Supporting Information

A novel bicomponent Co_3S_4/Co cocatalyst on CdS accelerating charge separation for highly efficient photocatalytic hydrogen evolution

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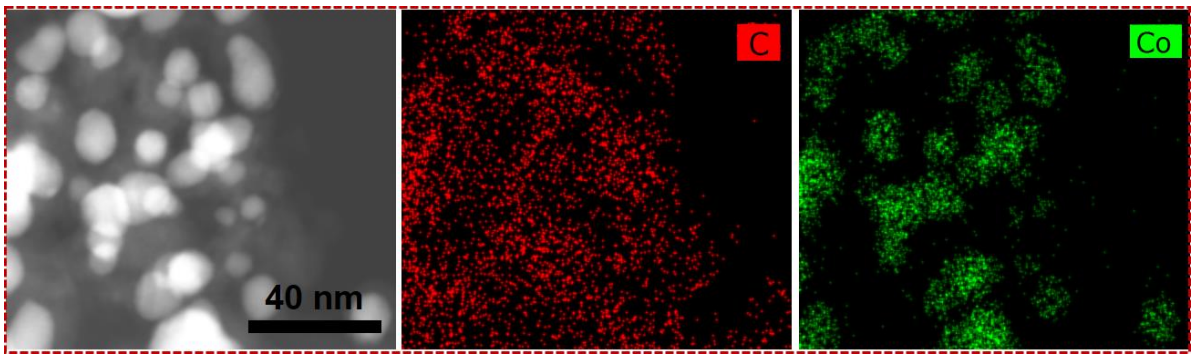

Fig. S1 HAADF-STEM images and the corresponding elemental mapping images of Co@C.

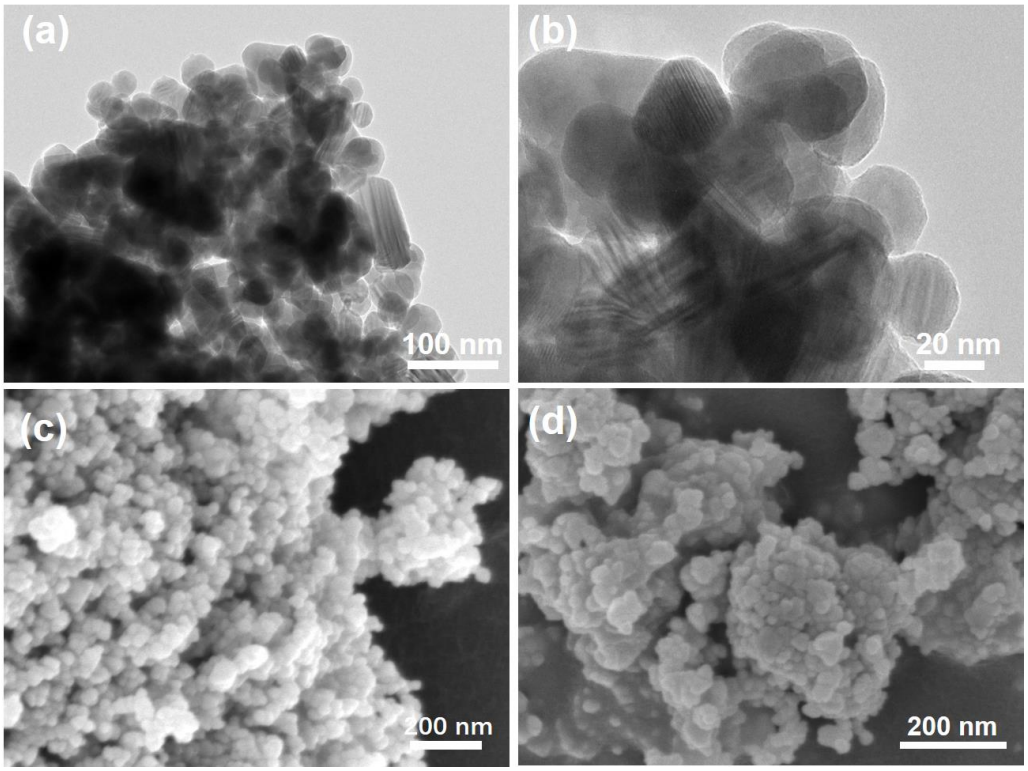

Fig. S2 (a, b) TEM images of CdS. SEM images of (c) CdS and (d) SCS-5.

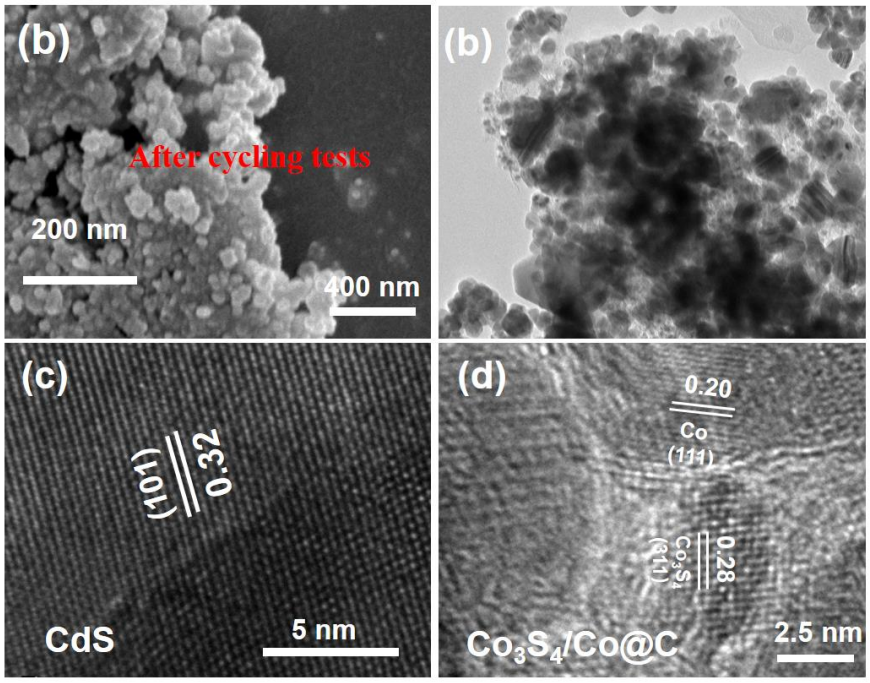

Fig. S3 (a) SEM, (b) TEM, and (c, d) HR-TEM images of SCS5 after cycling tests.

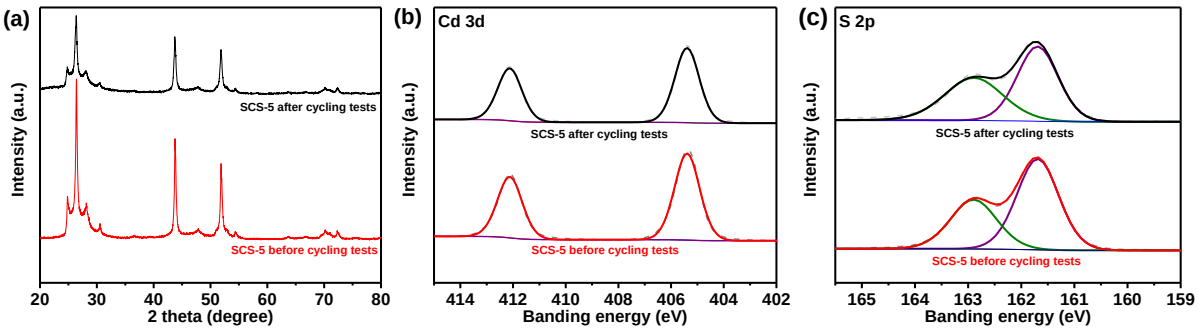

Fig. S4 (a) XRD patterns, (b) Cd 3*d* XPS spectra, and (c) S 2*p* XPS spectra of SCS5 sample before and after cycling tests.

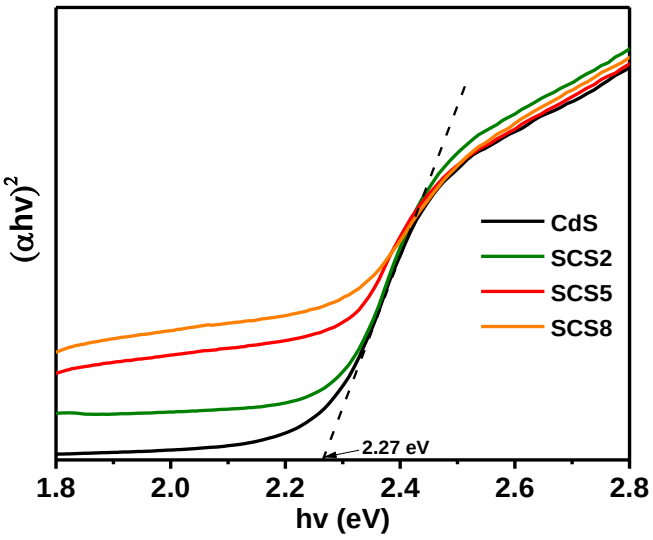

Fig. S5 Tauc plots of the samples.

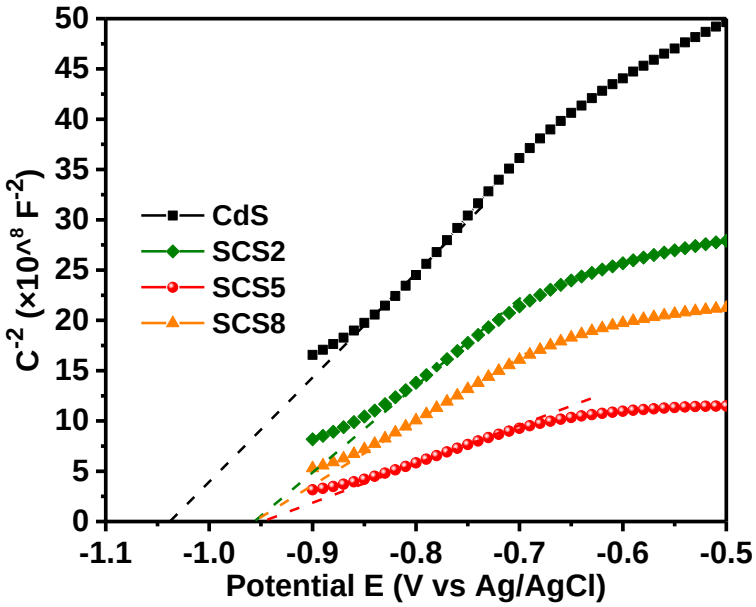

Fig. S6 Mott–Schottky plots of CdS, SCS2, SCS5 and SCS8.

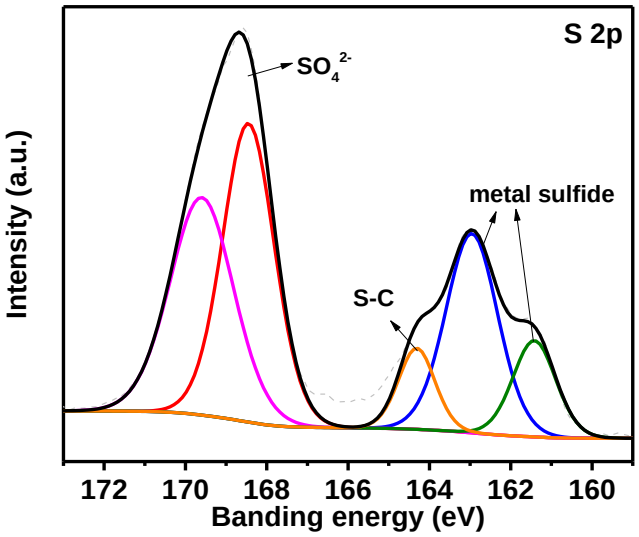

Fig. S7 S 2*p* XPS spectrum of Co_3S_4/Co@C.

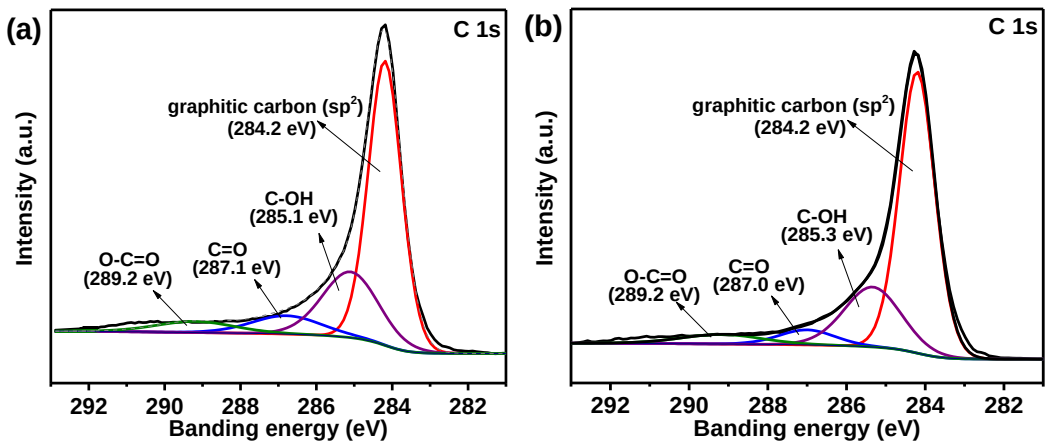

Fig. S8 C 1*s* XPS spectra of (a) Co@C and (b) Co_3S_4/Co@C.

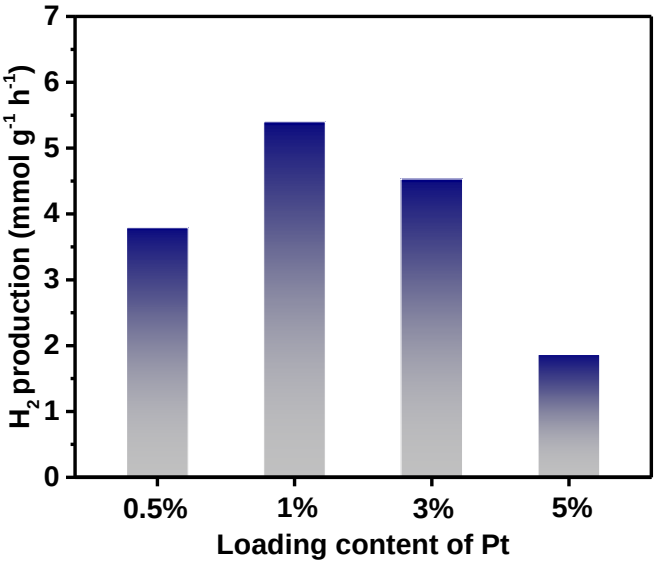

Fig. S9 Photocatalytic H_2 evolution of Pt-CdS with different Pt loadings.

Different amounts of H_2PtCl_6 aqueous solution were used to prepare the Pt-CdS with different loading content of Pt. The result shows that the most optimum loading content of Pt is 1%. The optimal sample Pt-CdS is used to compare with SCS5 for photocatalytic H_2 evolution.

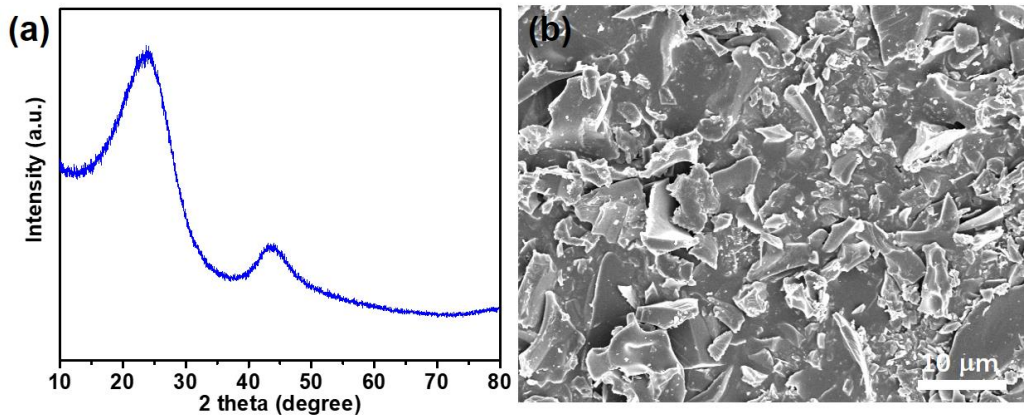

Fig. S10 (a) XRD pattern and (b) SEM image of C.

Fig. S10a is the XRD pattern of C cocatalyst without metallic Co. Compared with those of Co@C and Co_3S_4/Co cocatalysts, the SEM image in Fig. S10b shows the different structural morphology of C cocatalyst. The C-CdS photocatalyst was prepared using this C cocatalyst as precursor.

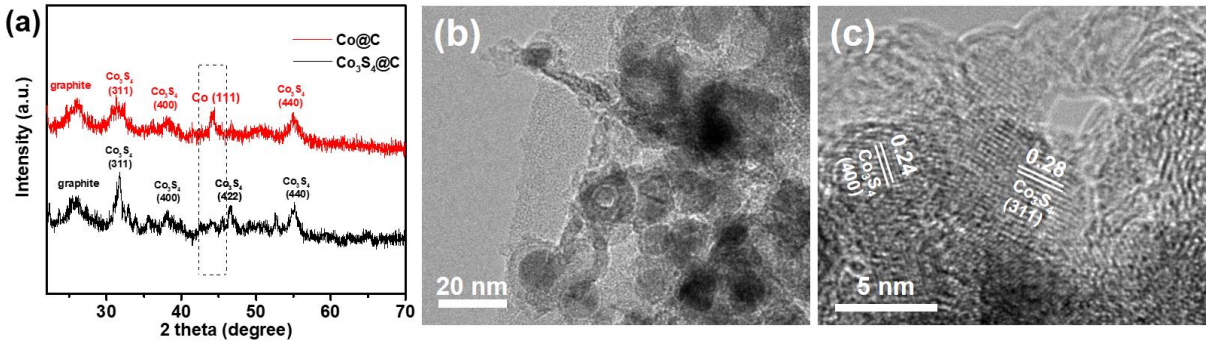

Fig. S11 (a) XRD pattern of Co_3S_4@C and Co@C, (b) TEM and HR-TEM of Co_3S_4@C.

Co_3S_4@C was also prepared by a method similar to Co@C, but the hydrothermal time was extended to 48 h when the metal Co was almost vulcanized into Co_3S_4. Fig. S11a is the XRD pattern of Co_3S_4@C and Co@C. Compared with the XRD pattern Co@C, the Co_3S_4@C shows no XRD peak of Co (111), which indicates that the metal Co is was almost vulcanized into Co_3S_4. Furthermore, the TEM images in Fig. S11b shows that the lattice spacing values of 0.24 and 0.28 nm are corresponded to (400) facet and (311) facet of Co_3S_4, further confirming that the existence of Co_3S_4 in Co_3S_4@C. The Co_3S_4-CdS photocatalyst was prepared using this Co_3S_4@C cocatalyst as precursor.

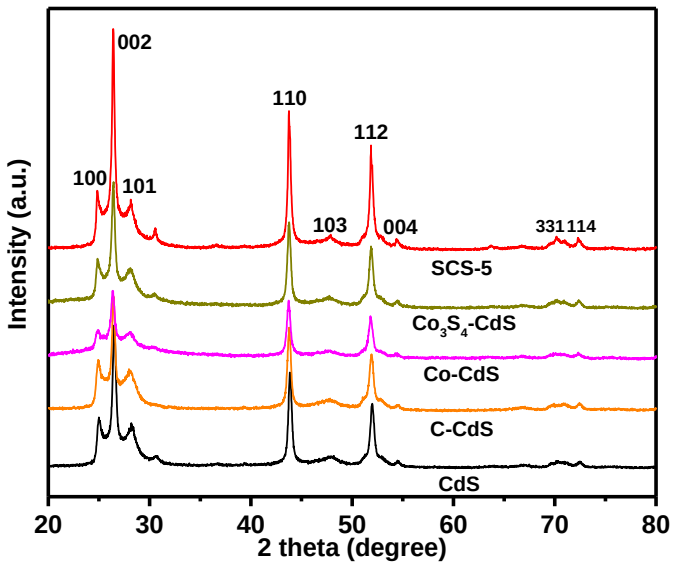

Fig. S12 XRD patterns of different samples.

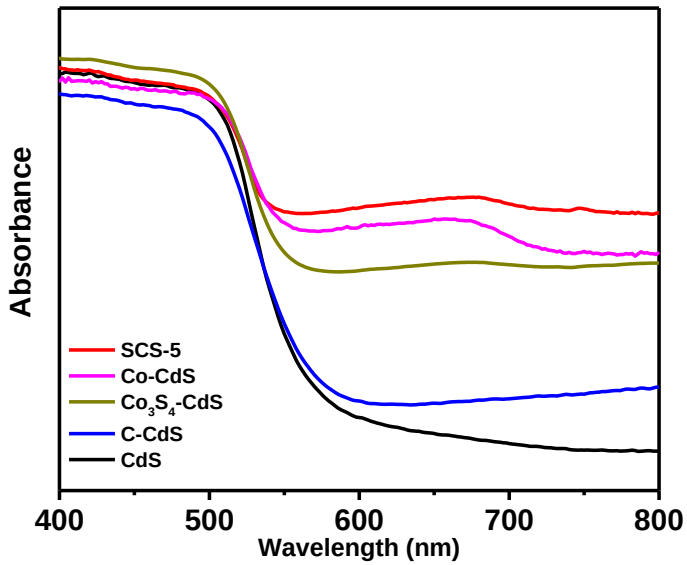

Fig. S13 UV–vis diffuse reflectance spectra of different samples.

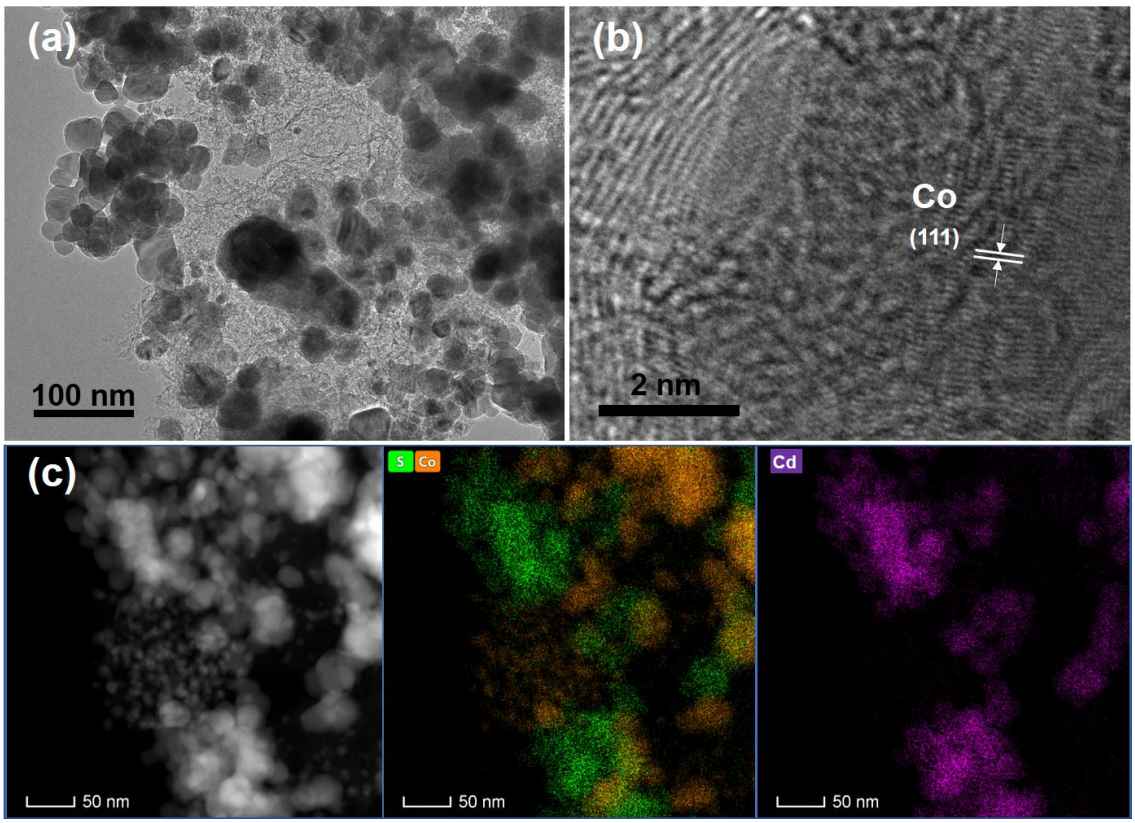

Fig. S14 (a) TEM, (b) HR-TEM, (c) HAADF-STEM images and EDX element mapping of mechanically mixed (Co_3S_4/Co)-CdS.

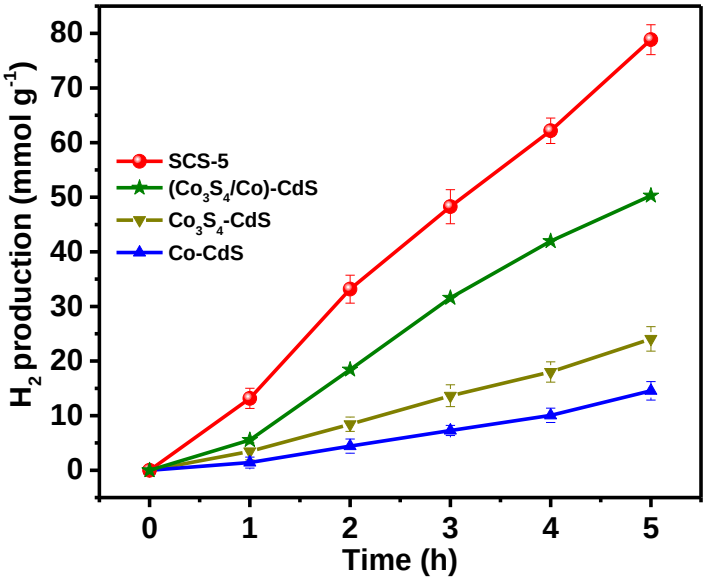

Fig. S15 Comparison of photocatalytic H_2 evolution of Co-CdS, Co_3S_4-CdS, SCS5 and the mechanically mixed (Co_3S_4/Co)-CdS.

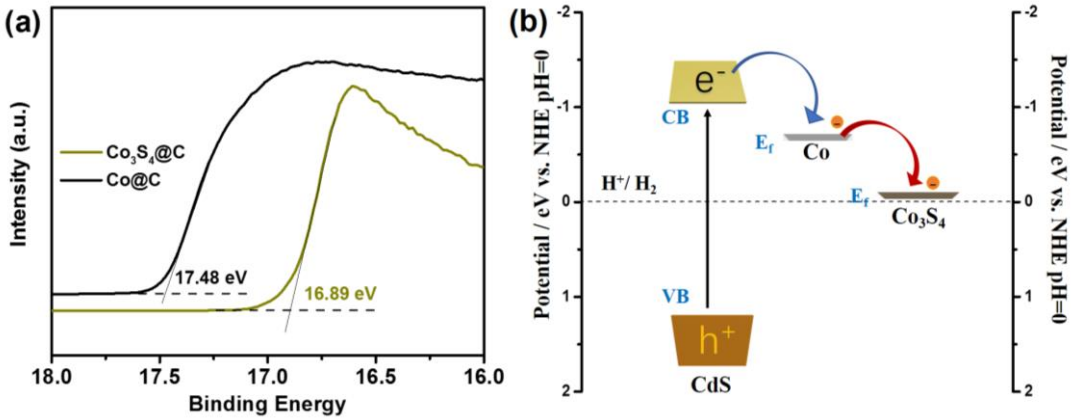

Fig. S16 (a) UPS spectra of Co@C and Co_3S_4@C. (b) Band gap structures of CdS, Co and Co_3S_4.

The work function (ϕ) was determined by the difference between the photon energy of the Helium I light source at 21.2 eV and the binding energy of the secondary cutoff edge. Hence, the work function of Co@C and Co_3S_4@C are 3.72 and 4.31 eV, respectively.

Table S1 The performance comparison of this work with other similar composites

Photocatalyst	Light source	Reactant solution	Activity (mmol h^{-1} g^{-1})	Ref. (year)
Co_3S_4/Co-CdS	λ > 420 nm (300 W Xe)	0.35 M Na_2S and 0.25 M Na_2SO_3	14.62	Our work
CdS-Co_3O_4	λ > 420 nm (350 W Xe)	10 vol % of lactic acid	3.014	1 (2013)
Co-Pi-CdS	λ > 420 nm (300 W Xe)	10 vol % of lactic acid	13.3	2 (2016)
CdS/CoO_x	λ > 420 nm (350 W Xe)	0.35 M Na_2S and 0.25 M Na_2SO_3	3.50	3 (2018)
CdS-Co_9S_8	AM 1.5 (300 W Xe)	Na_2S and Na_2SO_3	1.06	4 (2017)
a-$CoMoS_x$/CdS	λ > 420 nm (300 W Xe)	Lactic acid	3.57	5 (2018)
Co Single Atomic Cocatalysts-CdS	λ > 420 nm (300 W Xe)	1.0 M $(NH_4)_2SO_3$	7.27	6 (2017)
$Co_xMo_{1-x}S_2$/CdS	λ > 420 nm (300 W Xe)	10 vol % of lactic acid	14.10	7 (2018)
MoS_2/G-CdS	λ > 400 nm (300 W Xe)	0.35 M Na_2S and Na_2SO_3	6.00	8 (2014)
Co_2P-CdS	λ > 400 nm (300 W Xe)	10 vol % of lactic acid	6.06	9 (2018)
CdS/Co_9S_8	λ > 420 nm (Xe)	0.35 M Na_2S and 0.25 M Na_2SO_3	5.15	10 (2018)

References

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