Electronic Supplementary Material (ESI) for Dalton Transactions.

Controlled synthesis of bifunctional particle-like Mo/Mn-Ni_xS_y/NF electrocatalyst for highly efficient overall water splitting

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Table. S1 Comparison of HER properties for catalysts of superior electrochemistry materials

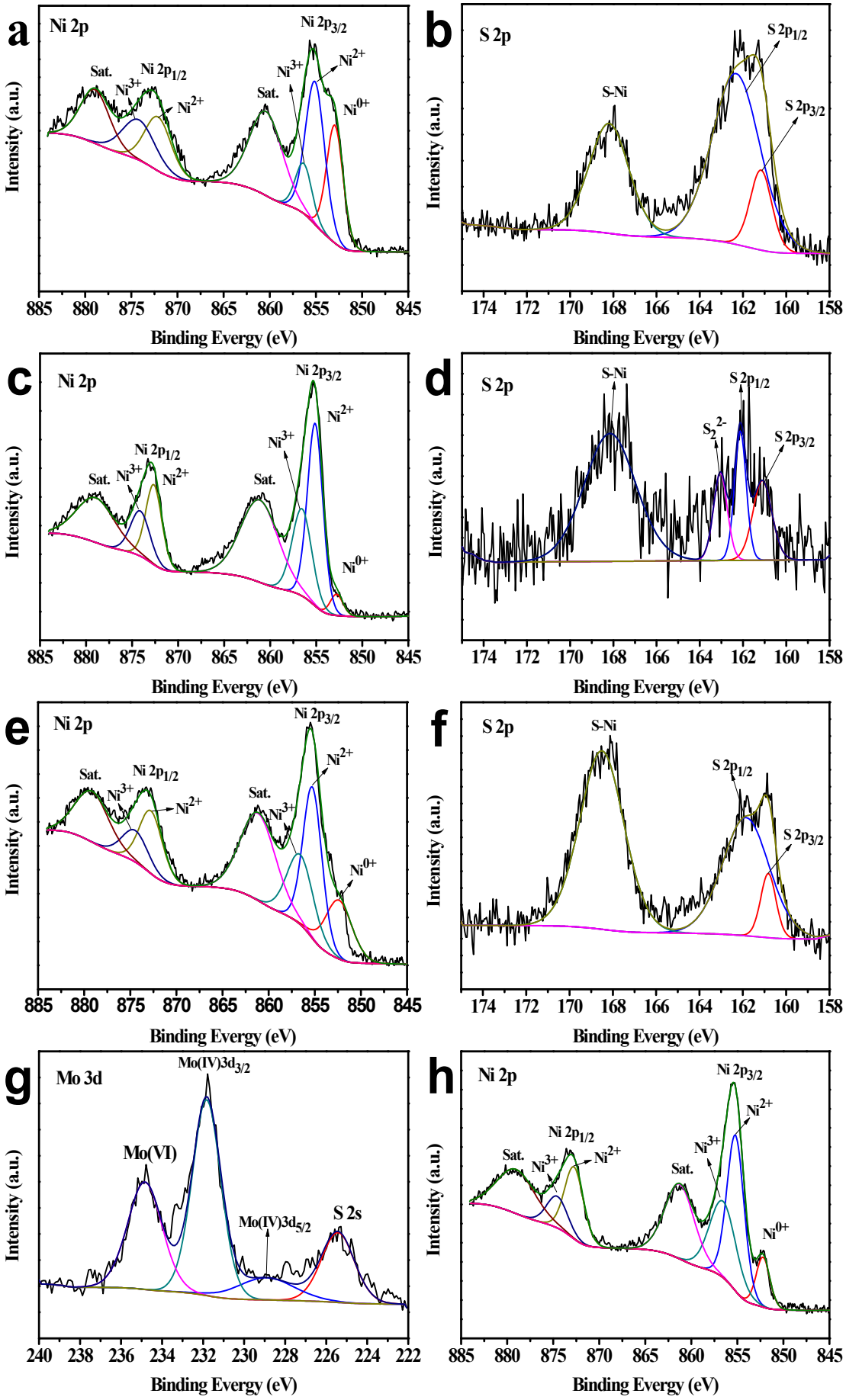
Catalyst	Overpotential (mV vs. RHE)	Ref
Mo/Mn-Ni_xS_y/NF	144 mV@10 mA cm^{-2}	This work
Mo, S- codoping NiSe	88 mV@10 mA cm^{-2}	[1]
Sn-Ni_3S_2/NF	170 mV@100 mA cm^{-2}	[2]
2H-MoS_2/G/NF	117 mV@10 mA cm^{-2}	[3]
$Ni_xCo_{3-x}S_4/Ni_3S_2$	136 mV@10 mA cm^{-2}	[4]
Co_1Mn_1CH/NF	180 mV@10 mA cm^{-2}	[5]
MoS_2-Ni_3S_2	211mV@10 mA cm^{-2}	[6]
$MoSe_2$-$CoSe_2$	148 mV@10 mA cm^{-2}	[7]
CoS_x/Ni_3S_2	204 mV@10 mA cm^{-2}	[8]
P-Doped Co-Ni-S	187 mV@100 mA cm^{-2}	[9]
Er-doped CoP NMs	66 mV@10 mA cm^{-2}	[10]
Mo, S-codoping NiSe/NF	88 mV@10 mA cm^{-2}	[22]
N,S-codoped $Zn_{0.975}Co_{0.025}S/CoS_2$	152 mV@10 mA cm^{-2}	[23]

Table. S2 Comparison of OER properties for catalysts of superior electrochemistry materials

Catalyst	Overpotential (mV vs. RHE)	Ref
Mo/Mn-Ni_xS_y/NF	162 mV @ 50 mA cm^{-2}	This work
CoS_x/Ni_3S_2	280 mV@ 20 mA cm^{-2}	[8]
Er-doped CoP NMs	256mV@10 mA cm^{-2}	[10]
MoS_2/NiS	271 mV @10 mA cm^{-2}	[11]
CoOOH	262 mV @10 mA cm^{-2}	[12]
Fe-doped Ni_3S_2	253 mV @100 mA cm^{-2}	[13]
$Ni_xCo_{3-x}S_4/Ni_3S_2$	160 mV@10 mA cm^{-2}	[4]
CS-NiFeCu	180 mV@10 mA cm^{-2}	[14]
$NiS_{1.03}$-NSCs	270 mV@10 mA cm^{-2}	[15]
Cu_2S/CF	336 mV@20 mA cm^{-2}	[16]
Ce-doped NiFe-LDH/CNT	227 mV@10 mA cm^{-2}	[17]
P-Doped Co-Ni-S	292 mV@100 mA cm^{-2}	[9]
Sn-Ni_3S_2/NF	270 mV@100 mA cm^{-2}	[2]
N,S-codoped $Zn_{0.975}Co_{0.025}S/CoS_2$	270 mV@10 mA cm^{-2}	[23]
P,N Co-doped PNGF	320 mV@10 mA cm^{-2}	[24]

Table. S3 Comparison of overall water splitting properties for catalysts of superior electrochemistry materials

Catalyst	Overpotential (mV vs. RHE)	Ref
Mo/Mn-Ni_xS_y/NF	1.49 V @ 10 mA cm^{-2}	This work
Er-doped CoP NMs	1.58 V@10 mA cm^{-2}	[10]
MoS_2/NiS	1.61 V @10 mA cm^{-2}	[9]
$Ni_xCo_{3-x}S_4/Ni_3S_2$	1.53 V@10 mA cm^{-2}	[4]
Co_1Mn_1CH/NF	1.68 V@10 mA cm^{-2}	[5]
Zn-doped Co_3O_4	1.39 V@10 mA cm^{-2}	[18]
MoP/Ni_2P	1.55 V@10 mA cm^{-2}	[19]
Co_3O_4@MoS_2/CC	1.59 V@10 mA cm^{-2}	[20]
NiFe-P/NF	1.56 V@10 mA cm^{-2}	[21]
CoS_x/Ni_3S_2	1.57 V@10 mA cm^{-2}	[8]
P-Doped Co-Ni-S	1.60 V@10 mA cm^{-2}	[9]
Sn-Ni_3S_2/NF	1.46 V@10 mA cm^{-2}	[2]
N,S-codoped $Zn_{0.975}Co_{0.025}S/CoS_2$	1.59 V@10 mA cm^{-2}	[23]


a
Ni 2p
Sat.
Ni 2p1/2
Ni3+
Ni2+
Sat.
Ni 2p3/2
Ni3+
Ni2+
Ni0+
Intensity (a.u.)
885 880 875 870 865 860 855 850 845
Binding Evergy (eV)
b
S 2p
S-Ni
S 2p1/2
S 2p3/2
Intensity (a.u.)
174 172 170 168 166 164 162 160 158
Binding Evergy (eV)
c
Ni 2p
Sat.
Ni 2p1/2
Ni3+
Ni2+
Sat.
Ni 2p3/2
Ni3+
Ni2+
Ni0+
Intensity (a.u.)
885 880 875 870 865 860 855 850 845
Binding Evergy (eV)
d
S 2p
S-Ni
S 2p1/2
S2 2-
S 2p3/2
Intensity (a.u.)
174 172 170 168 166 164 162 160 158
Binding Evergy (eV)
e
Ni 2p
Sat.
Ni 2p1/2
Ni3+
Ni2+
Sat.
Ni 2p3/2
Ni3+
Ni2+
Ni0+
Intensity (a.u.)
885 880 875 870 865 860 855 850 845
Binding Evergy (eV)
f
S 2p
S-Ni
S 2p1/2
S 2p3/2
Intensity (a.u.)
174 172 170 168 166 164 162 160 158
Binding Evergy (eV)
g
Mo 3d
Mo(IV)3d3/2
Mo(VI)
Mo(IV)3d5/2
S 2s
Intensity (a.u.)
240 238 236 234 232 230 228 226 224 222
Binding Evergy (eV)
h
Ni 2p
Sat.
Ni 2p1/2
Ni3+
Ni2+
Sat.
Ni 2p3/2
Ni3+
Ni2+
Ni0+
Intensity (a.u.)
885 880 875 870 865 860 855 850 845
Binding Evergy (eV)

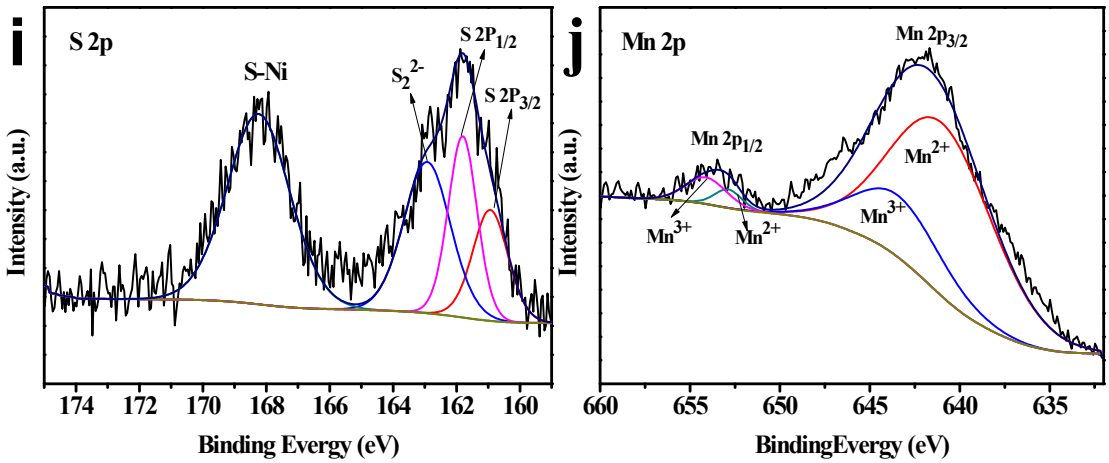


Fig. S1. High-magnification XPS spectra (a) Ni 2p and (b) S 2p of Ni_3S_2/NF, (c) Ni 2p and (d) S 2p of NiS@$Ni_{0.96}$S/NF, (e) Ni 2p, (f) S 2p and (g) Mo 3d of Mo-Ni_3S_2/NF, (h) Ni 2p, (i) S 2p, and (j) Mn 2p of Mn-NiS@$Ni_{0.96}$S/NF.

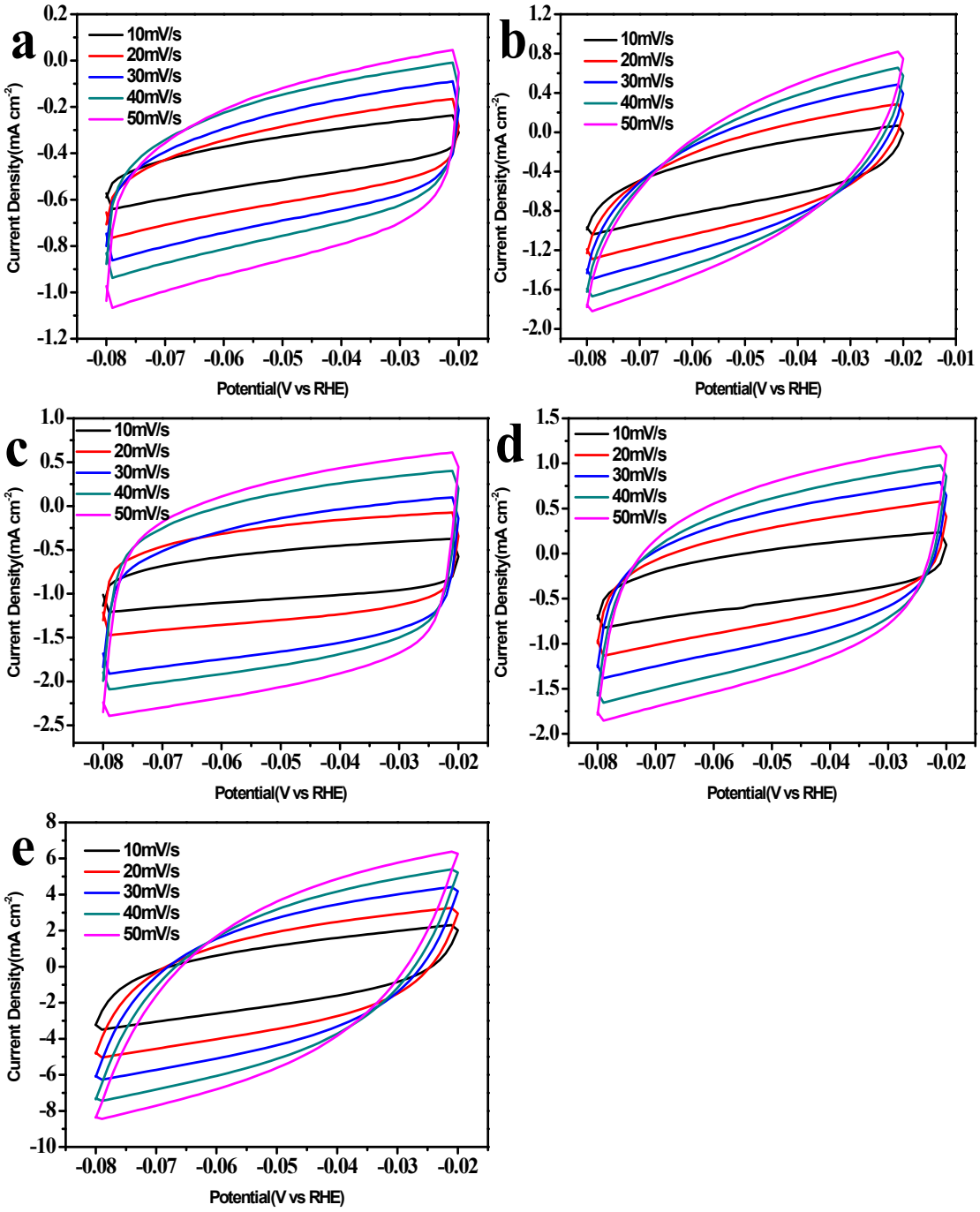


Fig. S2. CVs for HER of (a) Ni_3S_2/NF; (b) NiS@$Ni_{0.96}S$/NF, (c) Mo-Ni_3S_2/NF, (d) Mn-NiS@$Ni_{0.96}S$/NF, (e) Mo/Mn-Ni_xS_y/NF with different scan rates (10-50 mV s^{-1}) in the region from -1.08 to -1.02 vs RHE.

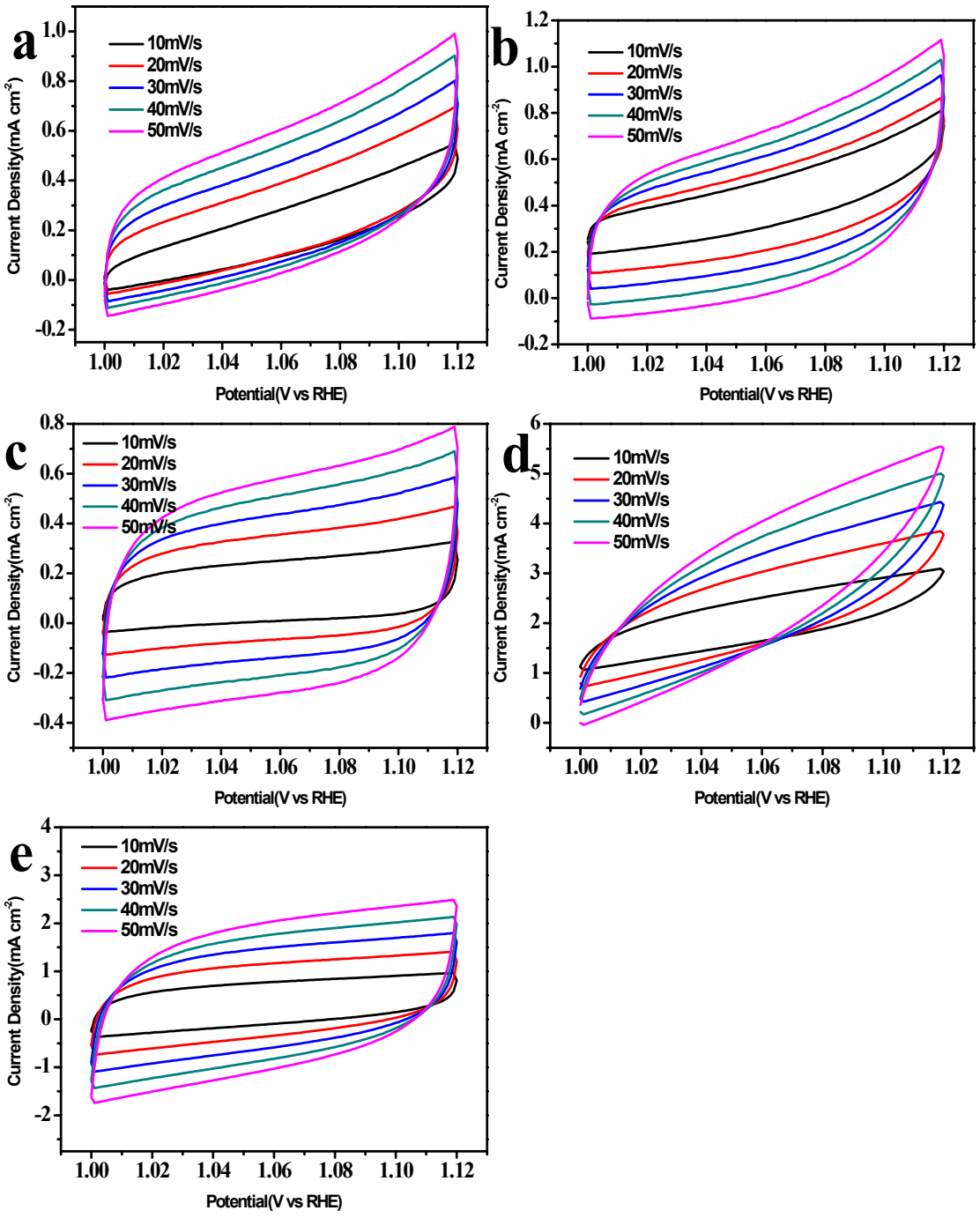


Fig. S3. CVs for OER of (a) Ni_3S_2/NF; (b) NiS@$Ni_{0.96}S$/NF; (c) Mo-Ni_3S_2/NF; (d) Mn-NiS@$Ni_{0.96}S$/NF, (e) Mo/Mn-Ni_xS_y/NF with different scan rates (10-50 mV s^{-1}) in the region from 1.00 to 1.12 vs RHE.

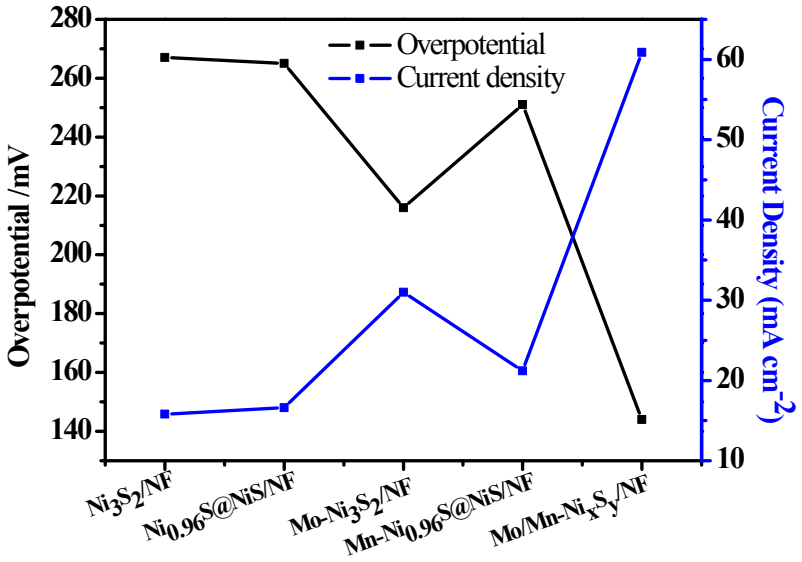


Fig. S4 Comparison of the overpotentil (HER) required for achieving current density of 10 mA cm-2, and the current density at overpotential of 300 mV for Ni3S2/NF, NiS@Ni0.96S/NF, Mo-Ni3S2/NF, Mn-NiS@Ni0.96S/NF, and Mo/Mn-NixSy/NF.

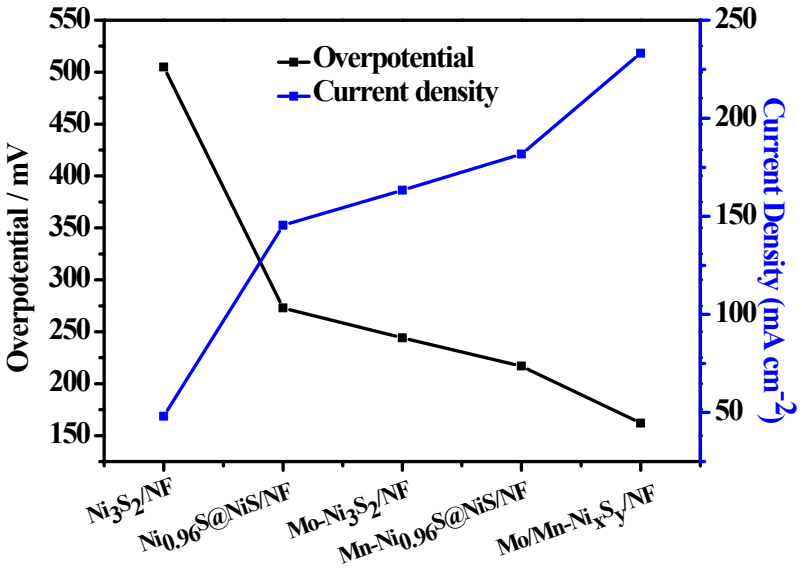


Fig. S5 Comparison of the overpotentil (OER) required for achieving current density of 50 mA cm-2, and the current density at overpotential of 500 mV for Ni3S2/NF, NiS@Ni0.96S/NF, Mo-Ni3S2/NF, Mn-NiS@Ni0.96S/NF, and Mo/Mn-NixSy/NF.

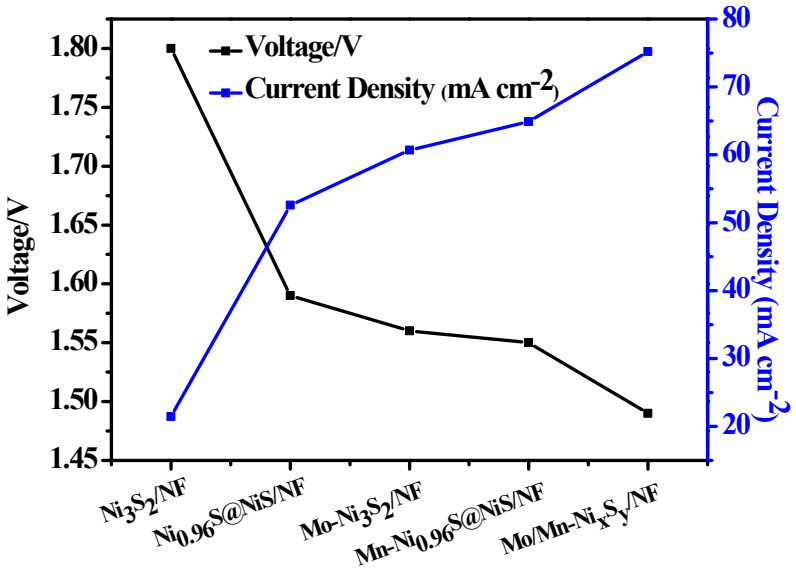


Fig. S6 Comparison of the voltage required for achieving current density of 10 mA cm-2, and the current density at voltage of 1.9 V for Ni3S2/NF, NiS@Ni0.96S/NF, Mo-Ni3S2/NF, Mn-NiS@Ni0.96S/NF, and Mo/Mn-NixSy/NF.

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