and this sample was designated as unmodified MoS<sub>2</sub>. As can be seen in Fig. S2a, the MPA sample shows a strong absorption band at 2574 cm<sup>-1</sup> corresponding to the -SH stretching. After conjugation with MoS<sub>2</sub>, this band disappeared in the resulted MoS<sub>2</sub>-COOH sample, possibly caused by the interaction between -SH with MoS<sub>2</sub>. The exfoliation process leads to deformation of MoS<sub>2</sub>'s crystal structure and

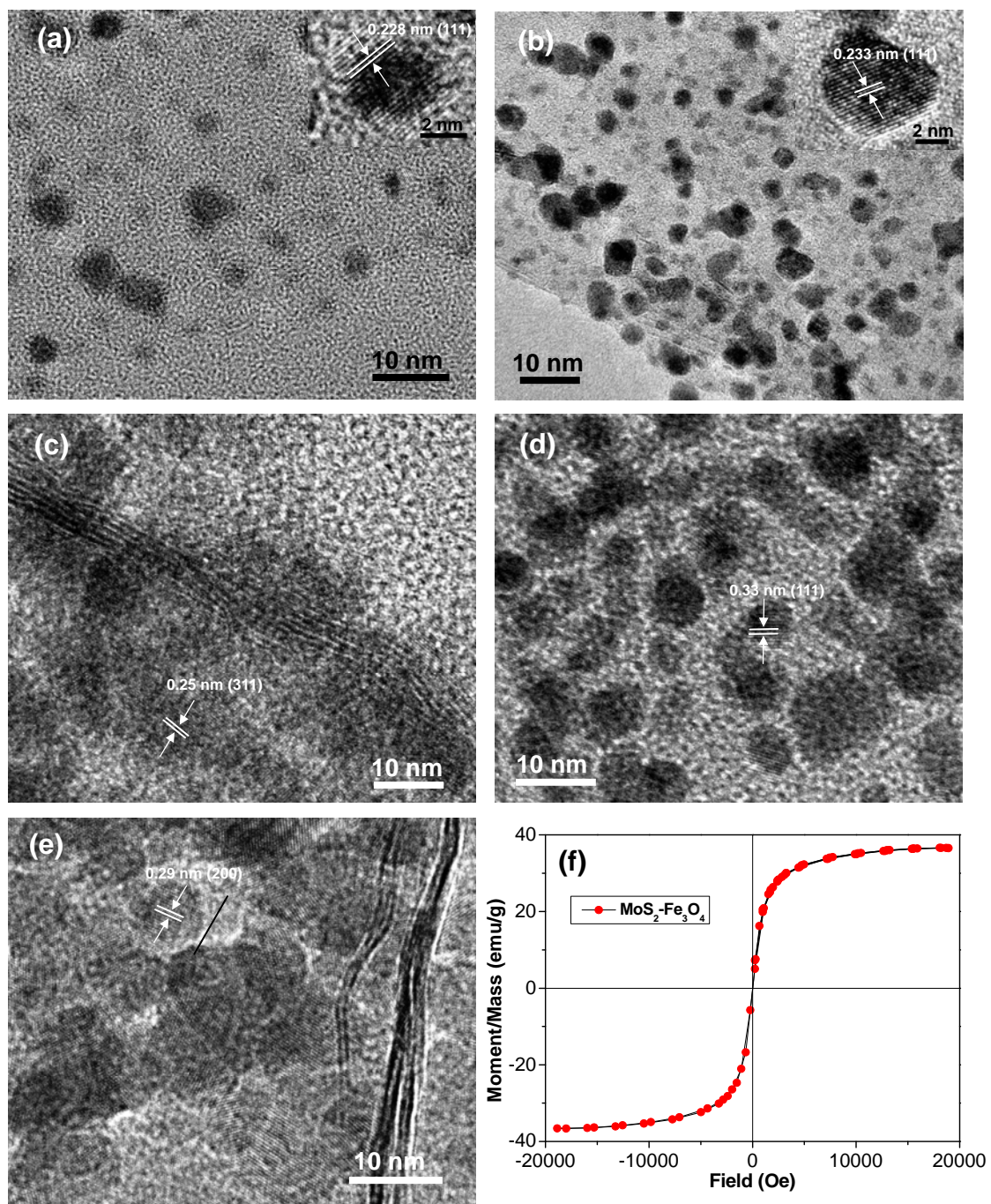
formation of numerous internal edges and defects. On the other hand, previous works suggested that the sites of internal edges and defects possess high affinities toward -SH group.<sup>1,2</sup> In addition, the MoS<sub>2</sub>-COOH sample shows obvious absorption bands at 2980, 2870 and 1457 cm<sup>-1</sup> due to the C-H stretching, 1101 cm<sup>-1</sup> corresponding to C-O stretching, and 1044 cm<sup>-1</sup> associated with C-S stretching, demonstrated the successful conjugation of MPA ligand.

According to the full survey spectrum (Fig. S2b), the elements of Mo, S, C and O are found for the MoS<sub>2</sub>-COOH sample. The mass percent of C and O were calculated according to the XPS results and found that the MoS<sub>2</sub>-COOH sample shows much higher content of C (2.6 wt% and 0.9 wt% for MoS<sub>2</sub>-COOH and unmodified MoS<sub>2</sub>, respectively) and O (1.9-2.5 wt% and 0.2 wt% for MoS<sub>2</sub>-COOH and unmodified MoS<sub>2</sub>, respectively) than that of unmodified MoS<sub>2</sub> nanosheets, further confirmed the successful attachment of carboxylic groups. In addition, the high-resolution C1s spectrum indicates the presence of O=C-O and C-C bonds for the MoS<sub>2</sub>-COOH sample (Fig. S2c). The content of carboxylic groups on the surface of MoS<sub>2</sub>-COOH was determined by TGA as shown in Figure S2d. The unmodified MoS<sub>2</sub> sample shows very low weight loss (about 1.3 wt%) between 150-700 °C, presumably due to the presence of residual organic component resulted from *n*-BuLi. In contrast, the MoS<sub>2</sub>-COOH sample shows much higher weight loss between 150-700 °C (7.1 wt%), further confirming that the carboxylic groups have been successfully introduced onto the surface of MoS<sub>2</sub> nanosheets.

## Reference

- 1 S. S. Chou, M. De, J. Kim, S. Byun, C. Dykstra, J. Yu, J. Huang and V. P. Dravid, *J. Am. Chem. Soc.*, 2013, **135**, 4584–4587.
- 2 Z. Tang, Q. Wei, B. Guo, *Chem. Commun.*, 2014, **50**, 3934–3937.

**Fig. S3**



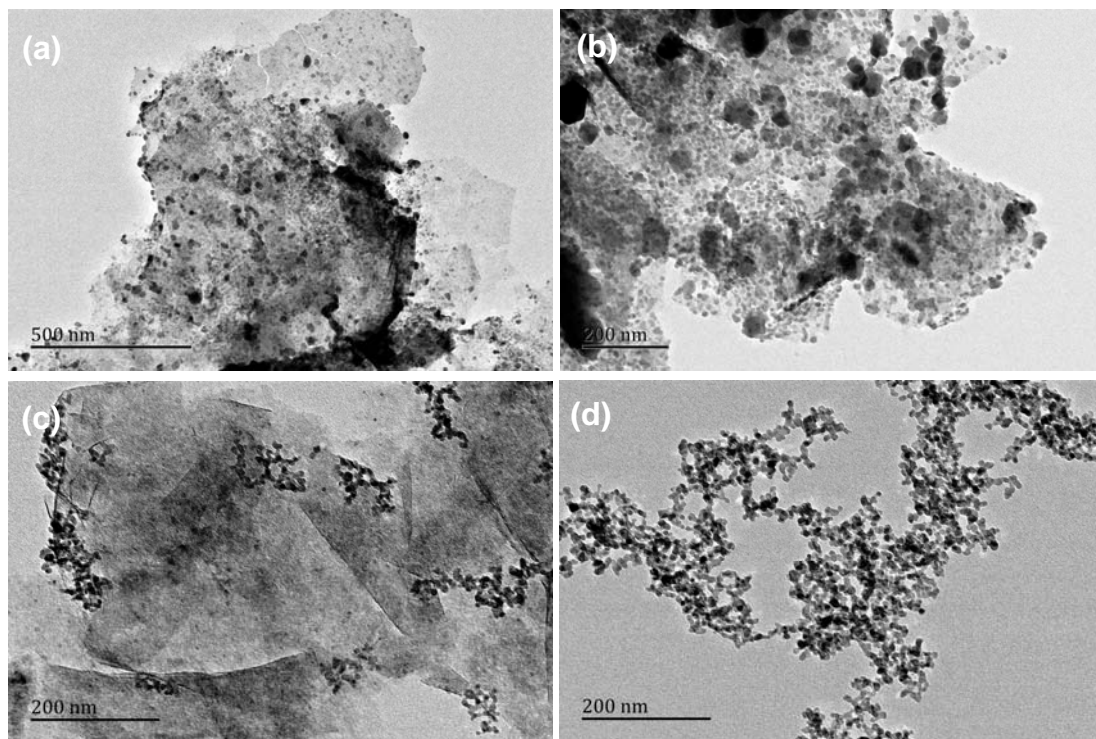
**Fig. S3.** Representative TEM images of MoS<sub>2</sub>-Pt (a), MoS<sub>2</sub>-Au (b), MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub> (c), MoS<sub>2</sub>-CdS (d) and MoS<sub>2</sub>-PbS (e). (f) Magnetization curve (at 300 K) of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub>.

**Fig. S4**



**Fig. S4.** Photographs of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub>/PVA nanocomposite film.

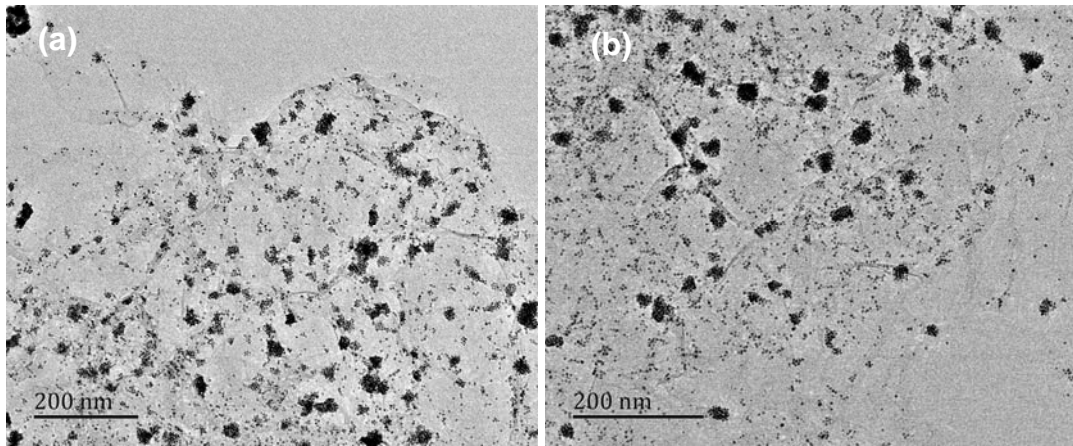
**Fig. S5**



**Fig. S5.** Representative TEM images of MoS<sub>2</sub>-Pt (a,b) and MoS<sub>2</sub>-CdS (c,d) by using unmodified MoS<sub>2</sub> as a support.

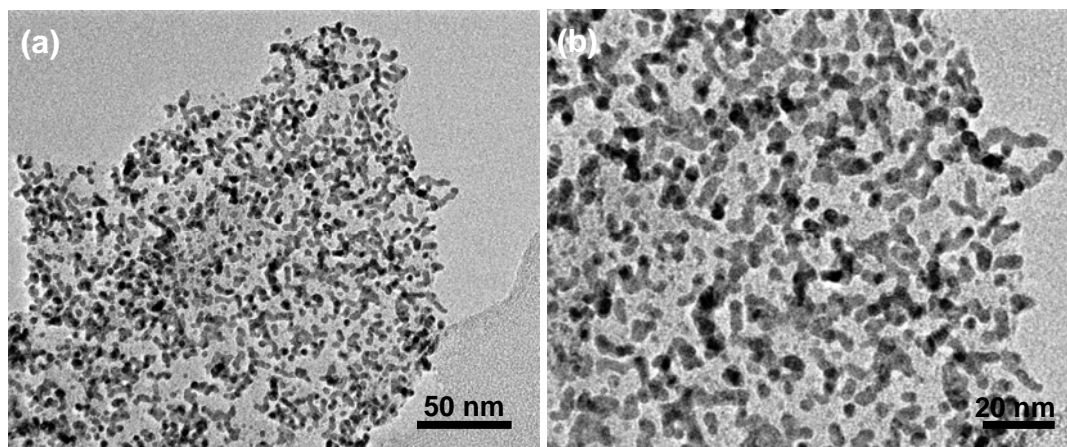


**Fig. S6**



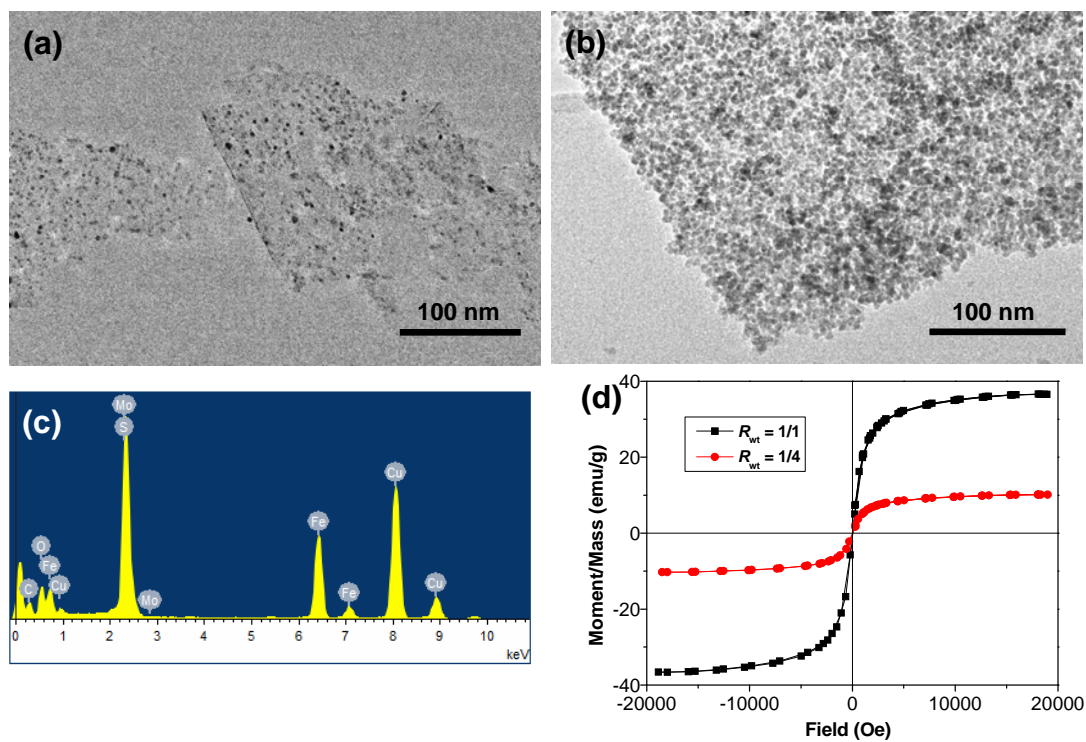
**Fig. S6.** TEM images of graphene-Pt.

**Fig. S7**



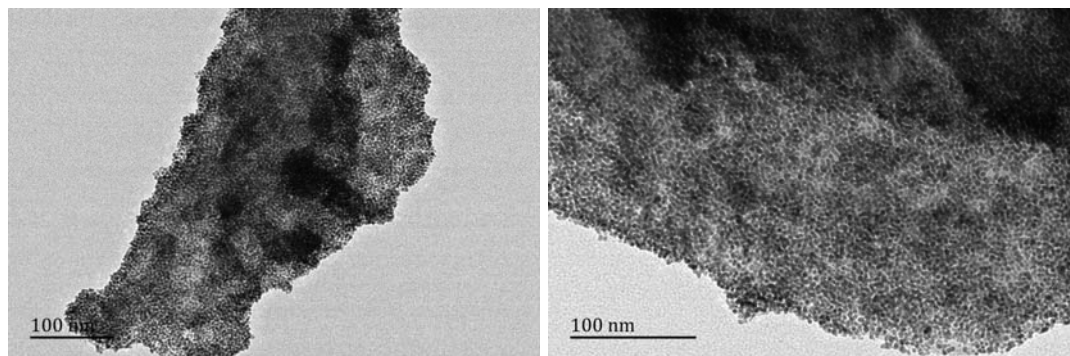
**Fig. S7.** TEM images of MoS<sub>2</sub>-Pt by using sodium citrate as reducing agent.

**Fig. S8**



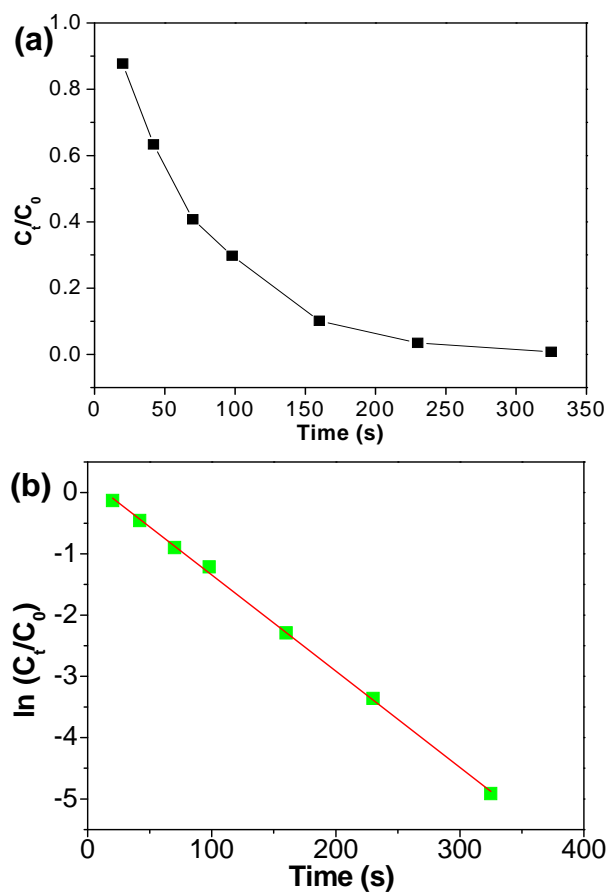
**Fig. S8.** Representative TEM images of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub> with  $R_{wt}$  (FeCl<sub>3</sub>/MoS<sub>2</sub>-COOH) value of 1/1 (a) and 4/1 (b). (c) EDS spectrum of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub> shown in (a). (d) Magnetization curves (at 300 K) of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub> with  $R_{wt}$  (FeCl<sub>3</sub>/MoS<sub>2</sub>-COOH) value of 1/1 and 4/1.

**Fig. S9**



**Fig. S9.** Representative TEM images of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub>/Pt sample.

**Fig. S10**



**Fig. S10.** (a) Concentration change in 4-nitrophenol compounds ( $C_t/C_0$ ) in the presence of MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub>/Pt nanocatalysts. (b) Plot of  $\ln(C_t/C_0)$  against time for the reduction of 4-nitrophenol with MoS<sub>2</sub>-Fe<sub>3</sub>O<sub>4</sub>/Pt nanocatalysts.