Electronic Supplementary Information for:

A Homojunction-Heterojunction-Homojunction scaffold boosts photocatalytic H_2 evolution over $Cd_{0.5}Zn_{0.5}S$/CoO hybrids

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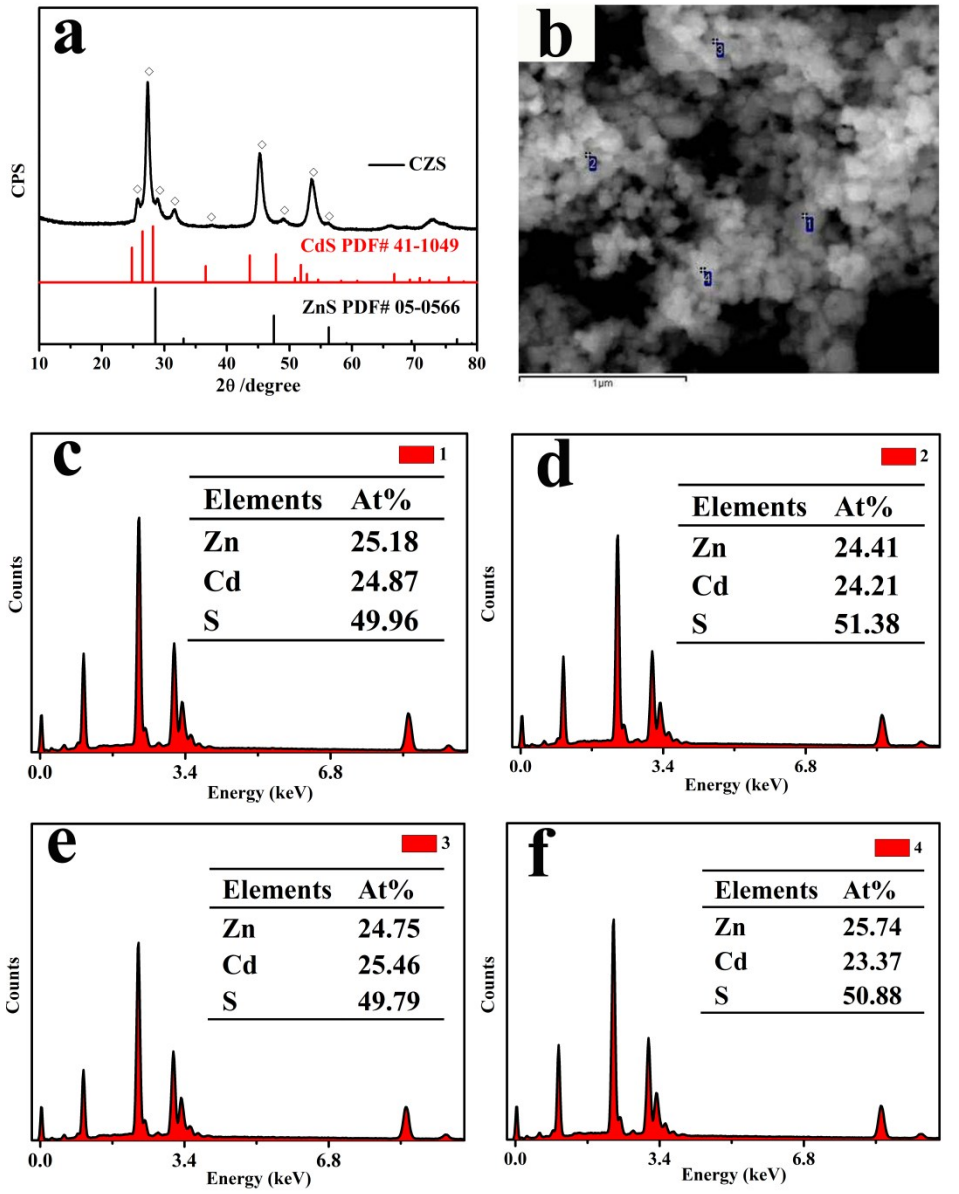

Figure S1. XRD pattern of CZS solid solution. The vertical lines at the top and bottom indicate CdS wurtzite structure (PDF #41-1049) and ZnS zinc blende structure (PDF #05-0566).

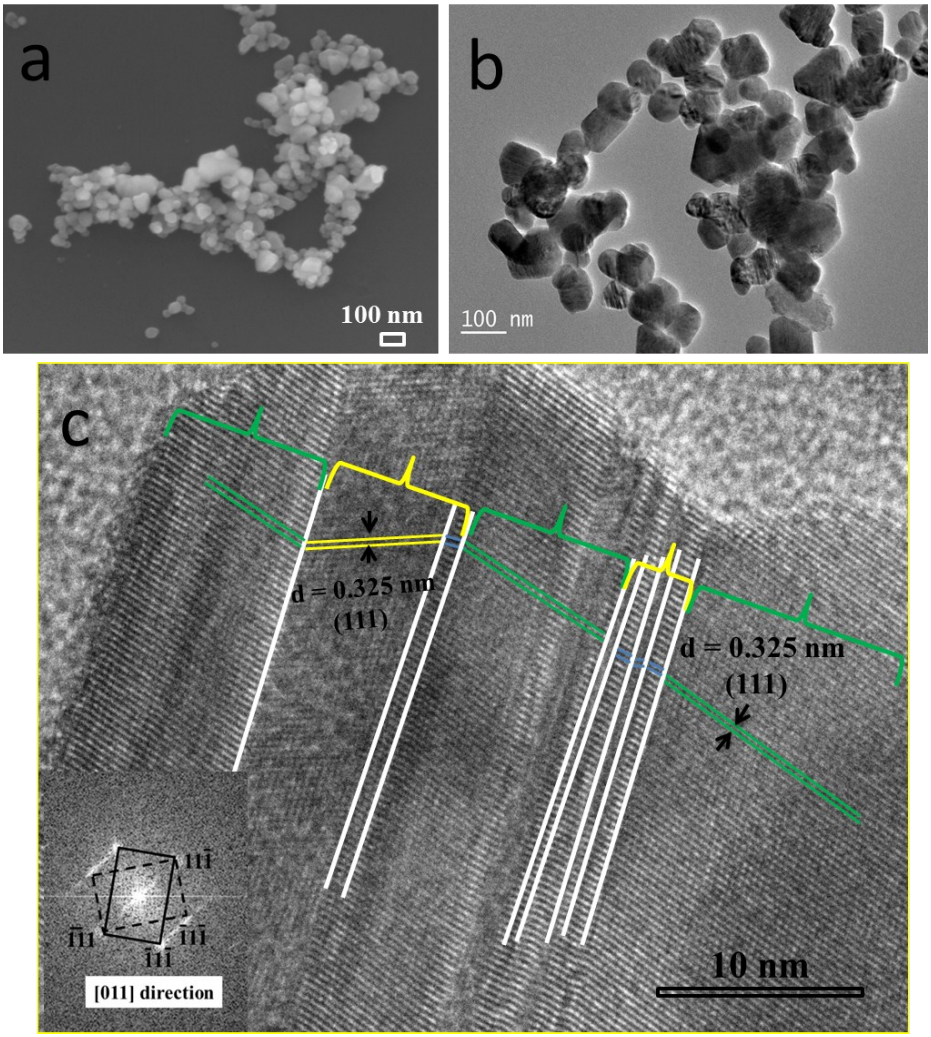

Figure S2. The SEM (a), TEM (b), HRTEM (c) and SAED (inset c) images of CZS.

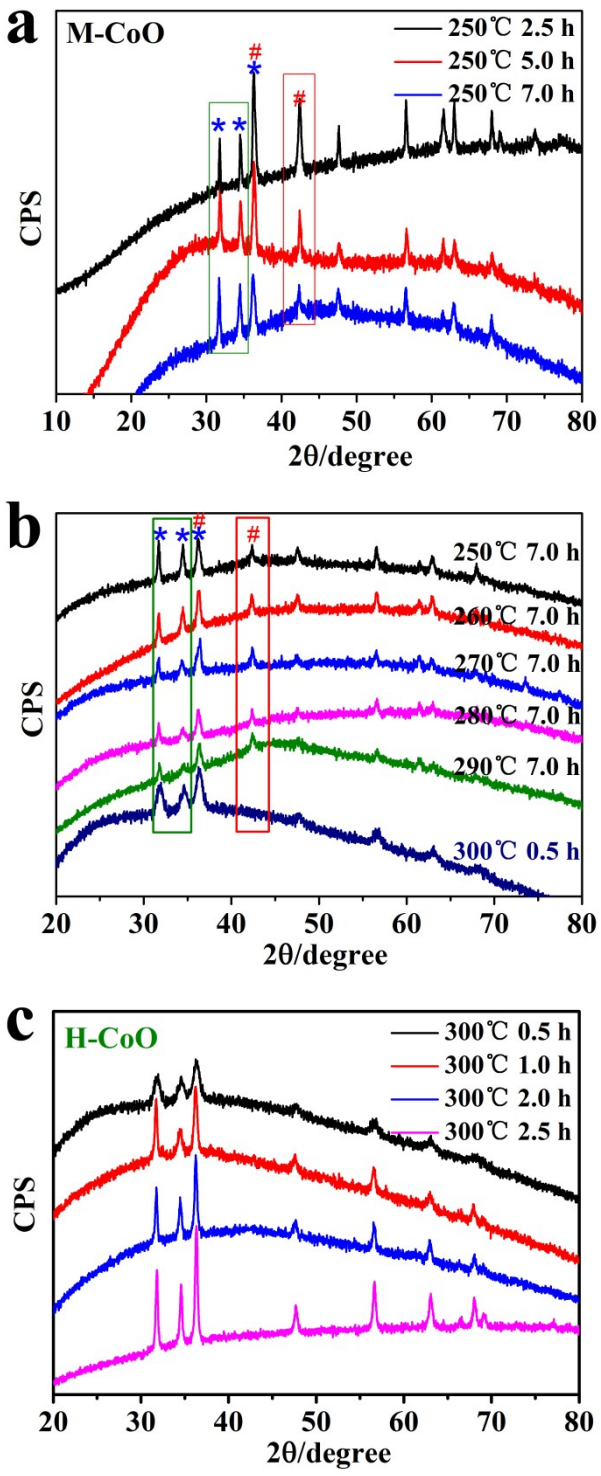

Figure S3. XRD patterns of M-CoO at 250℃ for 2.5 h, 5 h,7 h (a), as prepared CoO at 250-290℃for 7 h and at 300℃ for 0.5 h (b), H-CoO at 300℃ for 0.5 h,1.0 h,2.0 h,2.5 h (c).

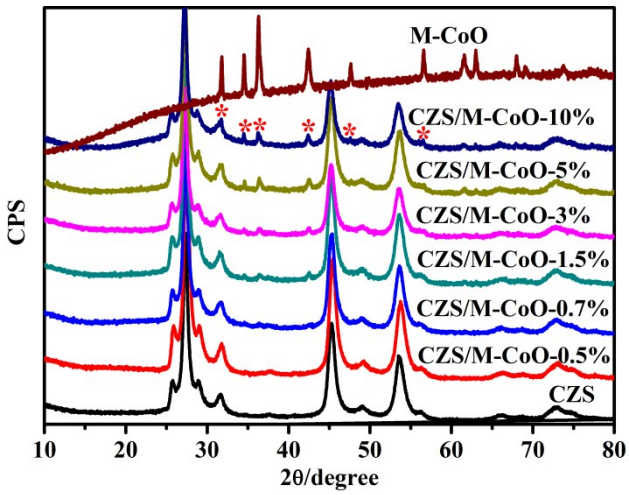

Figure S4. XRD patterns of CZS/M-CoO-x nanocomposites with variable M-CoO contents.

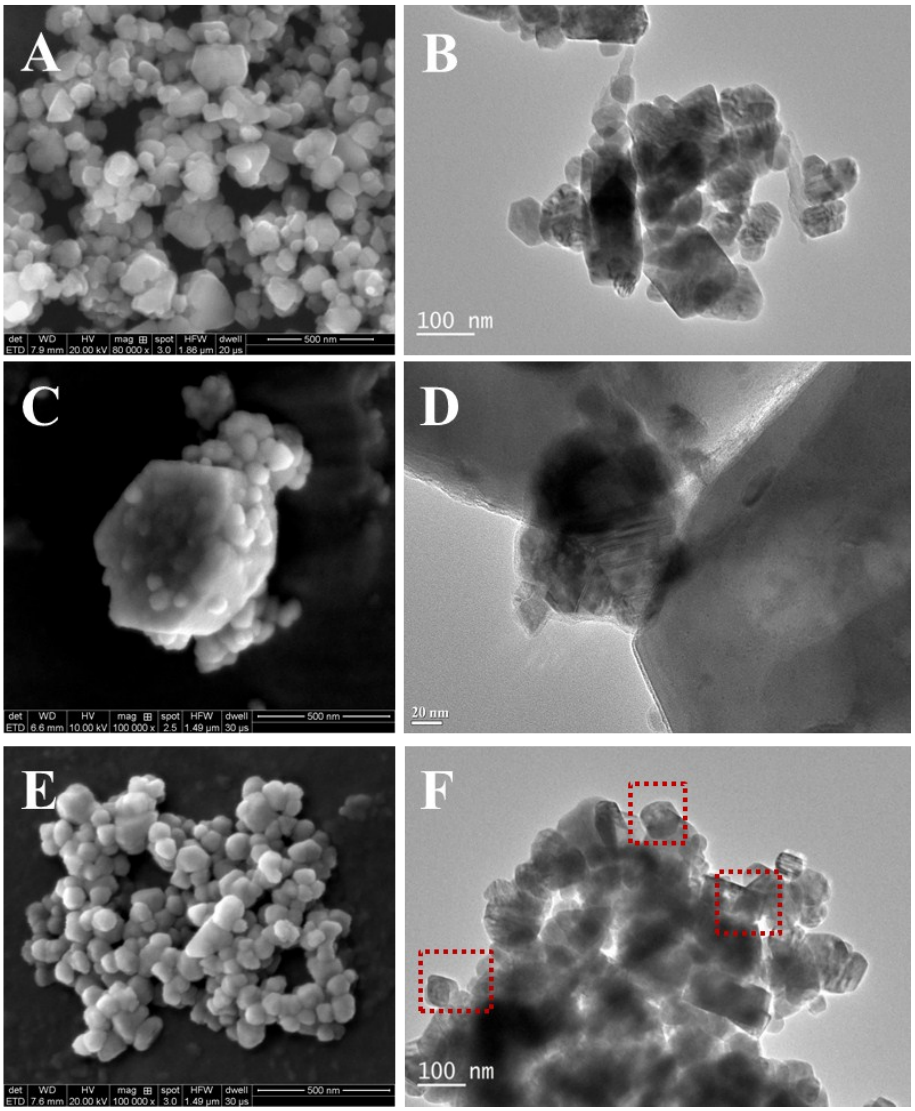

Figure S5. SEM and TEM images of CZS/C-CoO (A, B), CZS/H-CoO(C, D), CZS/M-CoO (E, F), respectively.

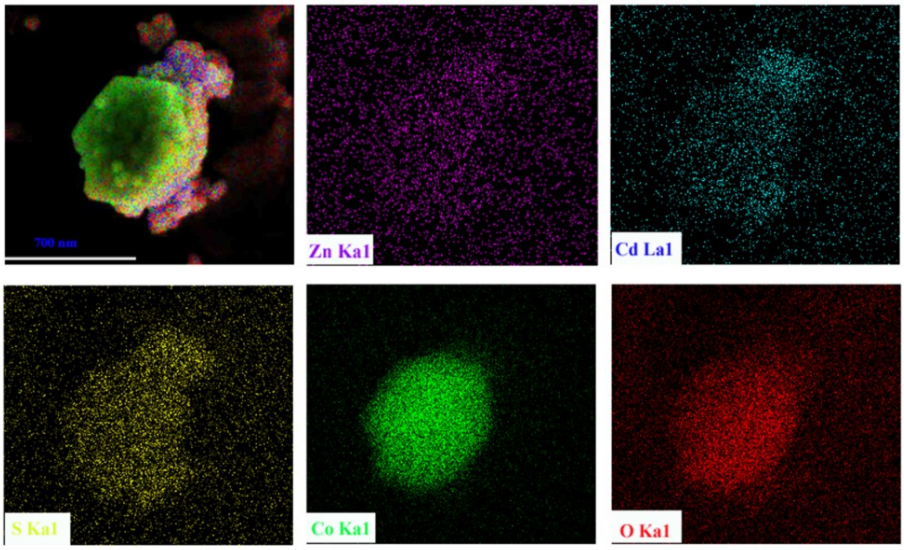

Figure S6. EDS mapping of CZS/H-CoO-10% nanocomposite.

Table S1. Comparisons of H_2 production rate of recently reported photocatalysts

Photocatalysts	**Light Source**	**Scavenger**	**H_2 rate (mmol/h)**	**Ref.**
10 mg Twin CZS/M-CoO	300 W Xe lamp (>420 nm)	0.35 M Na_2S/0.25 M Na_2SO_3	1.78	This work
1 mg $Zn_{0.5}Cd_{0.5}S/PdP_{\sim0.33}S_{\sim1.67}$	300 W Xe lamp (>420 nm)	0.75 M ascorbic acid	0.372	[29]
		0.7 M Na_2S/0.5 M Na_2SO_3	0.246	
30 mg $Zn_{0.5}Cd_{0.5}S$/Pt	500 W Xe lamp (>400 nm)	0.1 M Na_2S/0.1 M Na_2SO_3	0.114	[26]
5 mg $Zn_xCd_{1-x}S$/CdS(2 at%)	300 W Xe lamp (>420 nm)	0.35 M Na_2S/0.25 M Na_2SO_3	0.667	[61]
50 mg $Zn_{0.5}Cd_{0.5}S/Ni_{0.1}Co_{0.9}P$-4mol%	300 W Xe lamp (>400 nm)	0.35 M Na_2S/0.25 M Na_2SO_3	0.976	[62
20 mg $Zn_{0.5}Cd_{0.5}S@MoS_2$(10%)	300 W Xe lamp (>420 nm)	10 vol% Lactic acid	0.804	[63]
50 mg $NiCo_2O_4/Zn_{0.1}Cd_{0.9}S$	300 W Xe lamp (>400 nm)	0.35 M Na_2S/0.25 M Na_2SO_3	1.72	[57]
10 mg $NiCo_2O_4$/CdS	5 W LED	10 vol% Lactic acid	0.1098	[58]
25 mg MoO_2-C/CdS	300 W Xe lamp (>420 nm)	10 vol% Lactic acid	0.402	[59]
50 mg CdS/CoO	300 W Xe lamp (>420 nm)	20 vol% Lactic acid	0.0645	[60]
100 mg g-C_3N_4/CoO/Pt	300 W Xe lamp (>400 nm)	10 vol% TEOA	0.0651	[42]
40 mg CoO/C_3N_4 NTs	300 W Xe lamp (>420 nm)	10 vol% TEOA	0.0105	[43]
40 mg CdS/CoO_x	350 W Xe lamp (>420 nm)	0.35 M Na_2S/0.25 M Na_2SO_3	0.14	[46]
35 mg CoO_x/TiO_2/Pt	UV-light	15 vol% Methanol	0.276	[74]

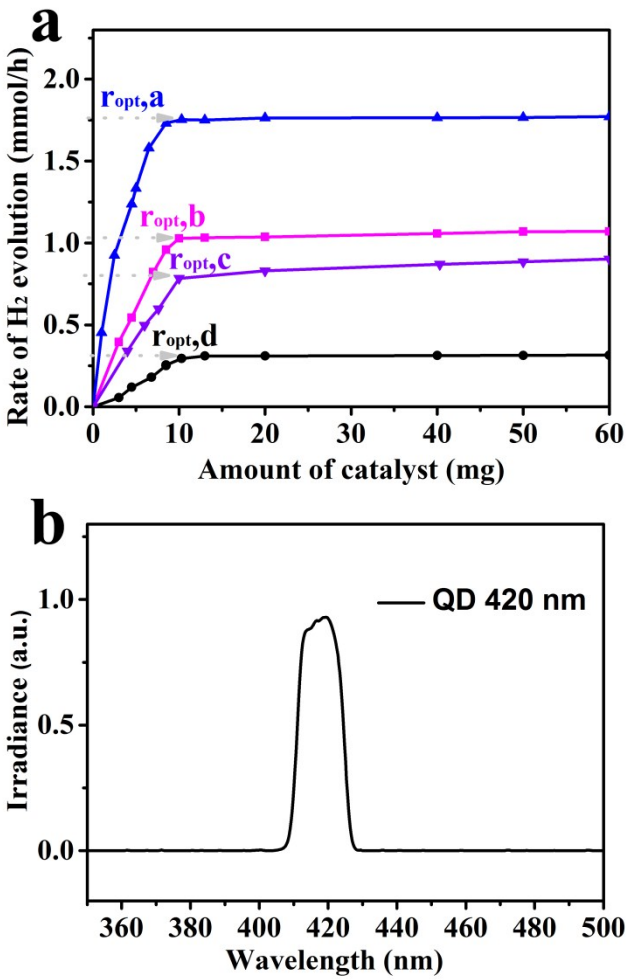

Figure S7. (a) Rate of H_2 evolution with different amount of photocatalysts over a: CZS/M-CoO-1.5%, b: CZS/C-CoO-1.5%, c: CZS/H-CoO-1.5%, d: CZS. (b) Relative light intensity of 300 W Xe lamp with bandpass filter 420 nm.

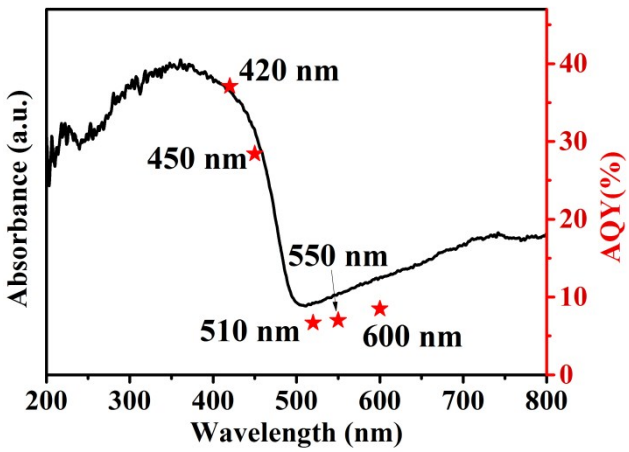

Figure S8. Wavelength dependent AQY of H_2 evolution for 10 mg of CZS/M-CoO-1.5%.

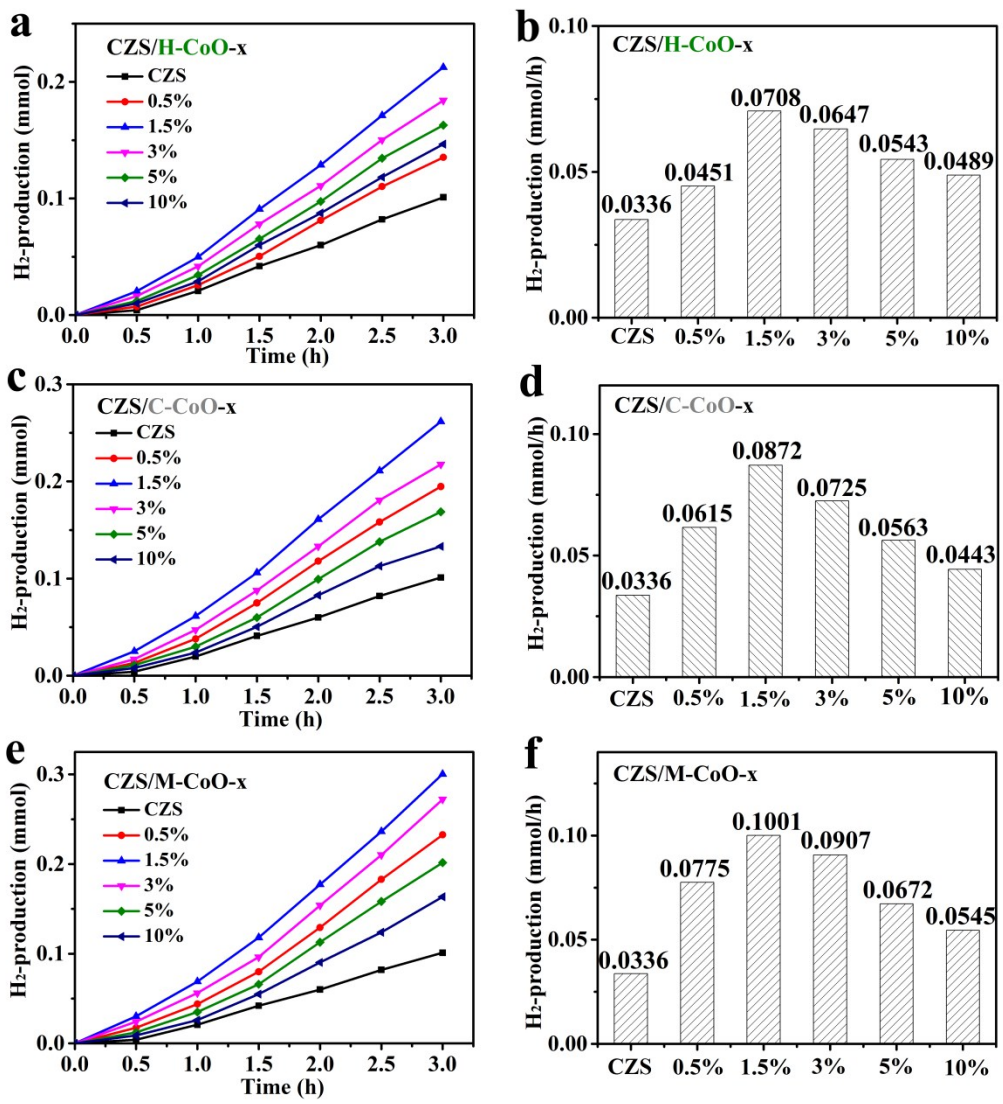

Figure S9. Photocatalytic H_2 generation curves for samples in 0.35 M Na_2S/0.25 M Na_2SO_3 aqueous solution under $\lambda > 510$ nm irradiation, 10 mg of photocatalysts.

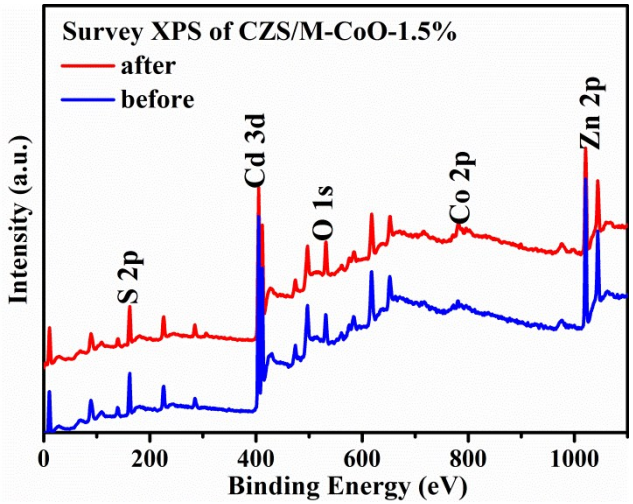

Figure S10. XPS survey spectra obtain before and after photocatalysis over CZS/M-CoO-1.5%.

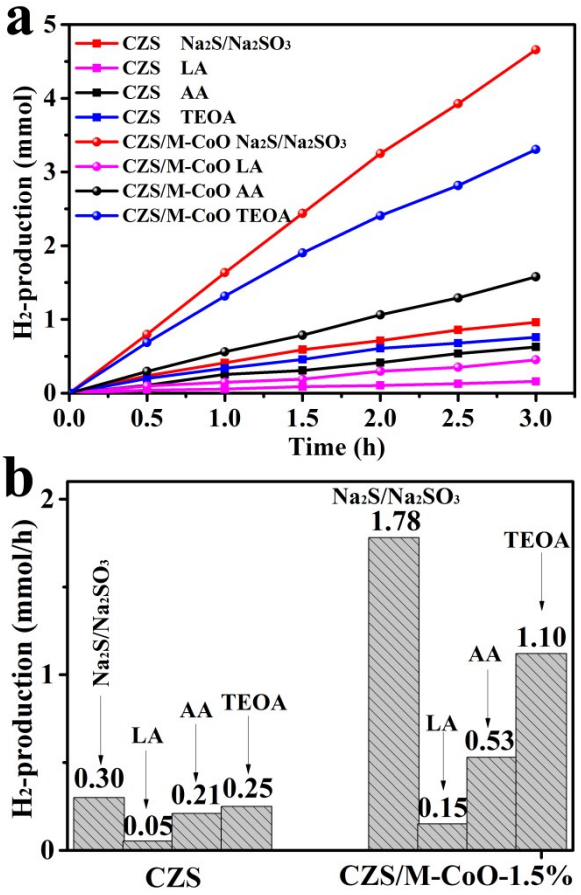

Figure S11. Photocatalytic HER activities of CZS/M-CoO-1.5% and CZS measured with different hole scavengers.

According to the following equations (S1):

$$AQY(\%) = \frac{Number\ of\ reacted\ electrons}{Number\ of\ incident\ photons} \times 100\%$$

$$= \frac{Number\ of\ evolved\ H_2\ molecules \times 2}{Number\ of\ incident\ photons} \times 100\%$$

$$= \frac{M \times N_A \times 2}{\frac{P \times t}{E_{g \times J}}} \times 100\%$$

Where $N_A = 6.02 \times 10^{23}$, I (light intensity) = 0.160 J/s, $E_g = 1240/\lambda$ (λ = 420 nm), t (Time) = 3600 s, J = 1.6×10^{-19} j.

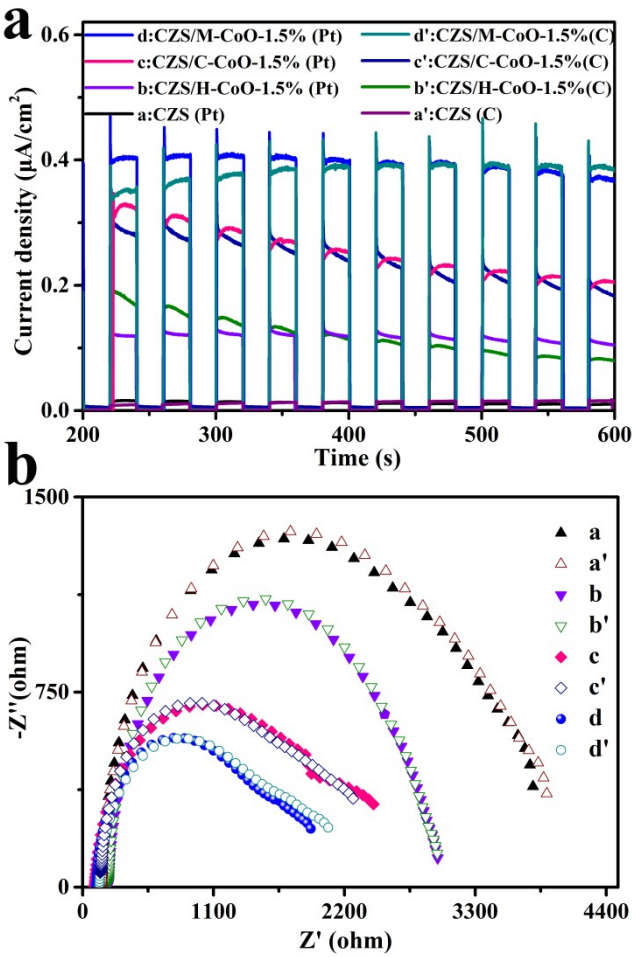

Figure S12. (a) Transient photocurrents, (b) Nyquist plots of electrochemical impedance spectra for pristine CZS, CZS/C-CoO-1.5%, CZS/H-CoO-1.5% and CZS/M-CoO-1.5%, using a Pt sheet and carbon rod as counter electrode, respectively.

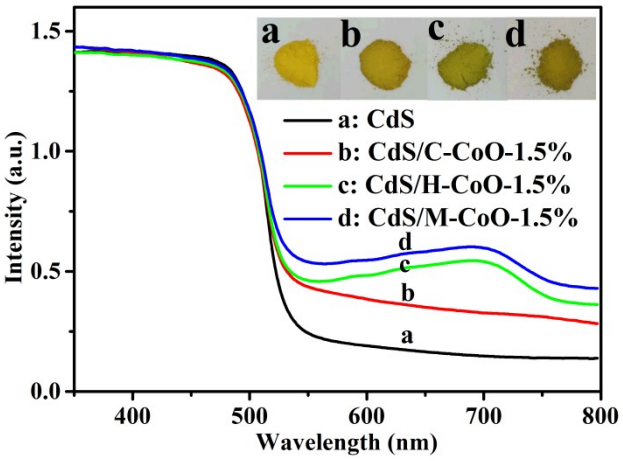

Figure S13. UV-Vis diffuse reflectance spectra of samples. The inset shows colors of samples.

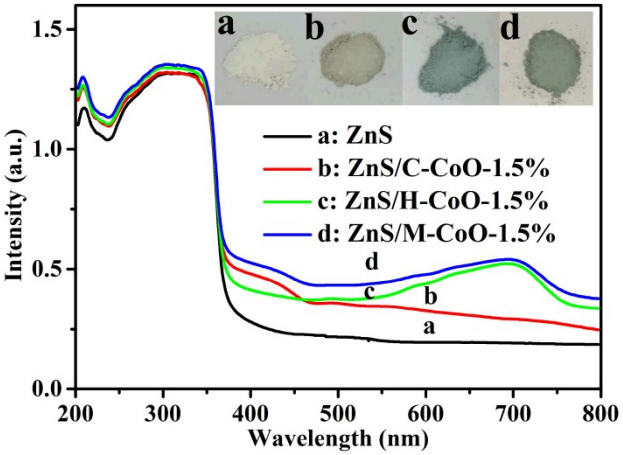

Figure S14. UV-Vis diffuse reflectance spectra of samples. The inset shows colors of samples.

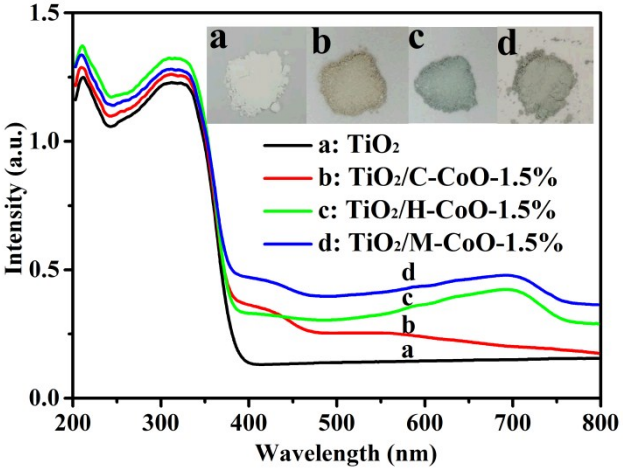

Figure S15. UV-Vis diffuse reflectance spectra of samples. The inset shows colors of samples.

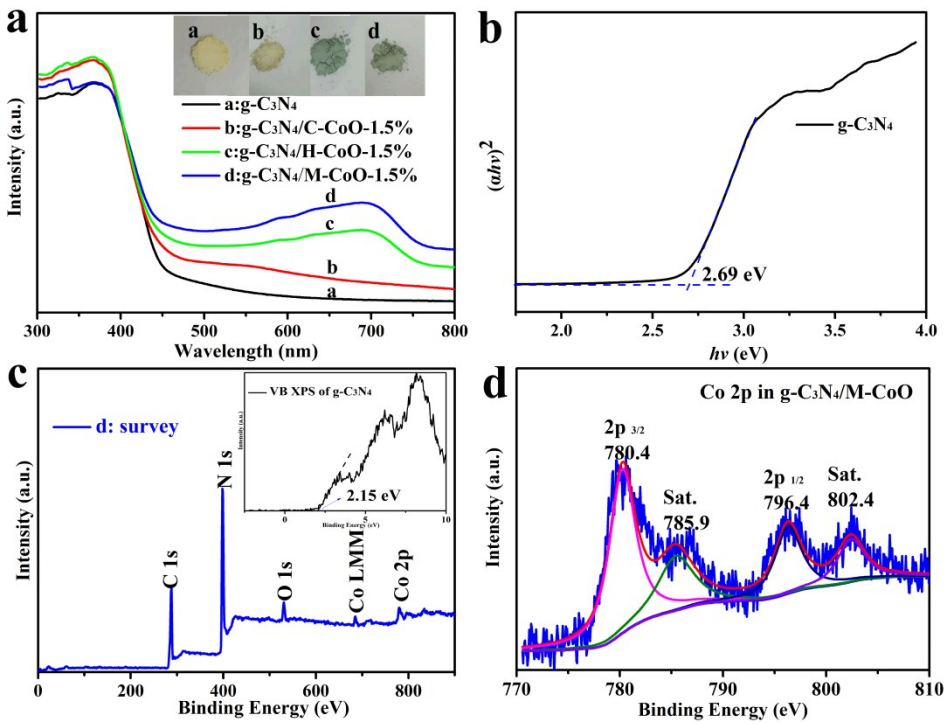

Figure S16. (a) UV-Vis diffuse reflectance spectra of sample. The inset shows the color of samples. (b) The Eg of g-C_3N_4. (c) XPS survey scan of g-C_3N_4/M-CoO (inset shows VB XPS of g-C_3N_4). (d) The high-resolution of Co 2p in g-C_3N_4/M-CoO.