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Electronic Supplementary Information

Developing an Efficient $NiCo_2S_4$ Cocatalyst for Improving Visible Light H_2 Evolution Performance of CdS Nanoparticles

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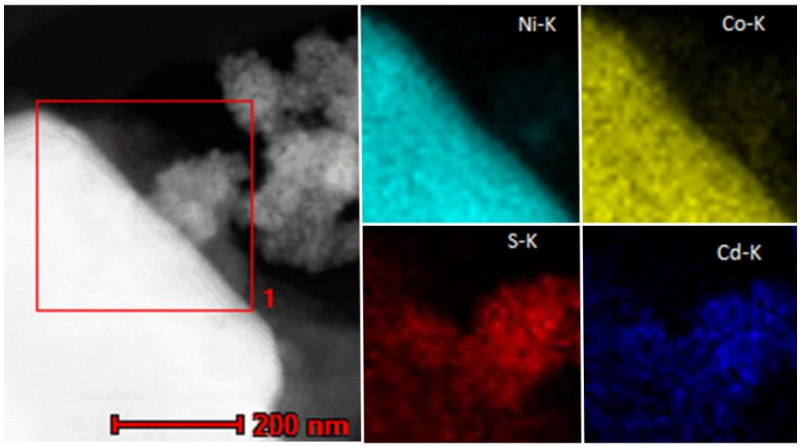

Fig. S1 EDX mappings of the $NiCo_2S_4$/CdS sample

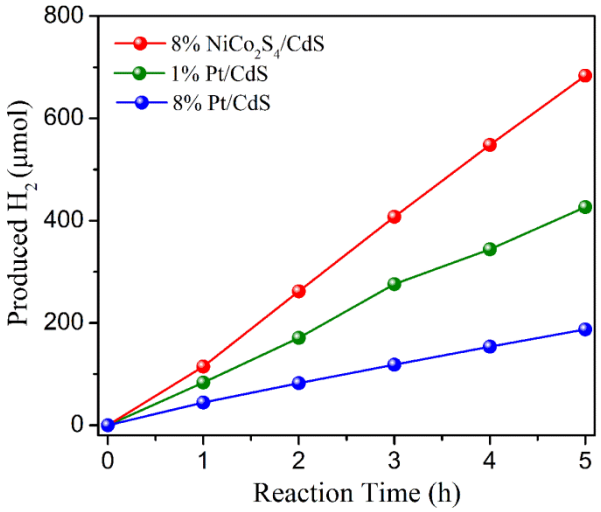

Fig. S2 Evolution of H_2 over the 8%$NiCo_2S_4$/CdS composite materials and Pt/CdS composite materials with different Pt content.

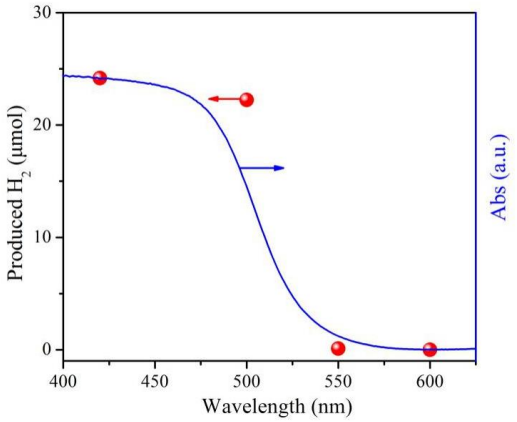

Fig. S3 Wavelength dependence of H_2 evolution over $NiCo_2S_4$/CdS sample.

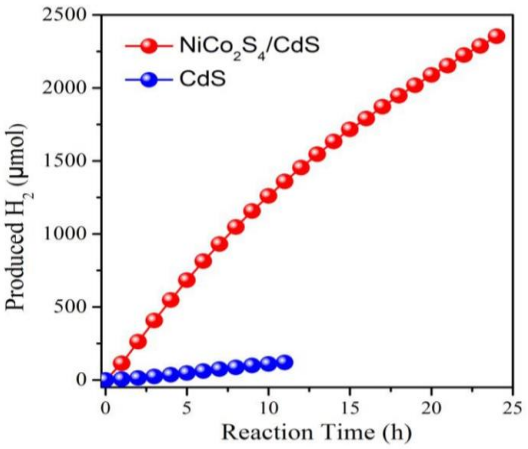

Fig. S4 Long term stability test of H_2 production over $NiCo_2S_4$/CdS and CdS samples under visible light irradiation.

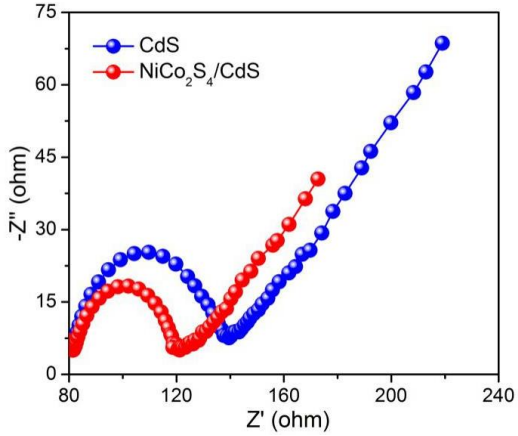

Fig. S5 Nyquist plots of CdS and $NiCo_2S_4$/CdS material electrodes.

Determinations of conduction and valence band potentials of $NiCo_2S_4$ and CdS. In the $NiCo_2S_4$/CdS hybrid system, $NiCo_2S_4$ holds an appropriate band structure with a suitable potential relative to CdS according to the theoretical calculation. The valence band potentials of a semiconductor from the absolute electronegativity follow the empirical formulas:[1]

$$E_{CB} = X - Ec + 0.5E_g$$

$$E_{VB} = E_{CB} + E_g$$

E_g is the band gap energy of the semiconductor, the values for $NiCo_2S_4$ and CdS are 2.5 eV and 2.4 eV, respectively [2,3]. E_{VB} is the valence band (VB) edge potentials, E_{CB} is the conduction band (CB) edge potentials, X is the electronegativity of the semiconductor that is the geometric mean of the electronegativity of the constituent atoms (the electronegativity of an atom is the arithmetic mean of the atomic electron affinity and the first ionization energy), and Ec is the energy of free electrons on the hydrogen scale (about 4.5 eV). The X values for $NiCo_2S_4$ and CdS are estimated to be 5.33 and 5.19 eV, respectively. Thus, the E_{CB} values of $NiCo_2S_4$ and CdS are calculated to be -0.42 and -0.51 eV, respectively. The E_{VB} values of $NiCo_2S_4$ and CdS is estimated to be 2.08 and 1.89 eV, respectively.

References

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[3] H. Chen, J. Jiang, L. Zhang, H. Wan, T. Qi, D. Xia, *Nanoscale*, **2013**, *5*, 8879-8883.