

# Ultrathin Bi<sub>2</sub>Se<sub>3</sub>/CdS composite for efficient photocatalytic hydrogen evolution via high interfacial charge separation and photothermal effect

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## Characterization

The phase and structure was tested by X-ray diffraction (XRD) (Bruker D8 Advance) at a scanning speed of 4 2 $\theta$  degree/min. The morphology of the samples was studied by transmission electron microscopy (TEM) and high-resolution TEM (HRTEM) analysis (FEI Tecnai G2 F20). The surface element and electron state were characterized by x-ray photoelectron spectroscopy(XPS) using Thermo ESCALAB 250x. The UV-Vis diffuse reflection spectroscopy (DRS) of the samples was detected by Shimadzu UV-4100 spectrophotometer. The transient photocurrent responses plots, electrochemical impedance spectroscopy(EIS) and Mott-Schottky plots are tested by a CHI760e electrochemical working station with 0.1 M Na<sub>2</sub>SO<sub>4</sub> solution, Pt as the counter electrode and Ag/AgCl as the reference electrode. The surface photovoltage (SPV) data was measured by PL-SPS/IPCE1000 surface photovoltage spectroscopy. A photoluminescence (PL) spectrum was provided by an FLS980 Series of fluorescence spectrometer.

## Photocatalytic test

The photocatalytic H<sub>2</sub> activity is measured by Perfectlight Labsolar IIAG with 8.4 g of Na<sub>2</sub>S and 3.15 g of Na<sub>2</sub>SO<sub>3</sub> as sacrificial reagents and 300W Xe lamp with a 420 nm cut-off filter as an irradiation source. Firstly, 50 mg of the sample, 100 ml of deionized

water and the sacrificial reagents were added into 300 ml of quartz photoreactor and ultrasonicated about 30 min to form a uniform suspension. Then, the reactor was evacuated for 40 min after connecting with the closed gas circulation system and the cooling water system about 4°. Finally, after opening the light source and keeping for 1 h. the photocatalytic H<sub>2</sub> rate was tested by chromatography (Beifen 3420A, TCD).

### Photothermal tests

The infrared photothermal photos are measured by Testo Thermography 865. Amounts of 0.1g of the samples were putted on a white paper. A 300W Xe lamp with a filter ( $\lambda \geq 420$  nm) was used as an irradiation source to treat the samples. Then Testo 865 recorded the temperature of the samples and the thermal images.

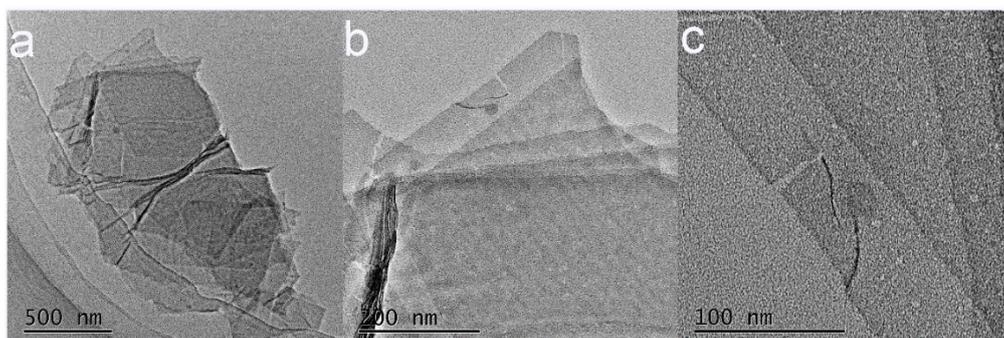


Fig. S1 (a, b, c) TEM images of Bi<sub>2</sub>Se<sub>3</sub> nanosheets under different magnifications

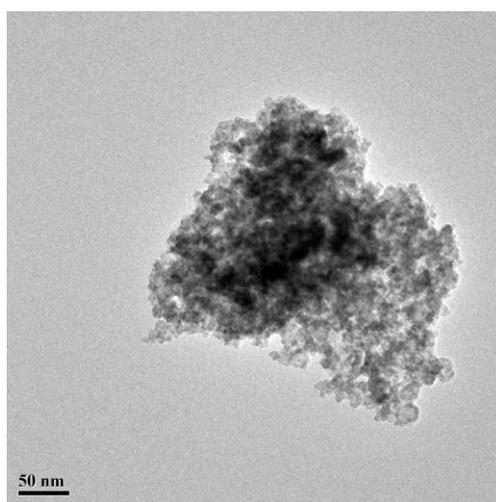


Fig. S2 TEM images of pure CdS nanoparticles