Electronic Supplementary Information (ESI)

MoS$_2$ nanodots decorated In$_2$S$_3$ nanoplates: a novel heterojunction with enhanced photoelectrochemical performance

Fangyang Liu,$^{a,b}$ Yan Jiang$^a$, Jia Yang$^a$, Mengmeng Hao$^a$, Zhengfu Tong$^a$, Liangxing Jiang$^a$ and Zhuangzhi Wu$^c$

$^a$School of Metallurgical Science and Engineering, Central South University, Changsha, 410083, China.

$^b$School of Photovoltaic and Renewable Energy Engineering, University of New South Wales, Sydney, NSW 2052, Australia.

$^c$School of Material Science and Engineering, Central South University, Changsha 410083 (China).

*Corresponding author. E-mail: zwu2012@csu.edu.cn;
Experimental Details

Synthesis of In$_2$S$_3$ nanoplates:
110.6 mg InCl$_3$ (99.9%, Aladdin), 24 mg S (AR, Sinopharm Chemical Reagent), and 10 mL oleylamine (C-18 content 80%-90%, Aladdin) were added into a three-neck flask (100 mL) connected to a Schlenk line (all chemicals were used as received). Then the temperature was raised up to around 110 °C with stirring, for degassing about an hour and purging with Ar for 3 times. All reaction conditions were kept inert to prevent the formation of the oxide. Then, the flask was heated to 215 °C and kept for 1 h. The final yellow precipitant was dispersed in approximately 20 mL toluene to form a stable ink solution.

Synthesis of MoS$_2$ nanodots:
163.1 mg Mo(acac)$_2$ [bis(acetylacetonato)dioxomolybdenum] (97%, Aladdin), 32 mg S (AR, Sinopharm Chemical Reagent) powder and 10 mL oleylamine (C-18 content 80%-90%, Aladdin) were added into a three-neck flask (100 mL) connected to a Schlenk line. Then the temperature was raised up to around 110°C with stirring, for degassing about an hour and purging with Ar for 3 times. All reaction conditions were kept inert to prevent the formation of the oxide. Then, the flask was heated to 300 °C and kept for 1 h. The final black precipitant was dispersed in approximately 20 mL toluene to form a stable ink solution.

Preparation for In$_2$S$_3$, MoS$_2$ and In$_2$S$_3$/MoS$_2$ nanocomposite films:
In$_2$S$_3$, MoS$_2$ and In$_2$S$_3$/MoS$_2$ nanocomposite were dissolved in toluene solution. To prepare films for optical and photoelectrochemical tests, 0.2-0.3 mL solution of the materials was coated on soda-lime glass (SLG) and FTO glass, respectively. Then the samples were kept in the draught cupboard to naturally evaporate toluene.

Materials characterizations
TEM images were obtained on a JEM-2100F field-emission transmission electron microscope with a working voltage of 200 kV. Raman spectra were obtained on a Jobin-YvonLabRamHR800-Horiba spectrometer with the wavelength of 532 nm. The optical absorption spectra were collected using a Hitachi U-4100 spectrophotometer. X-ray photoelectron spectroscopy (XPS) analysis was performed with the Spectrometer of Thermo-VG Scientific ESCALAB 250Xi. The photoelectrochemical characterization and EIS tests of the film were carried out in 0.2 M Na$_2$S+Na$_2$SO$_3$ solution in a Pyrex electrolytic cell. A 300 W xenon lamp was used as the light source, and the light intensity was kept at 40 mW/cm$^2$. Mott-Schottky plots were obtained in 0.1 M Na$_2$SO$_4$ solution without irradiation. The ICP test was performed using the Thermo Scientific iCAP 7000 series ICP Spectrometer.
Fig. S1 Additional TEM images of the obtained In$_2$S$_3$/MoS$_2$ composite.
Fig. S2 (A) TEM, (B) HR-TEM images and (C) EDS spectrum of MoS$_2$ nanodots.
Fig. S3 (A) TEM, (B) HR-TEM images and (C) EDS spectrum of In$_2$S$_3$ nanoplates.
Fig. S4 XRD patterns of (A) In$_2$S$_3$, (B) MoS$_2$ and (C) Oleylamine.
Fig. S5 Raman spectra of In$_2$S$_3$, MoS$_2$ and In$_2$S$_3$/MoS$_2$ nanocomposite.

Fig. S6 The XPS spectra of the In$_2$S$_3$/MoS$_2$ nanocomposite:
(A) Survey, (B) Mo 3d, (C) In 3d and (D) S 2p.
Fig. S7 The XPS spectra of MoS$_2$ nanodots: (A) Survey, (B) Mo 3d and (C) S 2p.
Fig. S8 The XPS spectra of In$_2$S$_3$ nanoplates: (A) Survey, (B) In 3d and (C) S 2p of In$_2$S$_3$. 
Fig. S9 Mott-Schottky plots of (A) In$_2$S$_3$ and (B) MoS$_2$ in 0.1 M Na$_2$SO$_4$ solution under the dark condition.

Fig. S10 Band gap values of In$_2$S$_3$, MoS$_2$ and In$_2$S$_3$/MoS$_2$ composite.