Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.


# Supporting Information for

## Cu doped $SnS_2$ nanosheets with superior visible-light photocatalytic $CO_2$ reduction performance

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## 1 Experimental

### *1.1 Characterization*

A Rigaku X-ray diffractometer (Japan) with Cu Ka radiation was used to test X-ray diffraction (XRD) patterns. Morphological observations were conducted on a JEOL JSM-7500 field emission scanning electron microscope (FESEM, Japan) and a JEOL JEM-2100F transmission electron microscope (TEM, Japan). UV–vis diffuse reflectance spectra were analyzed on a Shimadzu UV-2600 UV–vis spectrophotometer (Japan). The Brunauer–Emmett–Teller (BET) specific surface area ($S_{BET}$) and $CO_2$ adsorption of the powders were measured on a Micromeritics ASAP 3020 with nitrogen and carbon dioxide adsorption apparatus (USA), respectively. X-ray photoelectron spectroscopy (XPS) was performed on a Thermo ESCALA 250 XPS spectrometer system with Al Ka (1486.6 eV) radiation. The binding energies were referenced to the C1s peak at 284.8 eV from adventitious carbon. Time-resolved photoluminescence (TRPL) were obtained using a FLS920 fluorescence lifetime spectrophotometer (Edinburgh Instruments, UK) with 340 nm excitation. A Nicolet is50 spectrometer (Thermo fisher, US) was used to record the Fourier transform infrared (FTIR) and in situ FTIR spectra. Electrochemical measurements were implemented on an electrochemical analyzer (CHI660C, China) in a standard three-electrode system with the as-prepared samples as the working electrode, a Pt wire as the counter electrode, and Ag/AgCl (saturated KCl) as a reference electrode. A 420 nm LED light was utilized as the light source. A $Na_2SO_4$ (0.5 M) aqueous solution was used as the electrolyte. The working electrodes were prepared as follows: 0.05 g of photocatalyst was ground with

0.5 mL of ethanol to make a slurry. The slurry was then coated onto a 2 x 1.2 cm F-doped $SnO_2$-coated glass (FTO glass) electrode by the doctor blade technique. Next, these electrodes were dried in an oven at 80 °C for 30 min. All investigated electrodes have a similar film thickness of 10–11 μm.

*1.2 Photocatalytic performance*

The $CO_2$ photoreduction over photocatalysts in the presence of $H_2O$ was conducted in a photoreactor similar to that reported in our previous study [1]. The photocatalytic $CO_2$ reduction was carried out in a 200 mL homemade Pyrex reactor with two openings at ambient temperature and atmospheric pressure. Particularly, 50 mg of sample was uniformly dispersed in 10 mL of deionized water by ultrasonication, preheated to 80 °C, and then maintained for 2 h to evaporate water and deposited on the bottom of the reactor, forming a smooth and thin film. The two openings of the reactor were sealed with rubber stoppers, and $N_2$ was blown through the reactor to ensure anaerobic conditions of the reaction system before light irradiation. $CO_2$ and $H_2O$ sources were introduced by reaction of $NaHCO_3$ (84 mg, added into the reactor before seal) and $H_2SO_4$ aqueous solution (0.3 mL, 2 M, syringed into the reactor after $N_2$ blowing). A 300 W Xe light with a cutoff filter ($\lambda \geq 420$ nm) was positioned 20 cm vertically above the photocatalytic reactor as a visible light source. The gas product (1 mL, taken from the reactor) was analyzed using a gas chromatograph (GC-2014C, Shimadzu) equipped with a flame ionized detector (FID) and a methanizer. The reduced products in this experiment were calibrated with a standard gas mixture and determined from the retention time.

## 2 Results and discussion

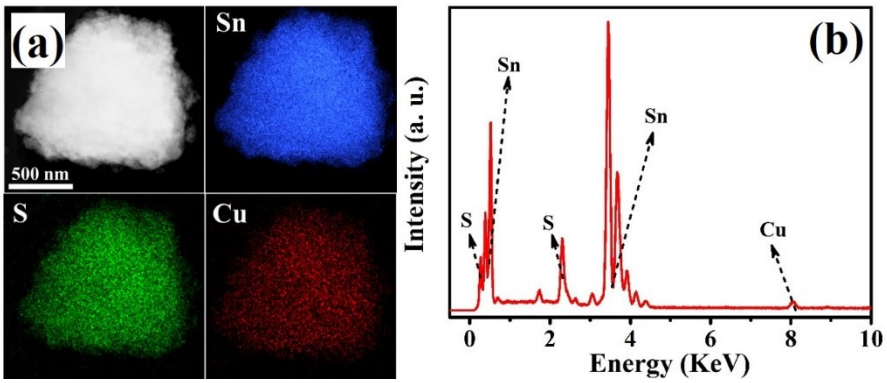


Figure S1. TEM mapping and the corresponding EDS spectrum of sample SC0.5.

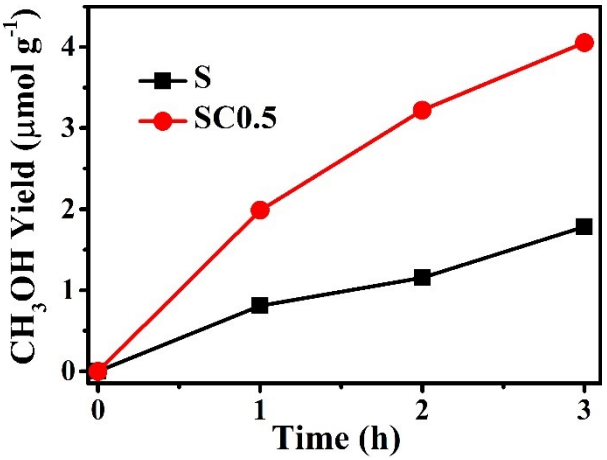


Figure S2. Time courses of photocatalytic CH3OH production over the prepared S and SC0.5 samples under visible light irradiation (λ > 420 nm).

[1] T. Di, B. Zhu, B. Cheng, J. Yu, J. Xu, J. Catal. 352 (2017) 532–541.