Electronic Supplementary Information

Two-Dimensional SnS$_2$ Nanosheets Exfoliated from Inorganic-Organic Hybrid toward Enhanced Photocatalytic Cr(VI) Reduction

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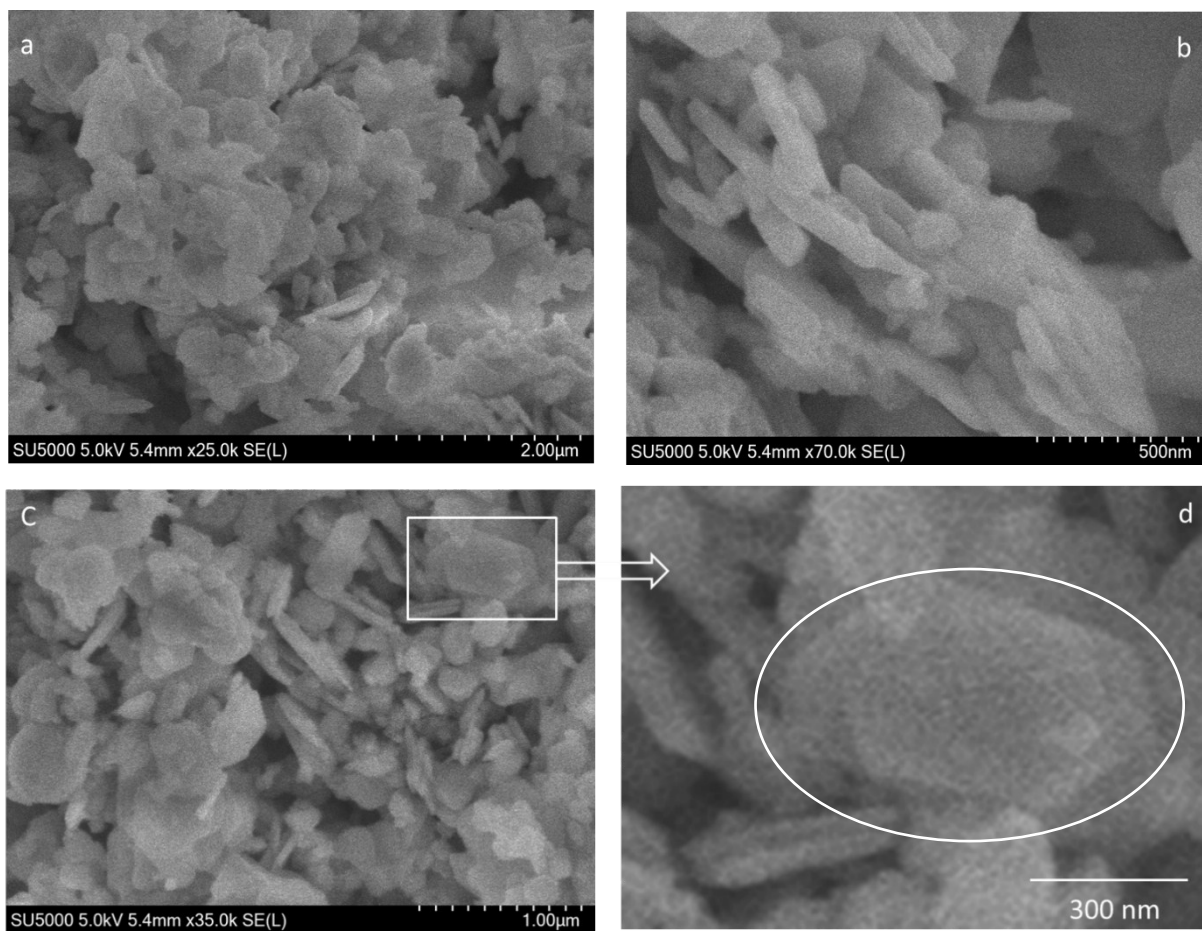
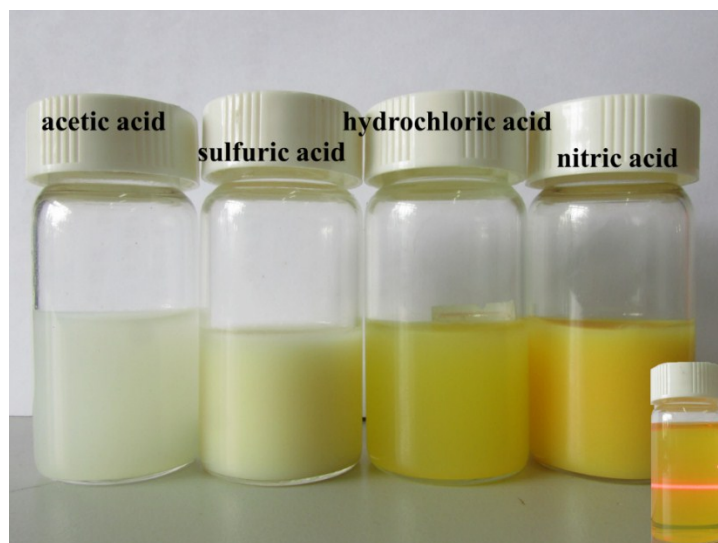*Corresponding author

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Figure S1-S5.

Fig. S1. SEM images of the SnS_2/n-propylamine hybrid at different magnifications (a, b, c, d).

Fig. S2. Photographs for the comparison of exfoliation efficiency in various acids.

Fig. S2 show the comparison of exfoliation efficiency of bulk SnS_2/n-propylamine composite in 3 M of acetic acid, sulfuric acid, hydrochloric acid and nitric acid, for 1 h respectively. When the bulk SnS_2/n-propylamine composite was ultrasonicated in acetic acid and sulfuric acid, the milk white color indicates the lower exfoliation efficiency of the bulk SnS_2/n-propylamine composite. The two yellow bottles display that the hydrochloric acid and nitric acid can exfoliate the bulk SnS_2/n-propylamine composite very well, however, the dark yellow color presents the higher exfoliation efficiency of the bulk SnS_2/n-propylamine composite in nitric acid than that in acetic acid. Therefore, the nitric acid was found to be an ideal solvent for the exfoliation of the bulk SnS_2/n-propylamine composite into 2D ultrathin nanomaterial. Exfoliation of the bulk SnS_2/n-propylamine composite in nitric acid could completely destroy and remove the mesophase n-propylamine during the process of sonication and attain to the higher exfoliation efficiency with a good exfoliation state. As observed, most of the proton acid can exfoliate SnS_2/n-propylamine composite, among which nitric acid shows the highest efficiency. The synthetic few-layers SnS_2 nanosheets were well dispersed in ethanol solution (ethanol/water = 1:1) showing the Tyndall effect.
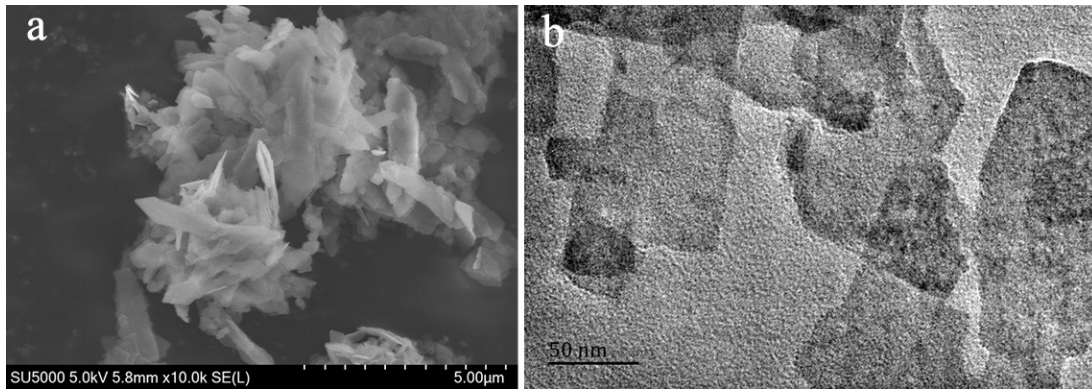
Fig. S3. SEM image of WO$_3$/n-propylamine hybrid precursors (a), TEM images (b) of few-layers WO$_3$ nanosheets by the same n-propylamine intercalated - exfoliated method.
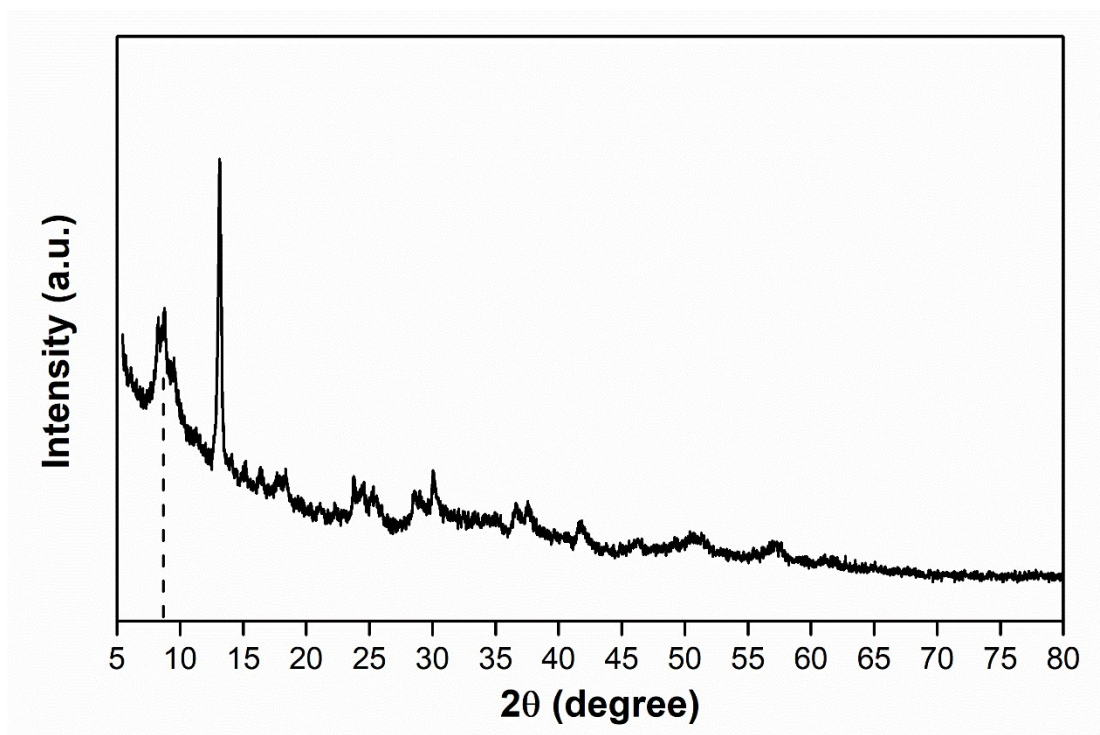
Fig. S4. XRD patterns of bulk SnS$_2$/n-propylamine.
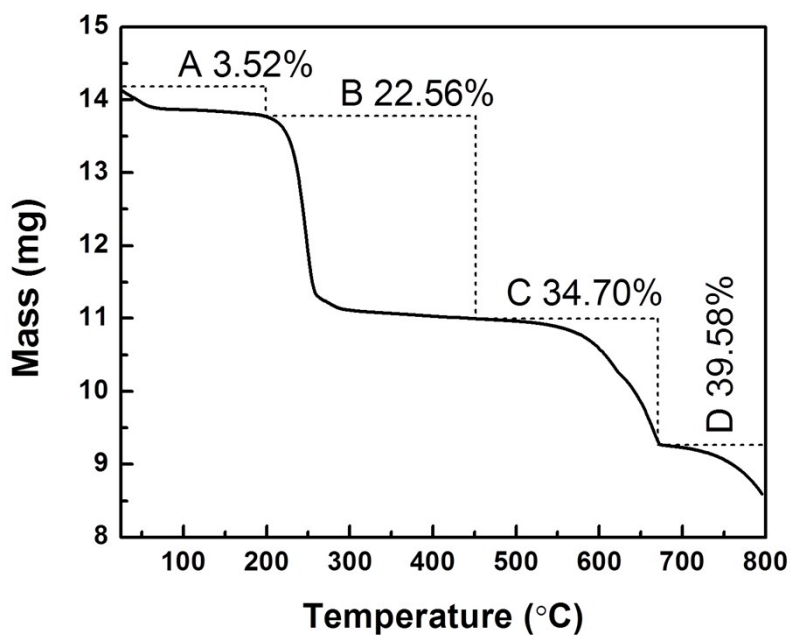
Fig. S5. The TG curve of the bulk SnS_2/n-propylamine composite.

The TG curve of bulk SnS_2/n-propylamine composite (Fig. S5) shows four steps of weight loss: (1) a 3.52 wt.% weight loss before 200 °C could be caused by the loss of adsorbed water and possibly free n-propylamine adsorbed on the surface of the bulk SnS_2/n-propylamine composite (step A); (2) Step B indicates a weight loss of 22.56 wt.% over 200-250 °C as a result of the decomposition of n-propylamine intercalated in the lamellar structure of bulk SnS_2; (3) Step C starts from 450 °C and presents a weight loss of 34.70 wt.% due to the transformation of SnS_2 into the SnS; (4) Step D goes up to 670.7 °C and displays the weight loss is about 39.58 wt.% because of the fractional decomposition and melting of SnS.
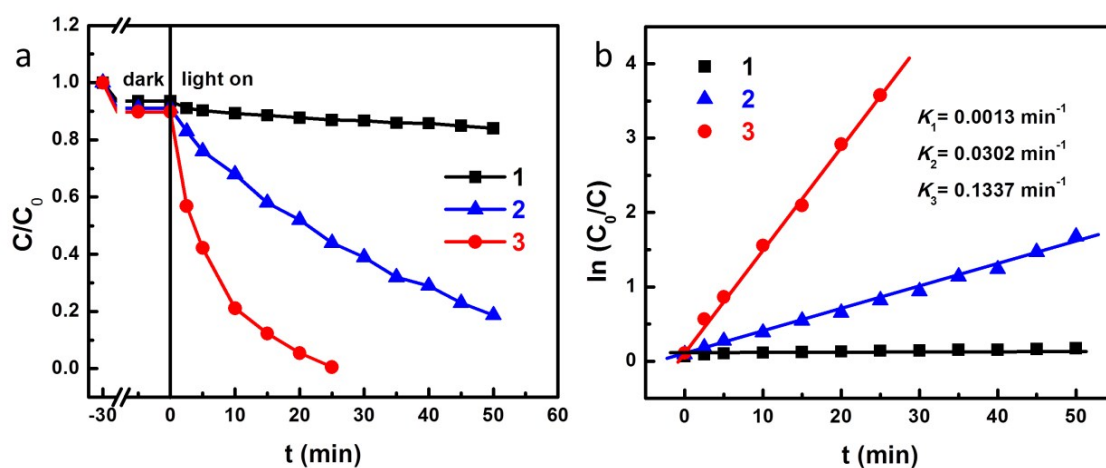
Fig. S6. (a) Photocatalytic degradation of methyl orange (MO) solution (10 mg/L, 100 mL) under visible light irradiation with a 300 W Xe lamp (Perfect Light, PLS-SEX300, a cutoff filter of 420 nm) with 10 mg as-prepared samples: (1) bulk SnS_2/n-propylamine, (2) bulk SnS_2, (3) few-layers SnS_2 nanosheets and (b) kinetic linear simulation curves.

Table S1 Summary of photocatalysis activities of Cr(VI) reduction using SnS_2 with various morphologies as photocatalysts in literatures.

Photocatalysts	Amount of catalyst	$C_{0,\ Cr(VI)}$	$(C_0-C_t)/C_0$ (t=60 min)	The calculated rate constant of per gram catalyst	light source (Xe lamp)	References
SnS_2 quantum dots	0.5 g	50 mg/L	0.58	0.0294 $min^{-1}g^{-1}$	300 W ($\lambda >$ 420 nm)	J.-R. Tu et al. / Materials Letters 185 (2016) 303
Ultrathin SnS_2 nanosheets	0.5 g	50 mg/L	0.48	0.0218 $min^{-1}g^{-1}$	350 W ($\lambda >$ 420 nm)	R. Wei et al. /Acta Materialia 66 (2014) 163
SnS_2 nanocrystals	0.3 g	50 mg/L	0.90	0.1313 $min^{-1}g^{-1}$	250W Xe lamp ($\lambda >$ 420 nm)	Y. C. Zhang et al. /Environ. Sci. Technol. 2011, 45, 9324
2D SnS_2 nanosheets	0.1 g	50 mg/L	0.53	0.1436 $min^{-1}g^{-1}$	300 W ($\lambda >$ 420 nm)	This work
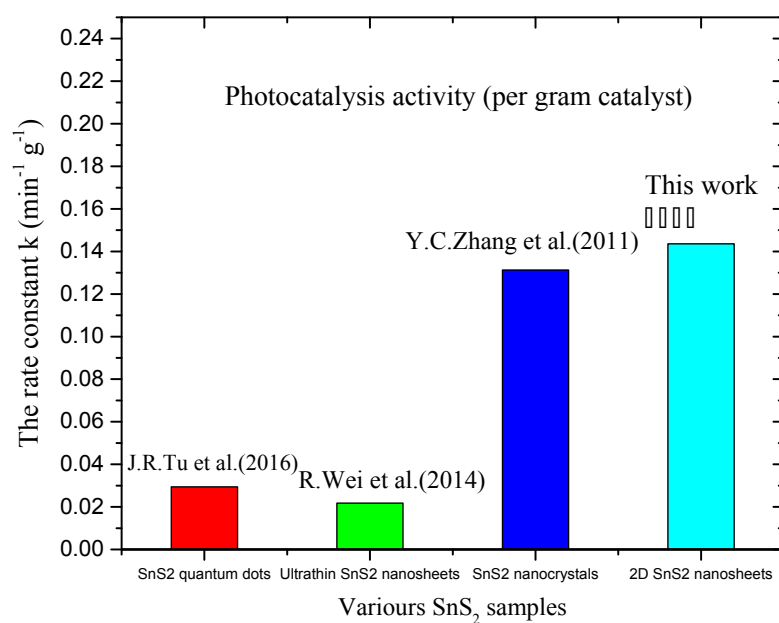
Fig. S7. The calculated rate constant of per gram catalyst (suppose all degradation curves follow a pseudo-first-order model) vs. SnS_2 with various morphology reported in literatures.

References:

[1] Y. C. Zhang et al. *Environ. Sci. Technol.* 2011, 45, 9324–9331

[2] J.-R. Tu et al. *Materials Letters* 2016, 185, 303–306

[3] R. Wei et al. *Acta Materialia* 2014, 66, 163–171