

# Supporting information

## Electrostatic Self-Assembly of CdS Quantum Dots with Co<sub>9</sub>S<sub>8</sub> Hollow Nanotubes for Enhanced Visible Light Photocatalytic H<sub>2</sub> Production

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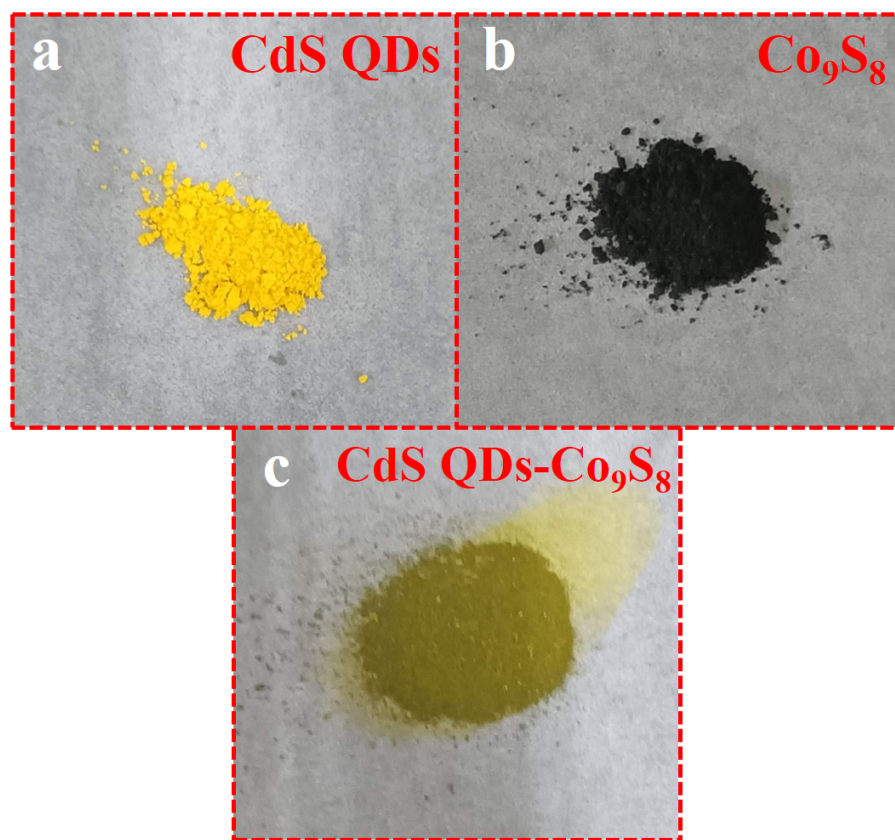
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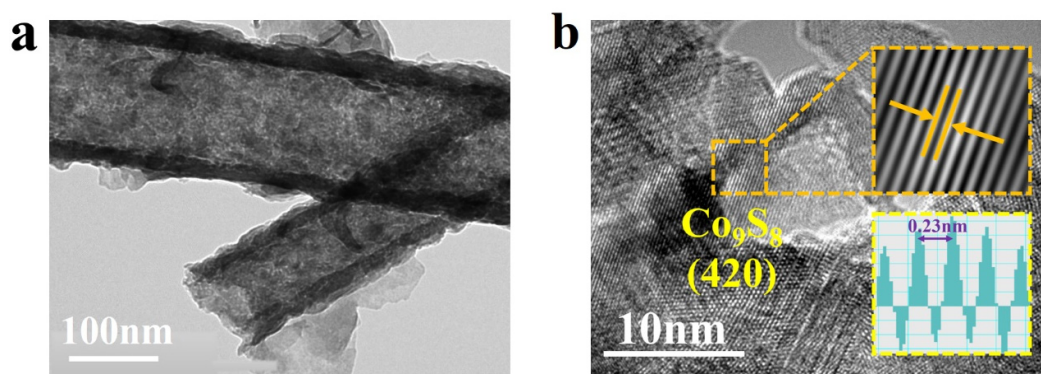
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## 1.1 Characterization methods

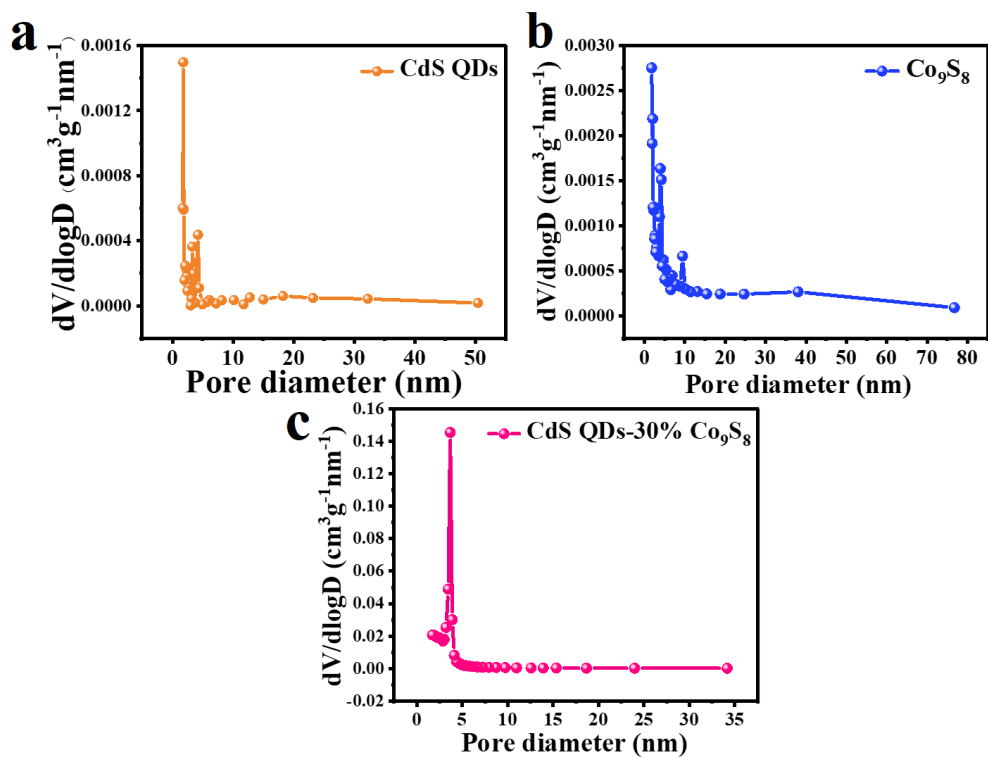
The crystal phase structure and composition of the catalyst were determined by X-ray powder diffraction (Bruker D8 Advance, Billerica, MA, USA). Scanning electron microscope (FESEM Zeiss Sigma 500, Oberkochen, Battenwerburg, Germany) and transmission electron microscope (TEM, JEM-2100F, Jeol, Akishima, Tokyo) were used to analyze the morphology and microstructure of the composite photocatalyst. The elemental composition of the composite photocatalyst was measured by inductively coupled plasma emission spectrometer (ICP-OES). The composition and valence of the composite photocatalyst were analyzed by Thermo Fisher K-Alpha Plus (X-ray photoelectron spectroscopy). The UV-visible diffuse reflectance spectrometer (DRS, Shimadzu UV-2600, Kyoto, Japan) was utilized to test the optical response of the catalyst. Photoluminescence (PL) spectra were obtained using a spectrofluorometer (FLS 980, Edinburgh Instruments Ltd., Edinburgh, UK) with an excitation wavelength of 500 nm. The Zeta potential ( $\zeta$ ) in deionized water was determined by dynamic light scattering analysis (Zetasizer Nano ZS90, Malvern, UK) at room temperature. Furthermore, all the electrochemical measurements of the photocurrent and the electrochemical impedance spectra (EIS) were carried out in the three-electrode cell, in which Ag/AgCl was used as a reference electrode, a Pt wire was used as a counter electrode, and an indium in oxide (ITO) conductive glass was used with the samples as a working electrode in 0.1 M Na<sub>2</sub>SO<sub>4</sub> electrolyte (pH=7.56), all measurements were carried out on CH instruments CHI-660E electrochemical workstation (Shanghai Chenhua CHI-660E, Shanghai, China). The specific surface area and pore size of the composite photocatalyst were determined by nitrogen physical adsorption desorption (ASAP2020).



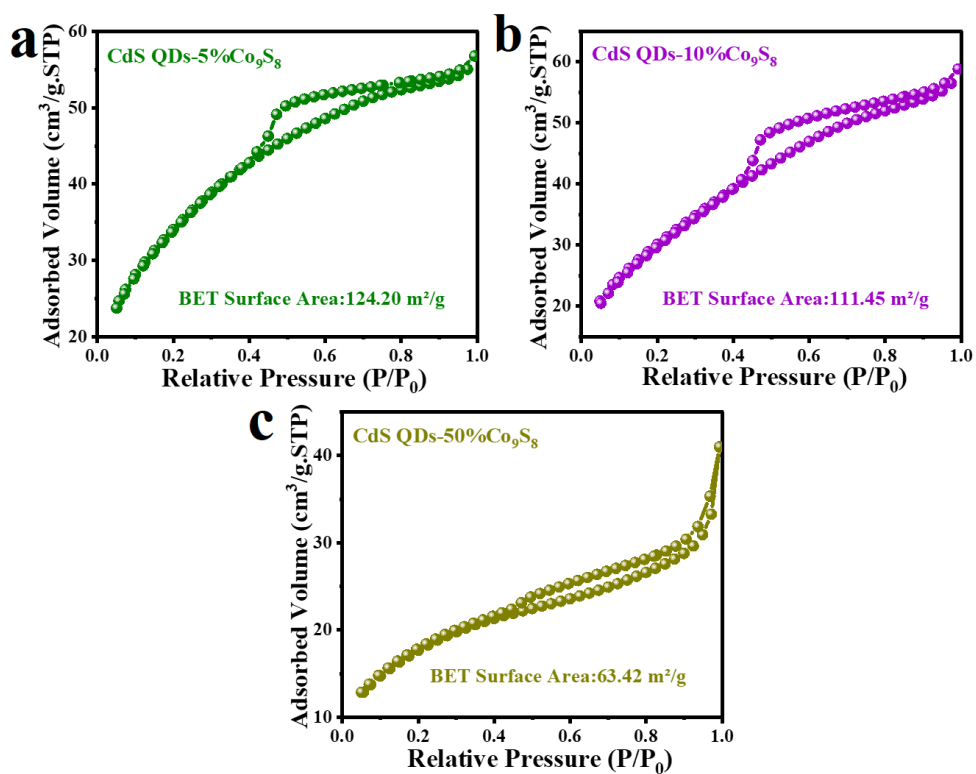
**Figure S1.** Schematic representation of the samples for (a) CdS QDs, (b) Co<sub>9</sub>S<sub>8</sub> and (c) CdS QDs-Co<sub>9</sub>S<sub>8</sub>.



**Figure S2.** (a) TEM image and (b) HRTEM image of Co<sub>9</sub>S<sub>8</sub>.



**Figure S3.** Pore size distributions of (a) CdS QDs, (b) Co<sub>9</sub>S<sub>8</sub> and (c) CdS QDs-30%Co<sub>9</sub>S<sub>8</sub>.



**Figure S4.** Nitrogen adsorption–desorption isotherms of (a) CdS QDs-5%Co<sub>9</sub>S<sub>8</sub>, (b) CdS QDs-10%Co<sub>9</sub>S<sub>8</sub> and (c) CdS QDs-50%Co<sub>9</sub>S<sub>8</sub>.

**Table S1**

Summary of the ICP analysis results of the samples of CdS QDs-5%Co<sub>9</sub>S<sub>8</sub>, CdS QDs-10%Co<sub>9</sub>S<sub>8</sub>, CdS QDs-30%Co<sub>9</sub>S<sub>8</sub> and CdS QDs-50%Co<sub>9</sub>S<sub>8</sub>.

Samples	Cd (ppm)	Co (ppm)	S (ppm)
CdS QDs-5%Co <sub>9</sub> S <sub>8</sub>	60.5	1.4	13.0
CdS QDs-10%Co <sub>9</sub> S <sub>8</sub>	58.6	2.9	13.7
CdS QDs-30%Co <sub>9</sub> S <sub>8</sub>	54.6	8.2	15.8
CdS QDs-50%Co <sub>9</sub> S <sub>8</sub>	41.0	15.7	12.8

**Table S2**

The average pore size distributions of the prepared photocatalysts.

Photocatalysts	CdS QDs	Co <sub>9</sub> S <sub>8</sub>	CdS QDs-30% Co <sub>9</sub> S <sub>8</sub>
Average pore size (nm)	15.58	15.15	3.62