Cubic core-shell structure of $NiCoS_x/CoS_2$ as high-efficiency tri-functional catalyst for Zn-air battery and overall water splitting

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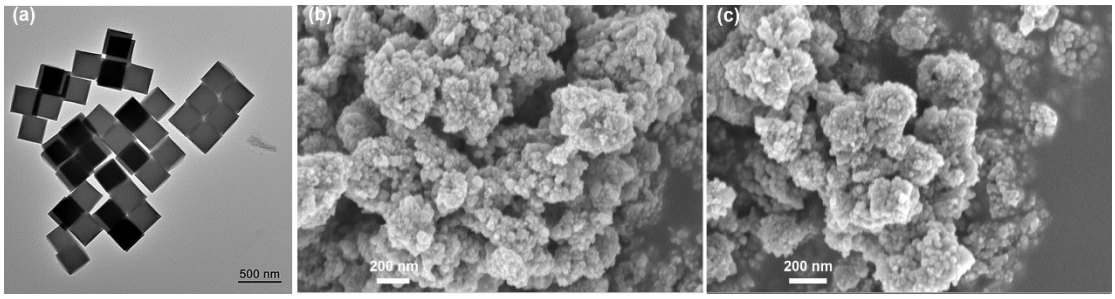

Fig. S1 (a) TEM images of the $Ni_3[Co(CN)_6]_2$. (b~c) SEM images of the $NiCoS_x$ without $Co(OH)_2$.

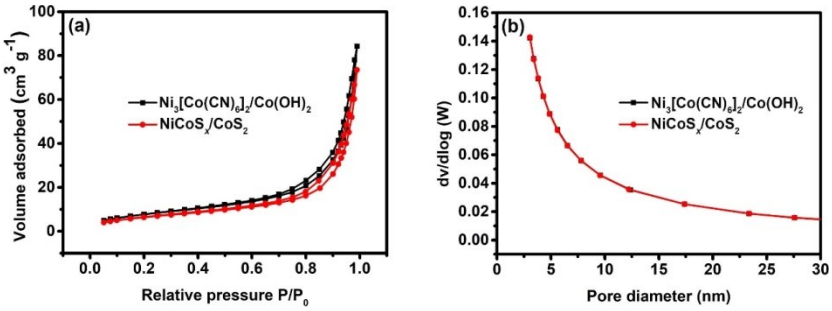

Fig. S2 The nitrogen adsorption-desorption isotherms (a) and the corresponding pore size distribution curves (b) of $Ni_3[Co(CN)_6]_2/Co(OH)_2$ and $NiCoS_x/CoS_2$.

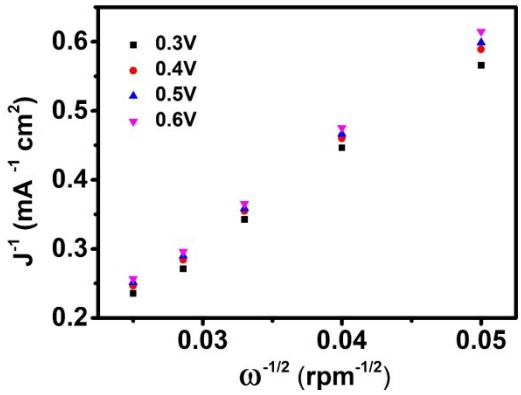

Fig. S3 K-L plots at 0.3 V, 0.4 V, 0.5 V, 0.6 V potentials for $NiCoS_x/CoS_2$.

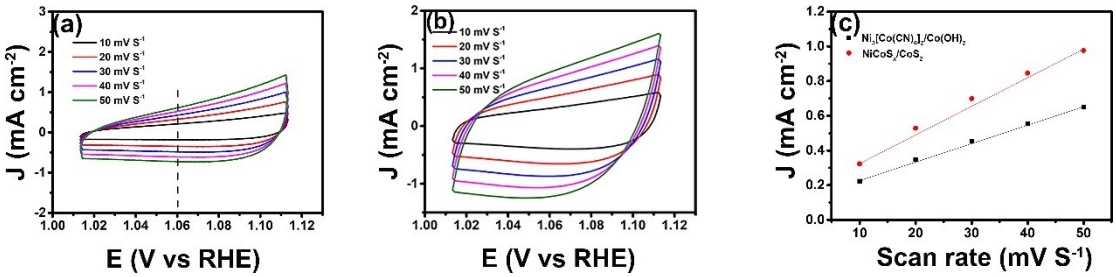

Fig. S4 CV curves of $Ni_3[Co(CN)_6]_2/Co(OH)_2$ (a), $NiCoS_x/CoS_2$ (b), in the potential range of 1.006 - 1.106 V (vs. RHE). (c) The corresponding linear fitting of the capacitive current densities vs. the scan rate.

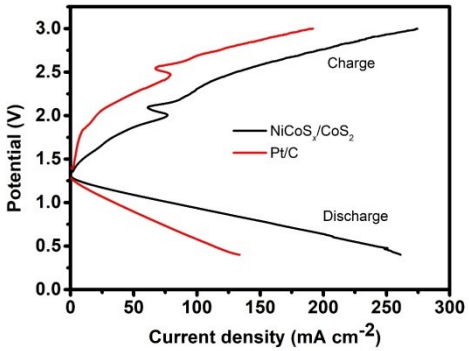

Fig. S5 Charge/discharge polarization curves of the rechargeable liquid ZABs based on the Pt/C catalyst and $NiCoS_x/CoS_2$ catalyst, respectively.

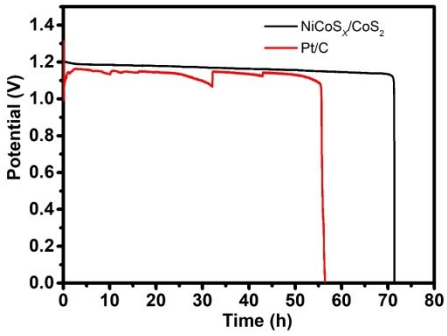

Fig. S6. Typical discharge curves of the rechargeable liquid ZABs based on the Pt/C catalyst and $NiCoS_x/CoS_2$ catalyst, respectively.

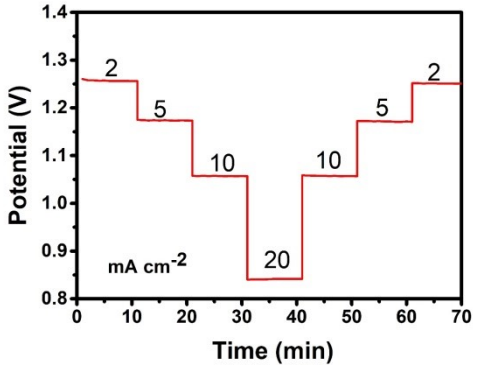

Fig. S7 Rate performance of $NiCoS_x/CoS_2$ at different current densities.

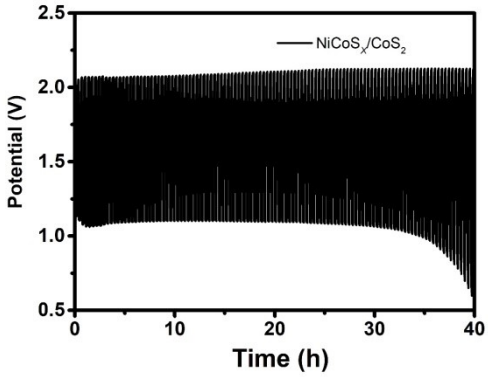

Fig. S8 Cycling stability of $NiCoS_x/CoS_2$ at 10 mA cm^{-2} charge/discharge.

Table S1 Comparison of the performance of the as-prepared other Co-based Ni-based sulfides catalysts ORR performance.

Catalyst	$E_{1/2}$	***Electrolyte***	***Ref.***
$NiCoS_x/CoS_2$	0.80	0.1 M KOH	This work
CoS_2@MXene	0.80	0.1 M KOH	[1]
N, P/CoS_2@TiO_2	0.71	0.1 M KOH	[2]
CuS/NiS_2	0.80	0.1 M KOH	[3]
Co_9S_8@NS-3DrGO	0.82	1 M KOH	[4]

Table S2 Comparison of the performance of the as-prepared other Co-based Ni-based sulfides catalysts OER performance.

Catalyst	$E_{j=20}$	***Electrolyte***	***Ref.***
$NiCoS_x/CoS_2$	1.54	0.1 M KOH	This work
$NiCo_2S_4$	1.56	1 M KOH	[5]
NiPS	1.63	1 M KOH	[6]
NiS_2	1.48	1 M KOH	[7]
S-NiCoP/CC	1.55	1 M KOH	[8]

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