Electronic Supporting Information (ESI)

Electrodeposition of Ni-Co-Fe mixed sulfide ultrathin nanosheets on Ni nanocones: low-cost, durable and high performance catalyst for electrochemical water splitting

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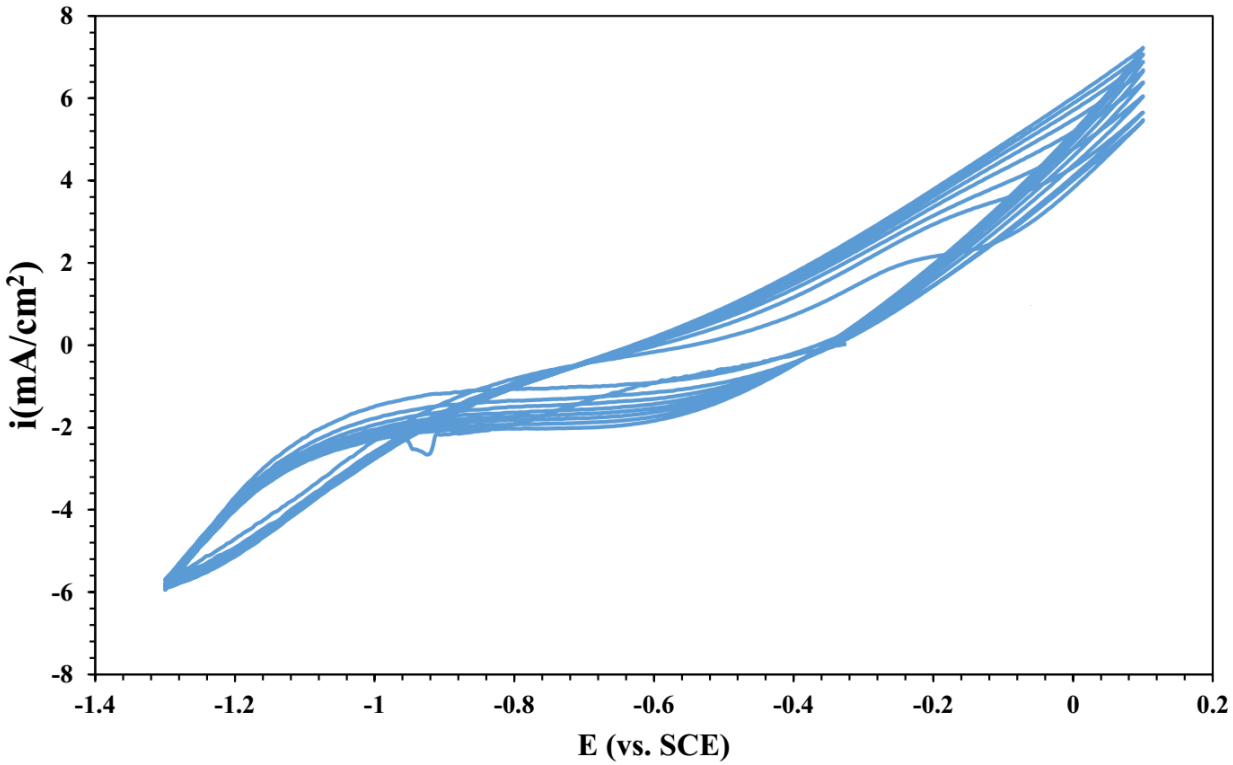


Fig. S1. CV curves during electrochemical deposition of Ni-Fe-Co-S nanosheets

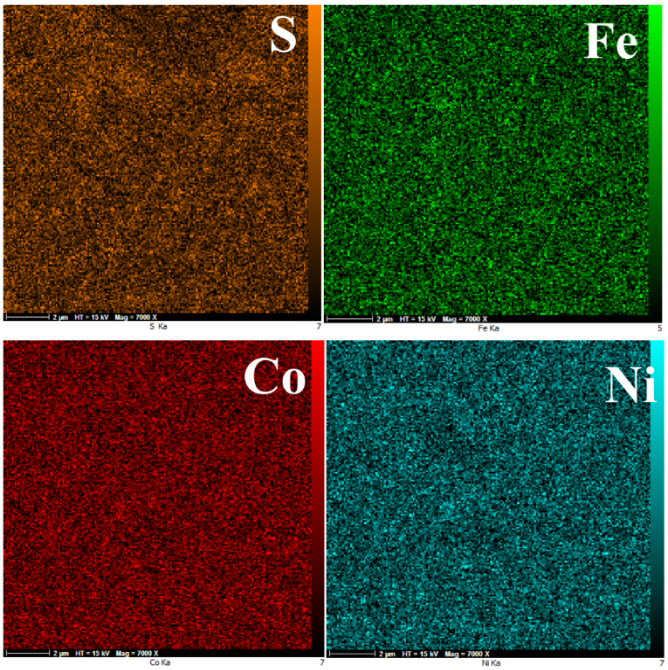
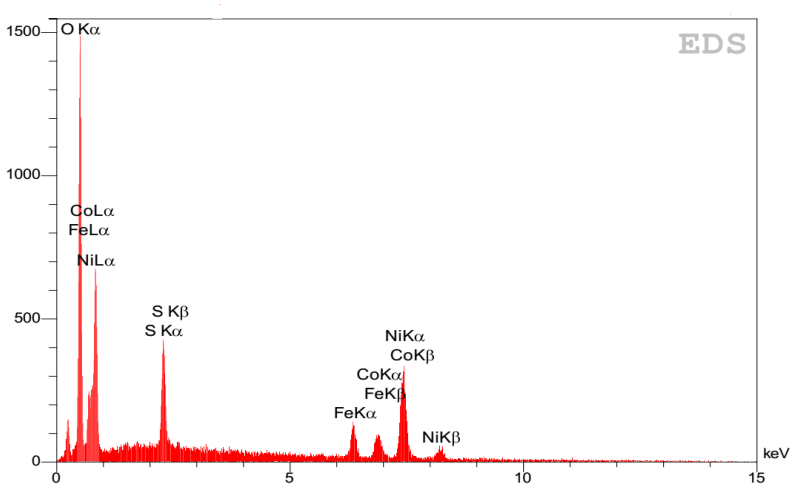


Fig .S2. Elemental mapping of Ni-Fe-Co-S electrode.



Element	Ni	Co	Fe	S	O
W%	41.22	8.80	7.23	5.27	37.48

Fig. S3. EDS pattern of Ni-Fe-Co-S electrode.

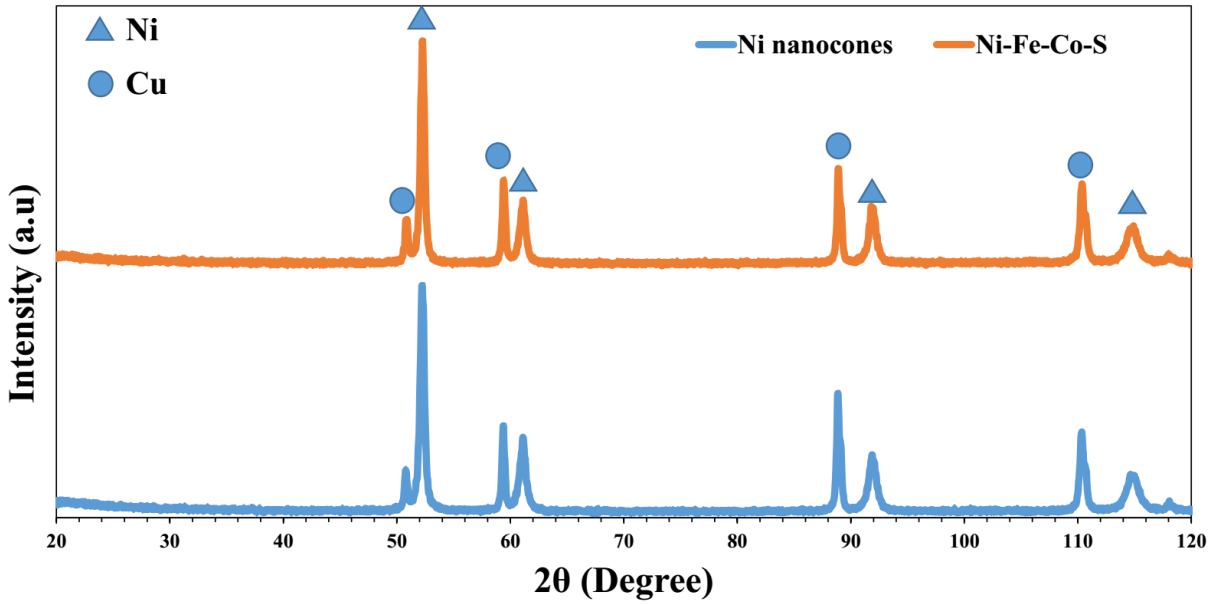


Fig. S4. XRD pattern of Ni nanocones and Ni-Fe-Co-S samples

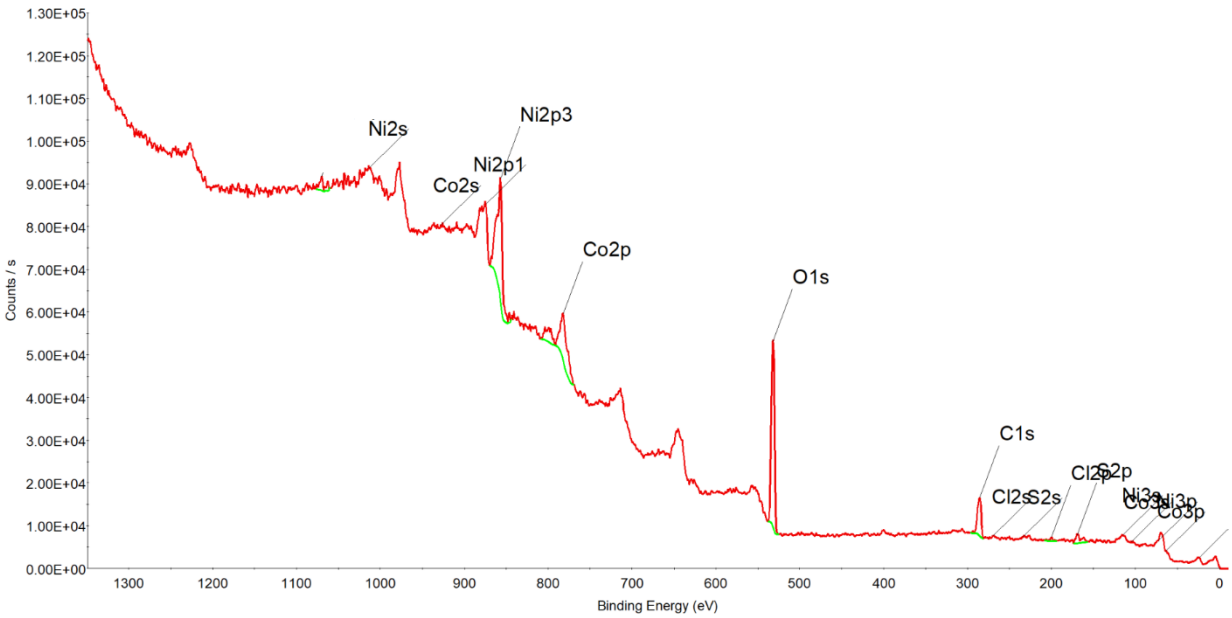


Fig. S5. XPS spectrum of Ni-Fe-Co-S nanosheets.

Table S1. Comparison of electrochemical catalytic hydrogen evolution of Ni-Fe-Co-S @NNCs with other recently reported sulfide-based catalyst in alkaline solution.

Catalyst	Electrolyte	η_{10} (mV vs.RHE)	η_{20} (mV vs.RHE)	η_{100} (mV vs.RHE)	b (mV/dec)	Ref
Ni-Fe-Co-S	1.0 M KOH	106	134	215	95	**This work**
$Fe_{0.1}$-NiS_2 NA/T	1.0 M KOH	200	243	310	108	**[1]**
MoO_x/Ni_3S_2/NS	1.0 M KOH	136		310		**[2]**
$Ni_xCo_{3-x}S_4/Ni_3S_2$/NF	1.0 M KOH	160		320	95	**[3]**
V-NiS_3-NW	1.0 M KOH		203	350	112	**[4]**
Ni-Ni_3S_2/NF	1.0 M KOH	110	160	230		**[5]**
Ni_3S_2/AT-NF	1.0 M KOH	200			107	**[6]**
$NiCo_2S_4$	1.0 M KOH	210				**[7]**
NiS_2nanosheets/CC	1.0 M KOH	149			104	**[8]**
Ni_3S_2 nanocomposites /CNT	1.0 M KOH	340			167	**[9]**
NiS Porous/ Copper plates	1.0 M KOH	301			107	**[10]**
NiS-Ni_9S_8-NiSe-NR/ NF composite	1.0 M KOH	112	148	243	94	**[11]**
NiS–$Ni_2P_2S_6$/NF	1.0 M KOH	140			72.8	**[12]**

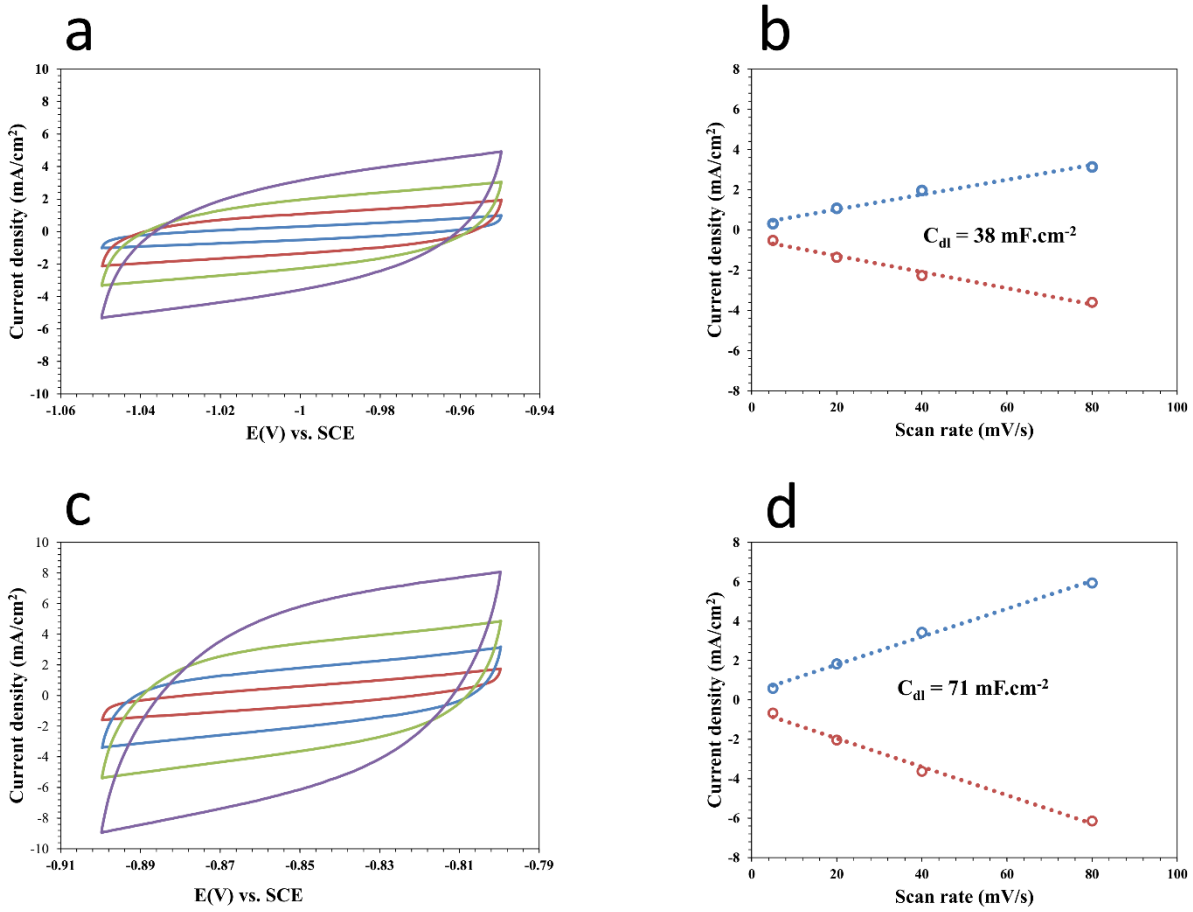


Fig. S6. CV curves of a) NNCs and c) Ni-S@NNCs together with i-scan rates curves of b) NNCs and d) Ni-S@NNCs.

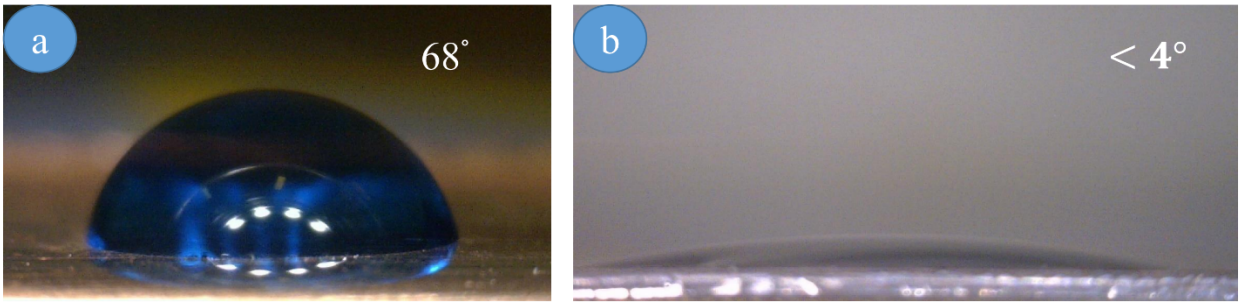


Fig. S7. Contact angle of a) flat Ni and b) Ni-S@NNCs electrodes.

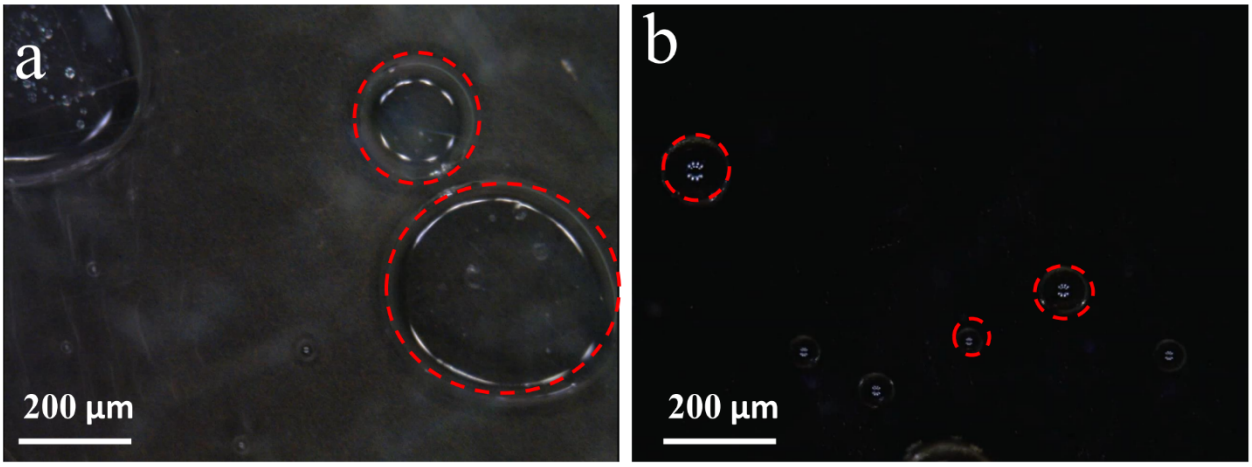


Fig. S8. Bubbles size on the a) flat Ni and b) Ni-S@NNCs electrodes during HER.

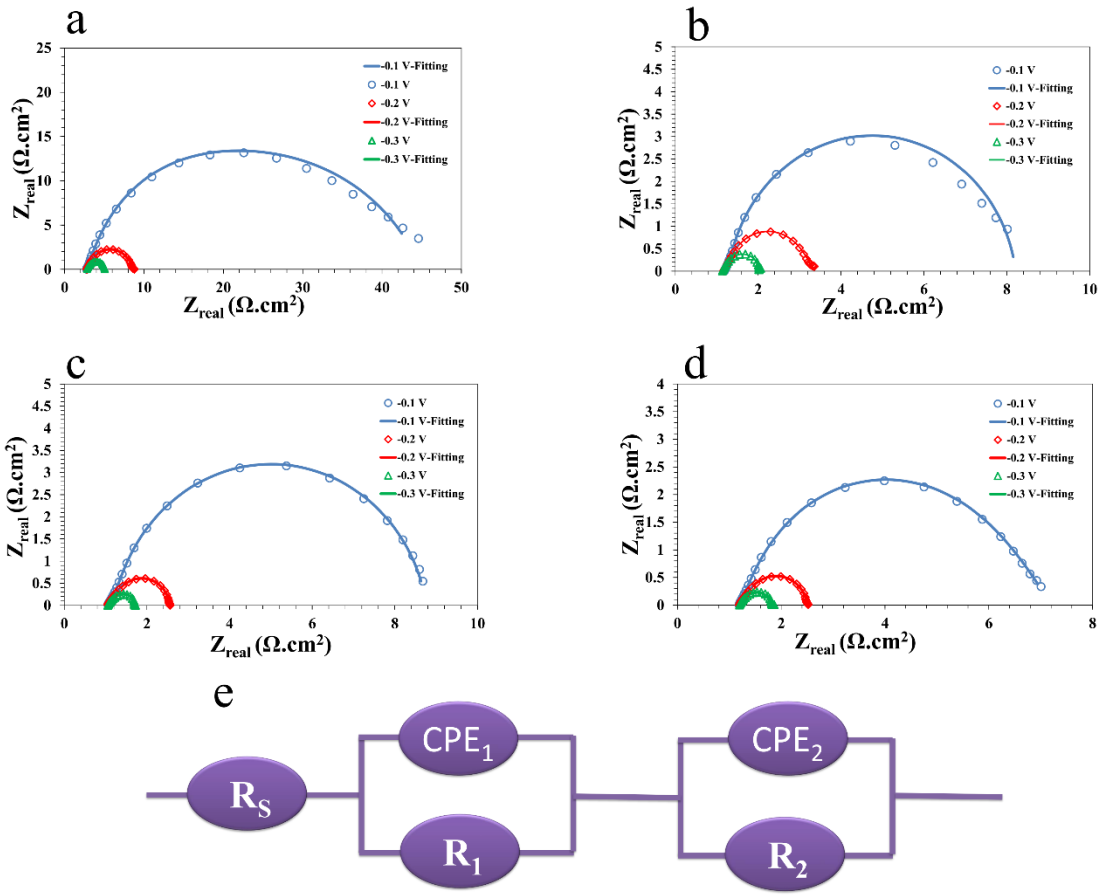


Fig.S9. Nyquist curves of different electrodes at varying overpotentials during HER on the a) Ni-S, b) Ni-Co-S and c) Ni-Fe-S d) Ni-Fe-Co-S and e) equivalent electrical circuit used for fitting the impedance data.

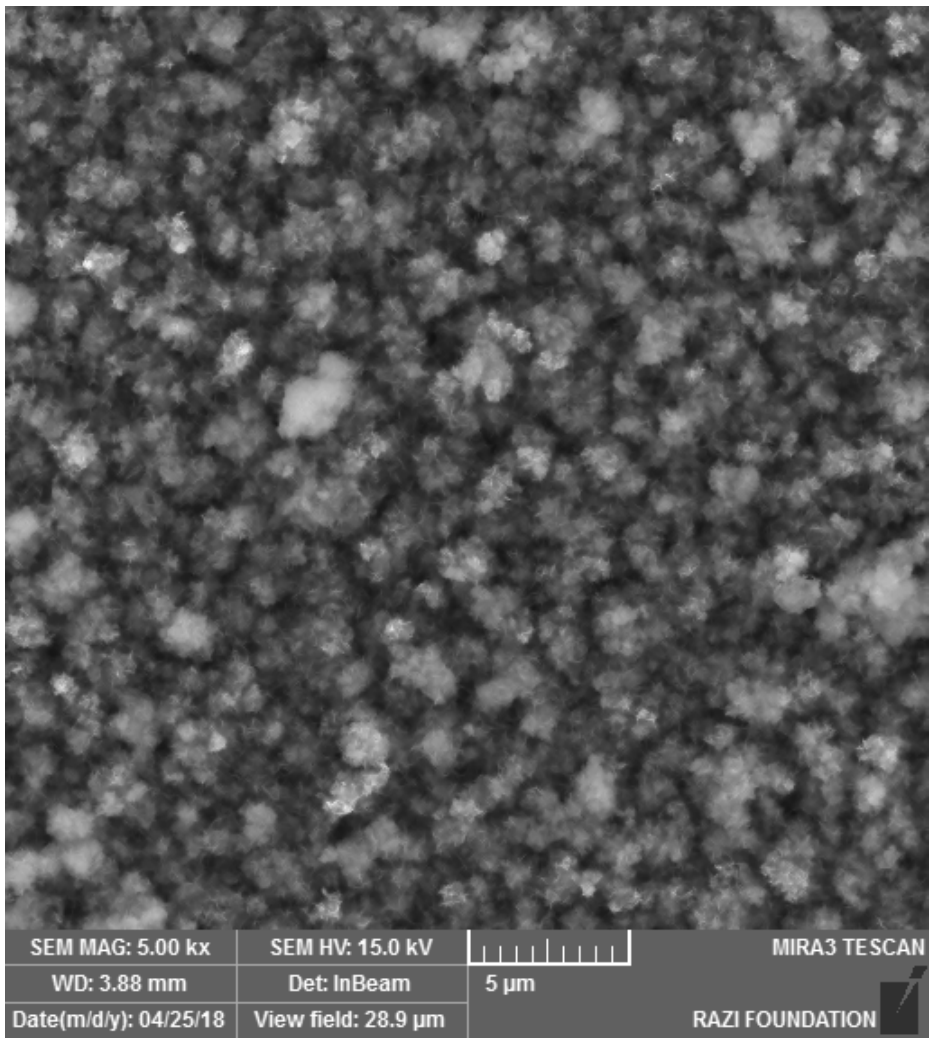


Fig. S10. FESEM image of Ni-Fe-Co-S nanosheets after long-term stability test.

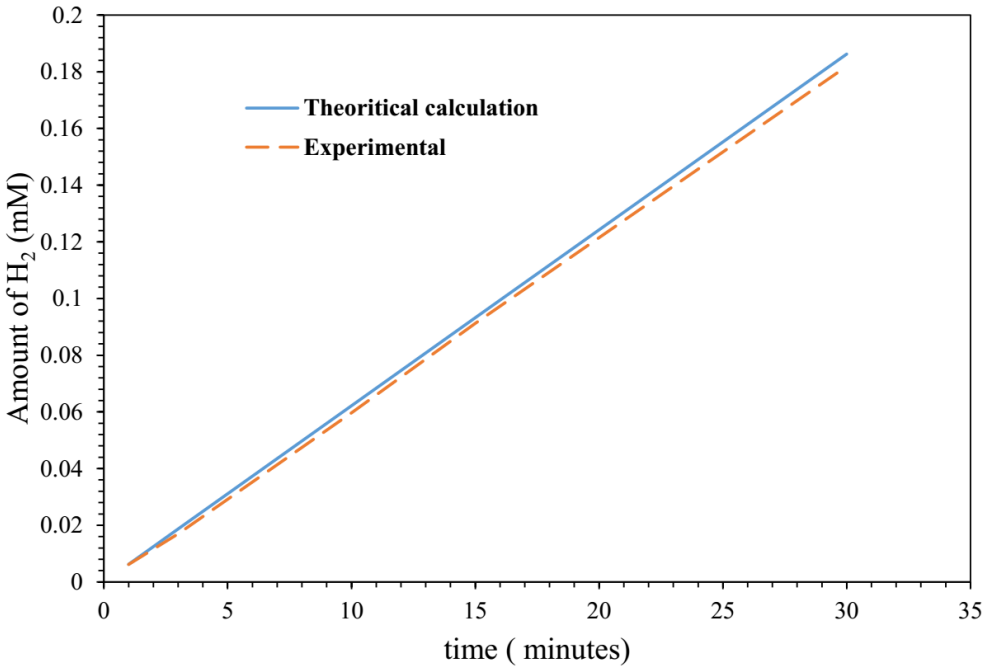


Fig. S11. Current efficiency for HER

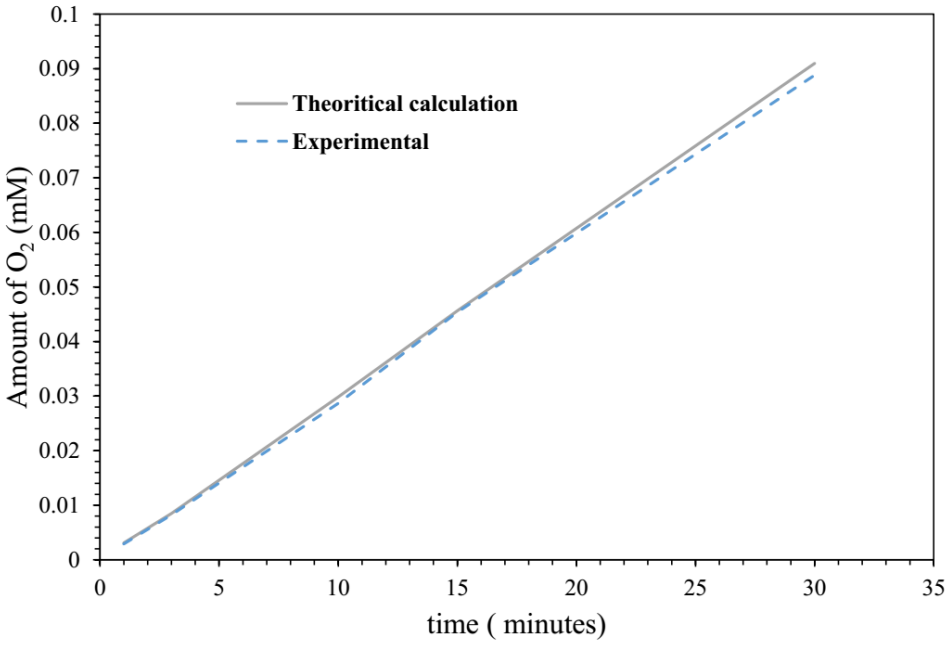


Fig. S12. Current efficiency for OER

Table.S2: Comparison of electrochemical catalytic oxygen evolution of Ni-Fe-Co-S @NNCs with other recently reported sulfide-based catalyst in alkaline solution.

Catalyst	Electrolyte	η_{10} (mV vs.RHE)	η_{20} (mV vs.RHE)	η_{100} (mV vs.RHE)	b (mV/dec)	Ref
Ni-Fe-Co-S	1.0 M KOH	207	232	272	63	**This work**
Fe-Ni_3S_2/FeNi	1.0 M KOH	283	320		54	**[13]**
N-Ni_3S_2/NF	1.0 M KOH			340	70	**[5]**
$FeNiS_2$NSs	1.0 KOH	310			46	**[14]**
$CoMoS_3$ nanotube	1.0 KOH	320	370			**[15]**
Ni/NiS	1.0 KOH		320	390	109.8	**[16]**
$NiCo_2S_4$	1.0 KOH	260			40	**[7]**
Ni_3S_2 Nanorod	0.1 KOH	217				**[6]**
Zn-Ni_3S_2/NF	1.0 KOH			300	87	**[17]**
Mo-doped Ni_3S_2	1.0 KOH			400	45.5	**[18]**
$CoMoS_4$/Ni_3S_2	1.0 KOH	200			63	**[19]**
MoS_2/Ni_3S_2	1.0 KOH	218			88	**[20]**
Ni_3S_2/Co_9S_8	1.0 KOH			340	66	**[21]**
CoPS	1.0 KOH	308.1				**[22]**

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