SUPPLEMENTARY INFORMATION

Self-assembled pearl-bracelet-like $CoSe_2$-$SnSe_2$/CNT hollow architecture as highly efficient electrocatalysts for hydrogen evolution reaction

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Figures

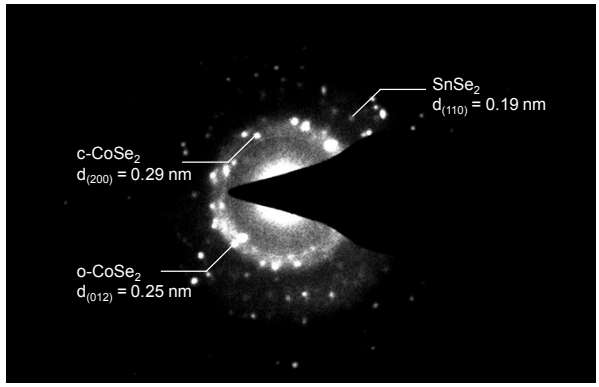

Fig. S1. SAED pattern of CSCB.

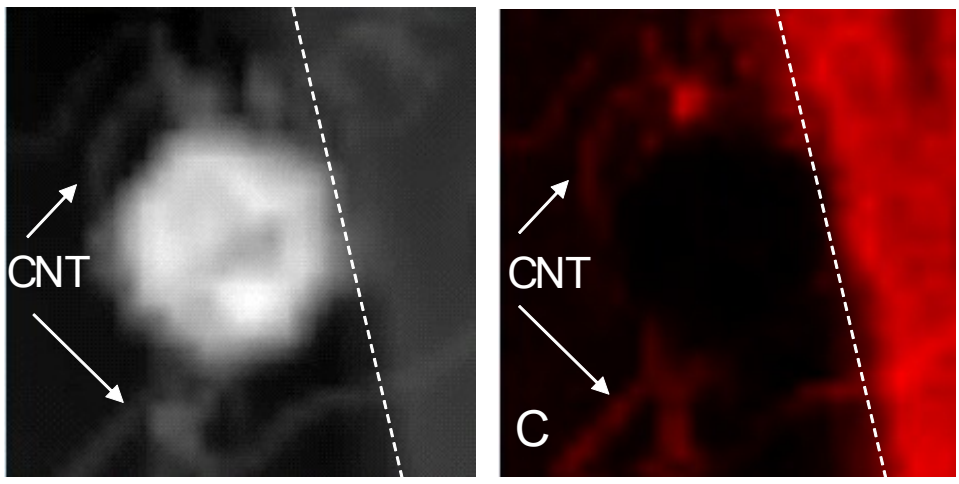

Fig. S2. Elemental mapping image of C in CSCB. The elemental C appear at the right of dotted white line which is due to the supporting carbon film of TEM grid.

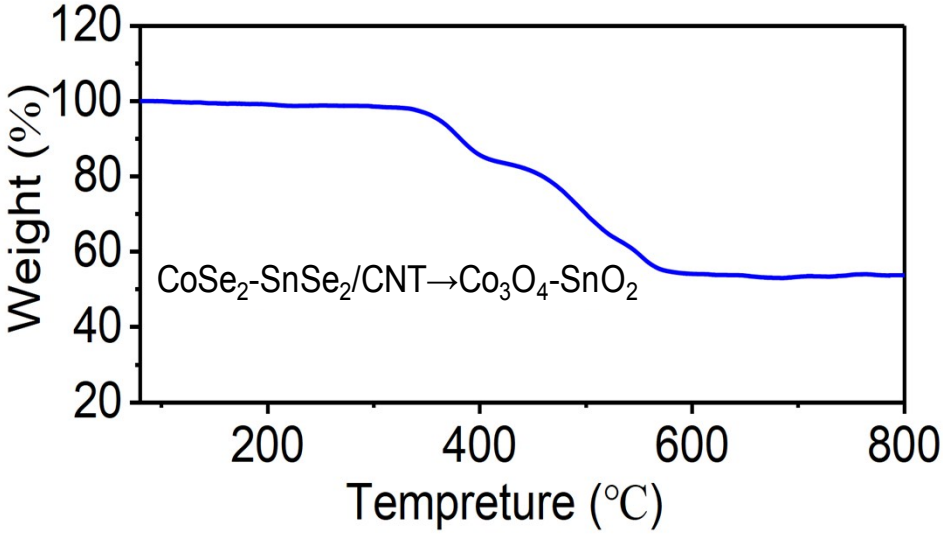

Fig. S3. TGA curve of the CSCB.

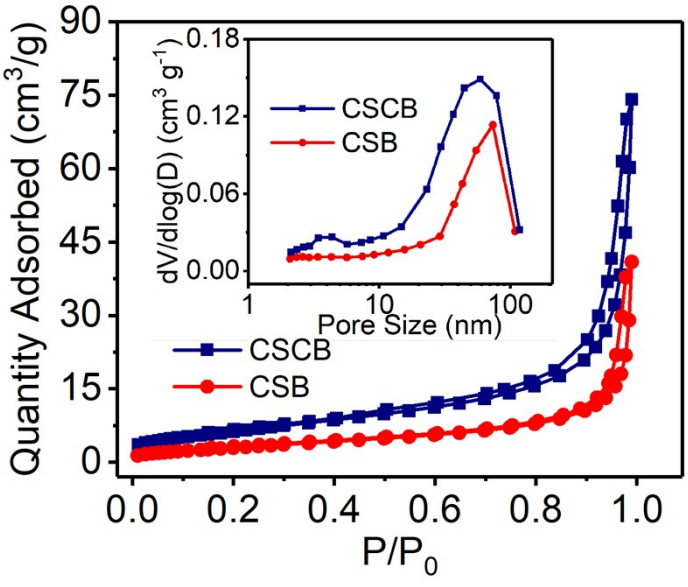

Fig. S4. N_2 sorption isotherm and pore sizedistribution (inset) of CSCB and CSB.

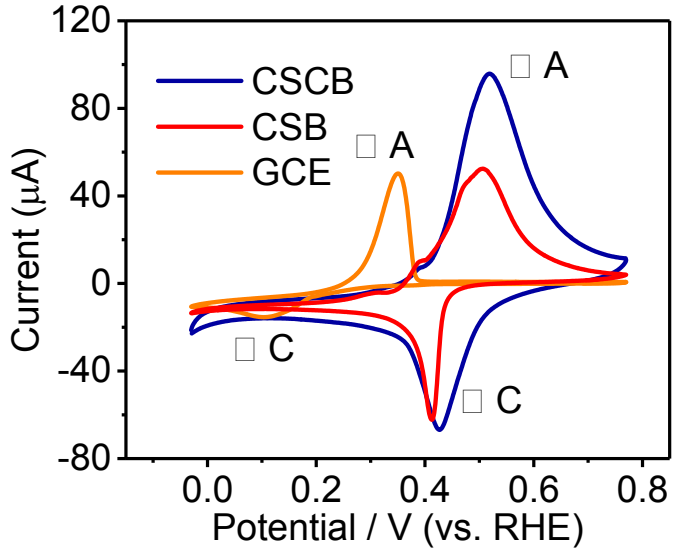

Fig. S5. Cyclic voltammograms of CSCB, CSB and bare GCE in a 0.1 M of $H_2SO_4$and 2 mM cupric sulfate solution. I A and I C peaks correspond to the overpotential of stripping and deposition signal, respectively. II A and II C peaks are assigned to theunderpotential processes of Cu adatoms.

In previous works, some researchers have demonstrated that at a particular potential the same quantity of copper adatoms as hydrogen adatoms are deposited on the surface of active sites.[1] According to previous reports [2, 3], the number of active sites can be calculated by applying underpotential deposition (UPD) of copper. Copper ions can be electrochemically reduced on CSCB and CSB at higher potentials (UPD) than itsthermodynamic potential (overpotential deposition, OPD), which has been added as Fig. S5. From the quantity of charges generated, the mol amount of Cu adatoms (Q_{Cu}/96500/2) can be calculated.

Assessment of turnover frequency (TOF)

Conversion of measured current to H_2 turnover (assuming 100% Faradaicefficiency)[2,3]:

$$\left(j\frac{mA}{cm^2}\right)\left(\frac{1\ A}{1000\ mA}\right)\left(\frac{1\ C/s}{1\ A}\right)\left(\frac{6.241\ \times 10^{18}\ e^-}{1\ C}\right)\left(\frac{1}{2\ e^-}\right) = \left(3.12 \times 10^{15}\frac{1/s}{cm^2}\right) \text{ per } \frac{mA}{cm^2}$$

TOF at -300 mV:

CSCB:

$$\left(\frac{3.079\ \times\ 10^{-3}\ C}{96500\ C/mol}\right) \times \frac{1}{2} \times \frac{1}{0.07065} \times \underset{6.022}{} \times 10^{23}\frac{1}{mol} = 1.360\ \times\ 10^{17}$$

$$\underset{78.69}{} \times \frac{mA}{cm^2}\left(3.12 \times 10^{15}\frac{1/s}{cm^2}\right)\left(\frac{cm^2}{1.360\ \times\ 10^{17}}\right) = 1.805\ s^{-1}$$

CSB:

$$\left(\frac{1.558\ \times\ 10^{-3}\ C}{96500\ C/mol}\right) \times \frac{1}{2} \times \frac{1}{0.07065} \times \underset{6.022}{} \times 10^{23}\frac{1}{mol} = 6.882\ \times\ 10^{16}$$

$$\underset{2.588}{} \times \frac{mA}{cm^2}\left(3.12 \times 10^{15}\frac{1/s}{cm^2}\right)\left(\frac{cm^2}{6.882\ \times\ 10^{16}}\right) = 0.117\ s^{-1}$$

Table

Table S1. HER parameters of various transition-metal chalcogenide-based electrocatalysts.

Catalysts	**Onset potential/ V**	**Tafel slope/ mV dec^{-1}**	**η/mV**	**TOF/s^{-1}**
CSCB (in this work)	-0.150	32.4	300	1.805
CSB (in this work)	-0.195	74.5	300	0.117
As-WS_2[1]	-0.10	60	288	175
Irradiated Au-MoS_2[3]	-0.16	71	300	8.76
WS_2[4]	-0.074	46	160	0.16
NiSe[5]	-0.25	118	250	0.51
$MoSe_2$-NiSenanohybrids[5]	-0.15	56	250	5.6
MoS_2/CNT[6]	-0.09	44.6	250	~15
$CoSe_2$[7]	~-0.13	39.6	N/A	N/A
CoS_2@MoS_2/rGO[8]	~0.09	37.4	N/A	N/A
$NiSe_2$[9]	-0.1	44	N/A	N/A
$NiSe_2$/Ni[10]	-0.08	49	N/A	N/A
WSe_2/RGO[11]	-0.15	57.6	N/A	N/A
rGO/$W_xMo_{1-x}S_2$[12]	-0.11	50.6	N/A	5.1

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