Supplementary Information (SI) for Journal of Materials Chemistry A.

Supporting Information

Self-adaptive ternary NiCoMo-carbon composite as a bifunctional electrocatalyst for high-current-density water splitting

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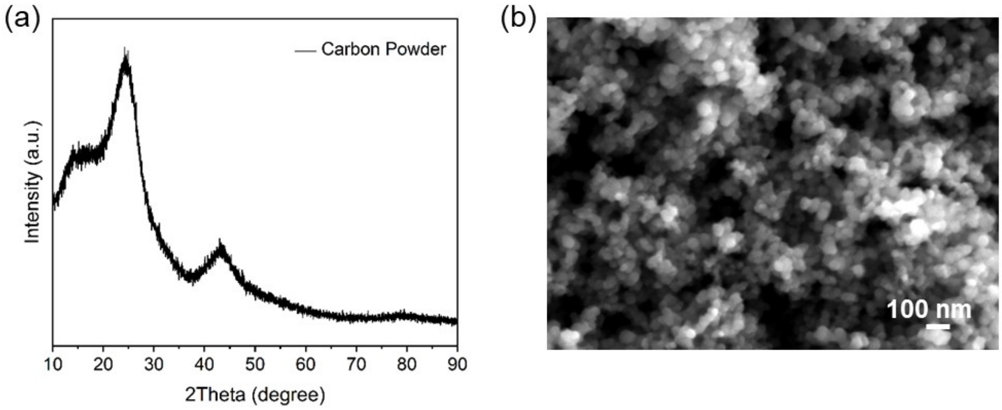

Fig. S1 (a) XRD pattern of carbon powders. (b) SEM image of carbon powders.

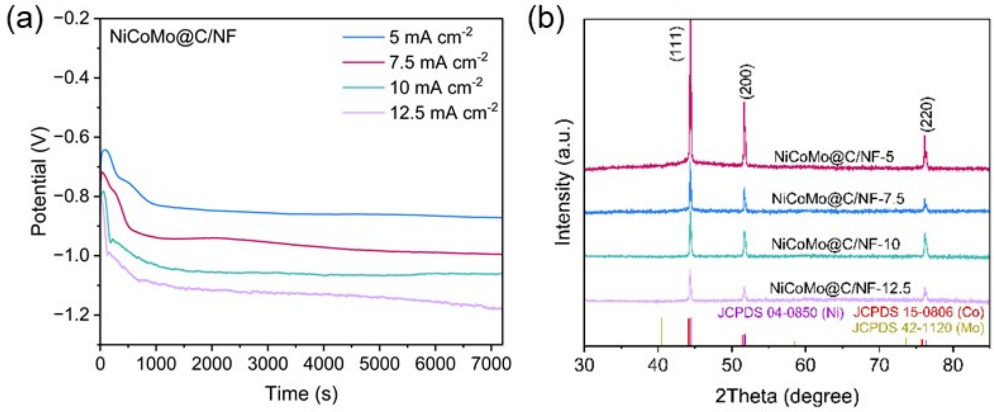

Fig. S2 (a) Voltage-time (V-t) curves of NiCoMo@C/NF at various current densities. (b) XRD patterns of NiCoMo@C/NF at various current densities.

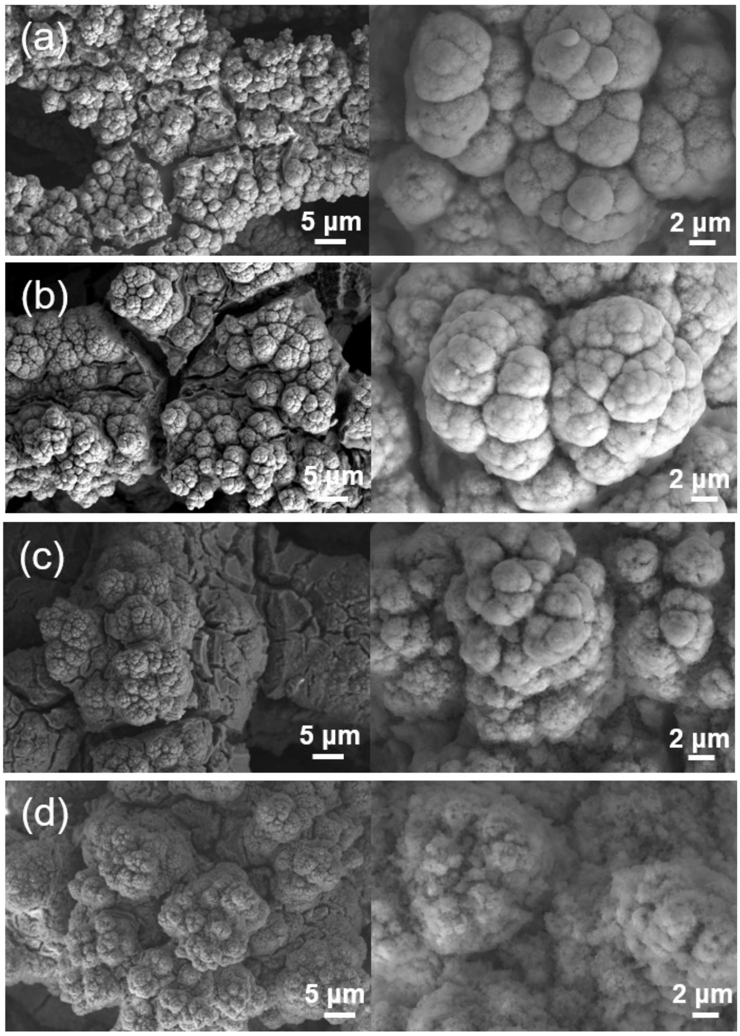

Fig. S3 SEM images of NiCoMo@C/NF at different densities: (a) −5 mA cm^{-2}; (b) −7.5 mA cm^{-2}; (c) −10 mA cm^{-2}; (d) −12.5 mA cm^{-2}.

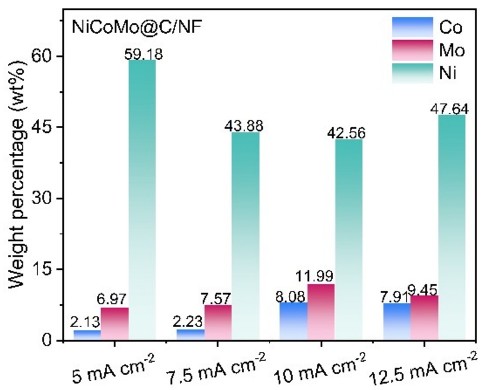

Fig. S4 Weight percentages of Ni, Co, and Mo in NiCoMo@C/NF under different current densities based on the EDX data.

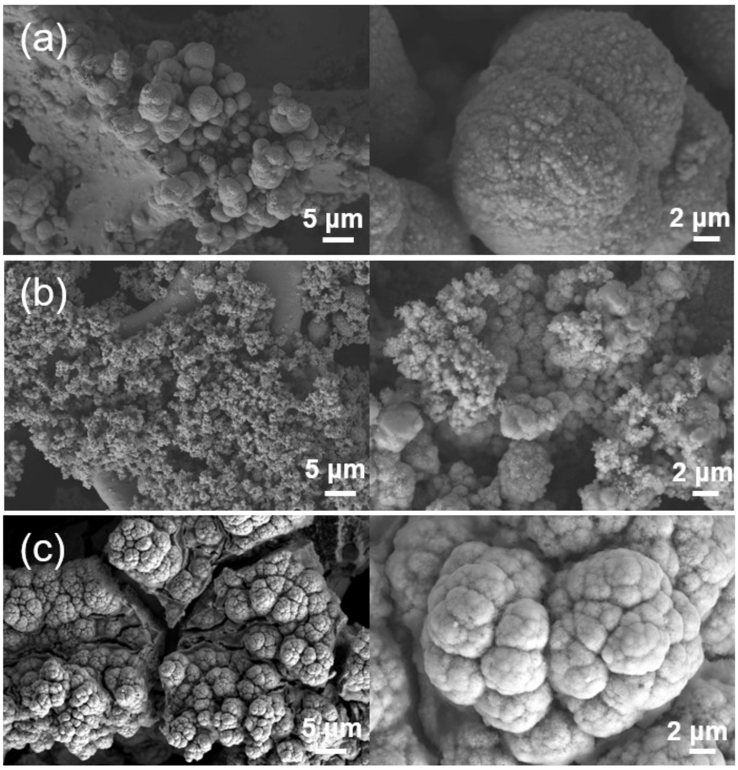

Fig. S5 SEM images of (a) Ni@C/NF, (b) NiCo@C/NF, and (c) NiCoMo@C/NF electrodeposited at a current density of −7.5 mA cm^{-2}.

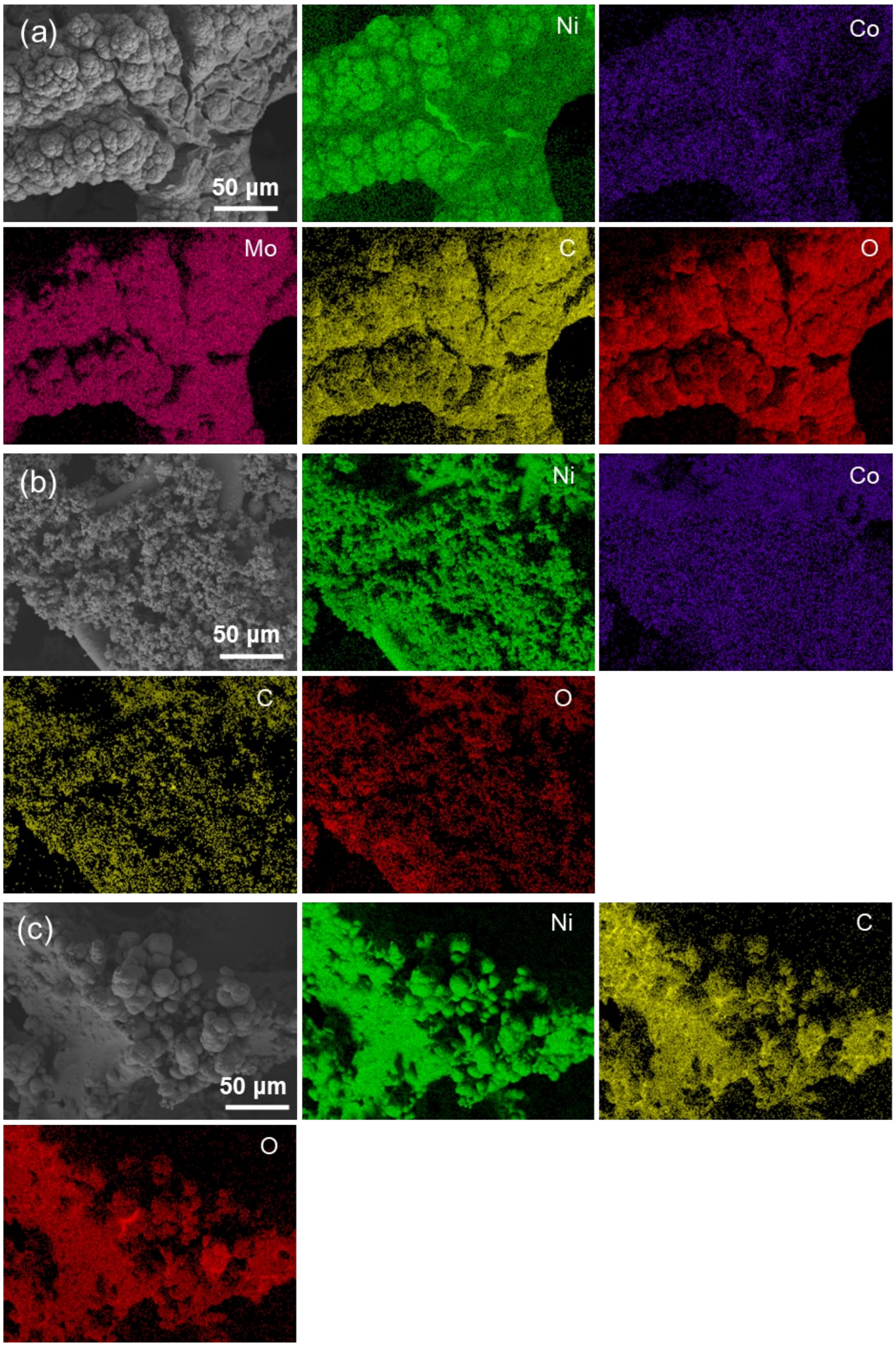

Fig. S6 (a) SEM and EDX elemental mapping images of NiCoMo@C/NF; (b) SEM and EDX elemental mapping images of NiCo@C/NF; (c) SEM and EDX elemental mapping images of Ni@C/NF.

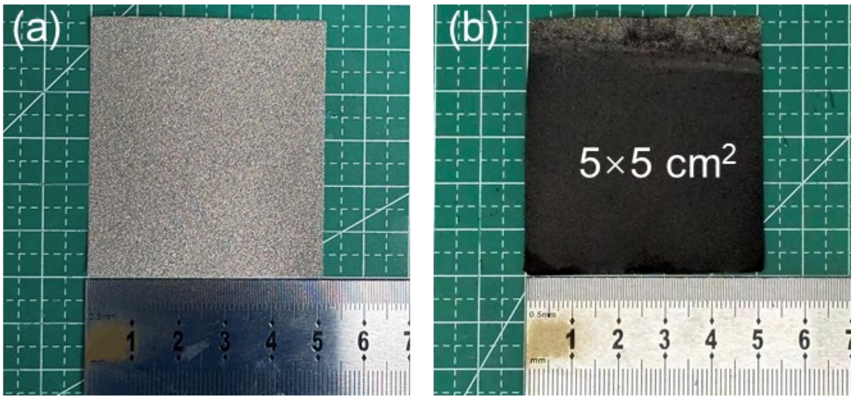

Fig. S7 Physical images of bare nickel foam and NiCoMo@C/NF with a size of 5 cm × 5 cm.

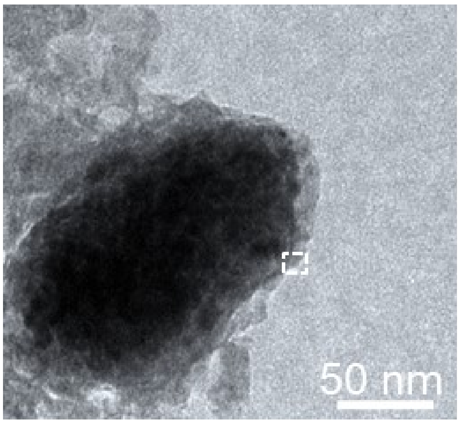

Fig. S8 TEM image of NiCoMo@C/NF.

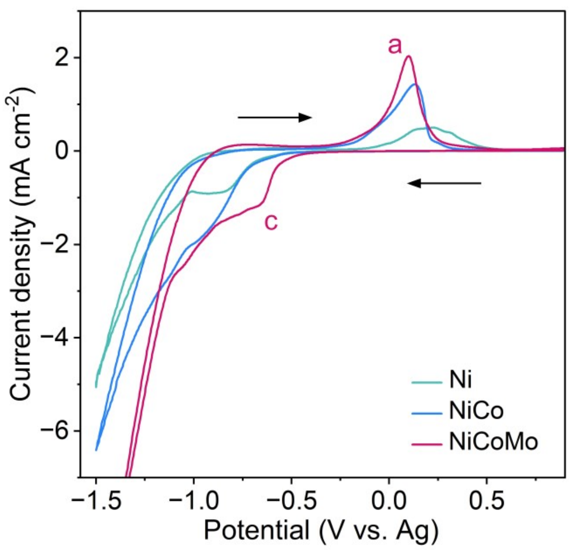

Fig. S9 CV curves in three ChCl-EG electrolytes containing $NiCl_2$, $NiCl_2$-$CoCl_2$, and $NiCl_2$-$CoCl_2$-Na_2MoO_4 systems with C powders, respectively.

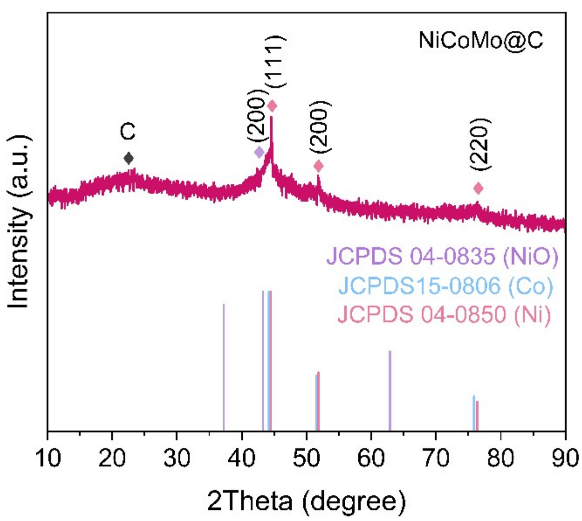

Fig. S10 XRD patterns of NiCoMo@C powders.

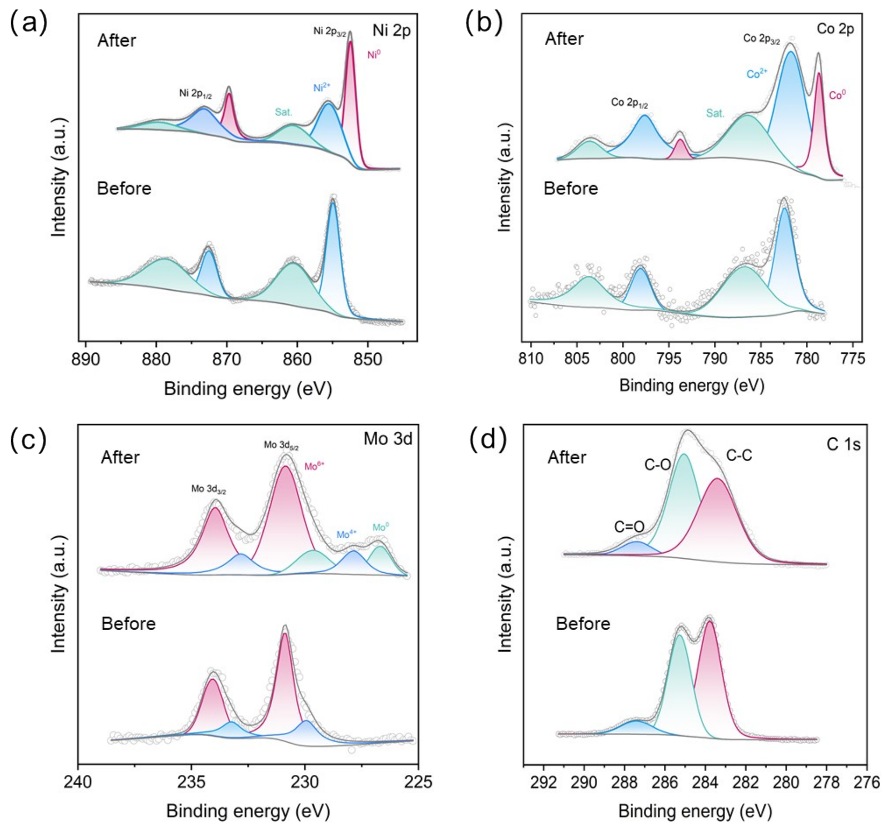

Fig. S11 XPS spectra of NiCoMo@C/NF before and after argon ion sputtering (with an etching depth of ~10 nm) : (a) Ni 2p; (b) Co 2p; (c) Mo 3d; (d) C 1s.

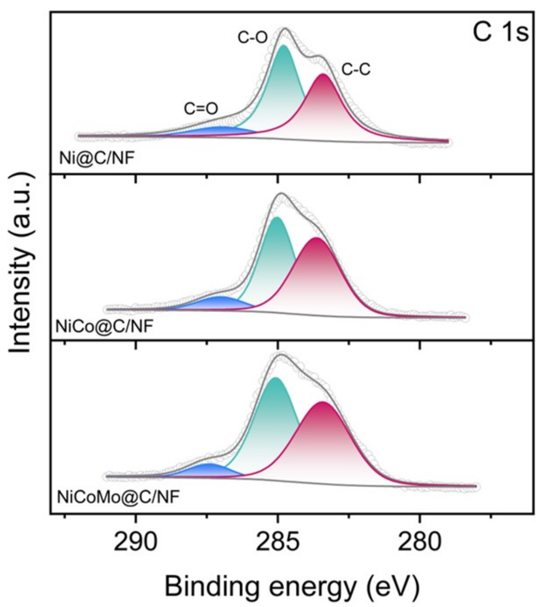

Fig. S12 XPS of C 1s region for Ni@C/NF, NiCo@C/NF, and NiCoMo@C/NF electrodeposited at a current density of −7.5 mA cm^{-2}.

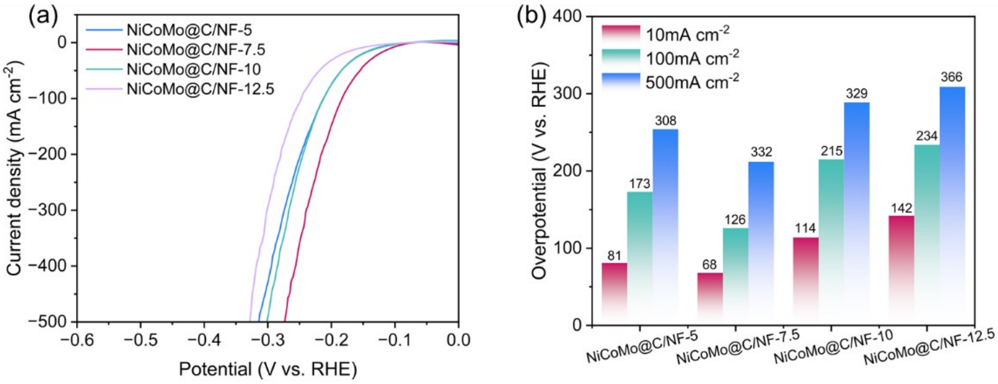

Fig. S13 (a) LSV curves for NiCoMo@C/NF electrodeposited at different current densities (−5 mA cm^{-2}, −7.5 mA cm^{-2}, −10 mA cm^{-2}, and −12.5 mA cm^{-2}); (b) Overpotentials of electrodes obtained at different current densities at 10 mA cm^{-2}, 100 mA cm^{-2}, and 1000 mA cm^{-2} for HER.

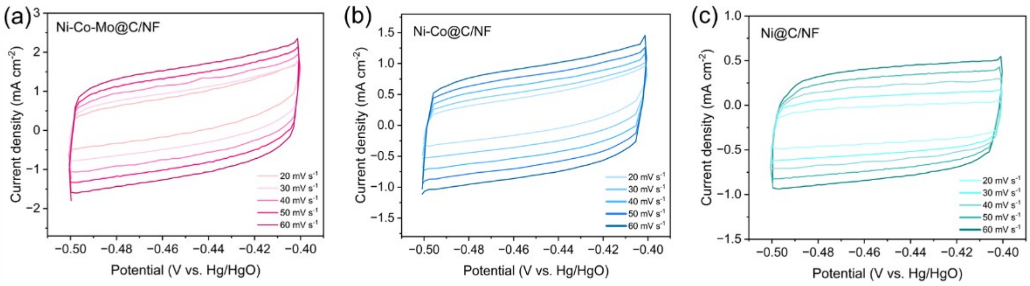

Fig. S14 Electrochemical active surface area analysis by the CV scans in a non-Faradaic potential range of as-prepared electrodes for HER: (a) NiCoMo@C/NF; (b) NiCo@C/NF; (c) Ni@C/NF in 1.0 M KOH at scan rate of 20 mV s^{-1}, 30 mV s^{-1}, 40 mV s^{-1}, 50 mV s^{-1}, and 60 mV s^{-1}.

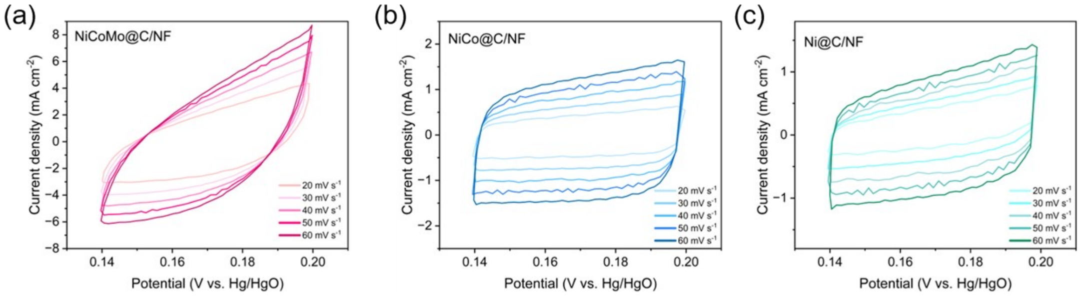

Fig. S15 Electrochemical active surface area analysis by the CV scans in a non-Faradaic potential range of as-prepared electrodes for OER: (a) NiCoMo@C/NF; (b) NiCo@C/NF; (c) Ni@C/NF in 1.0 M KOH at scan rate of 20 mV s^{-1}, 30 mV s^{-1}, 40 mV s^{-1}, 50 mV s^{-1}, and 60 mV s^{-1}.

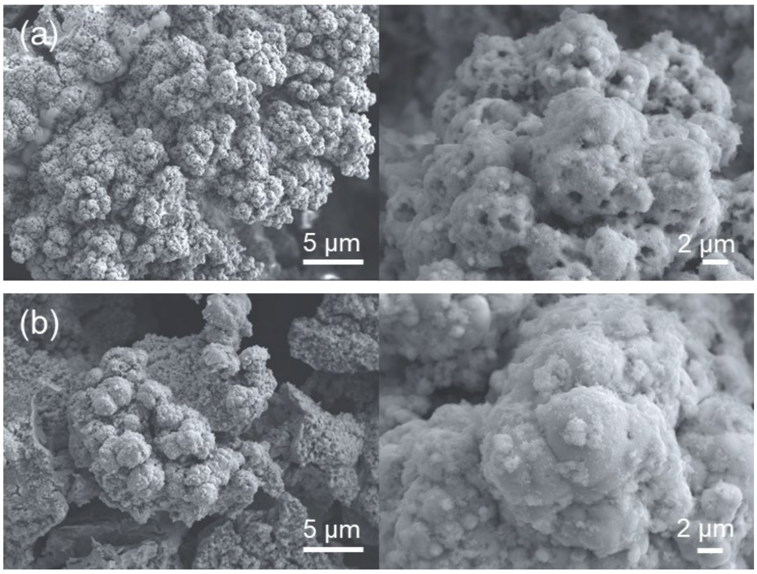

Fig. S16 SEM images of NiCoMo@C/NF after stability tests for (a) HER and (b) OER.

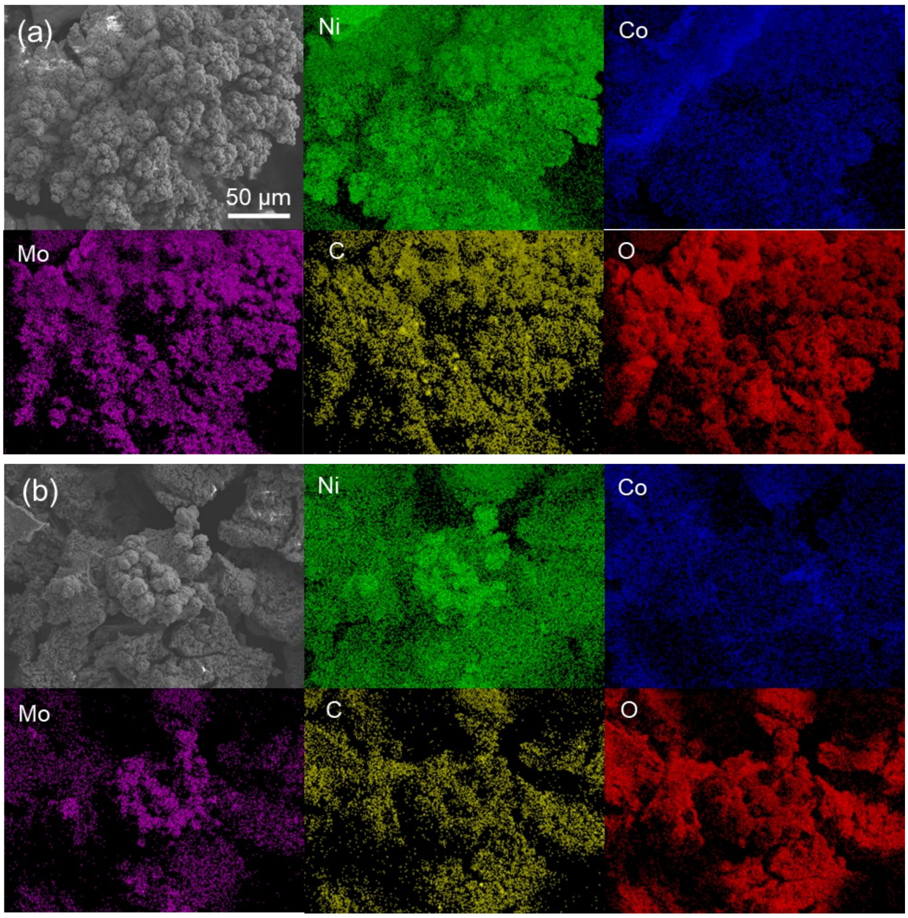

Fig. S17 SEM and EDX elemental mapping images of NiCoMo@C/NF after stability tests for (a) HER and (b) OER.

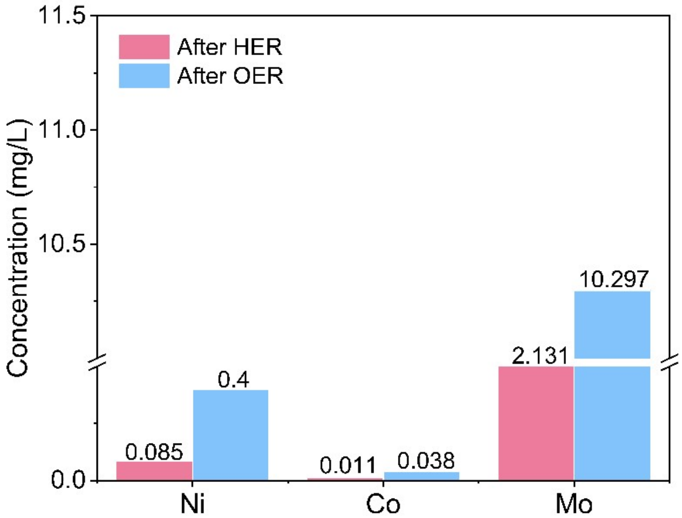

Fig. S18 Metal concentrations in the electrolyte after HER and OER stability testing.

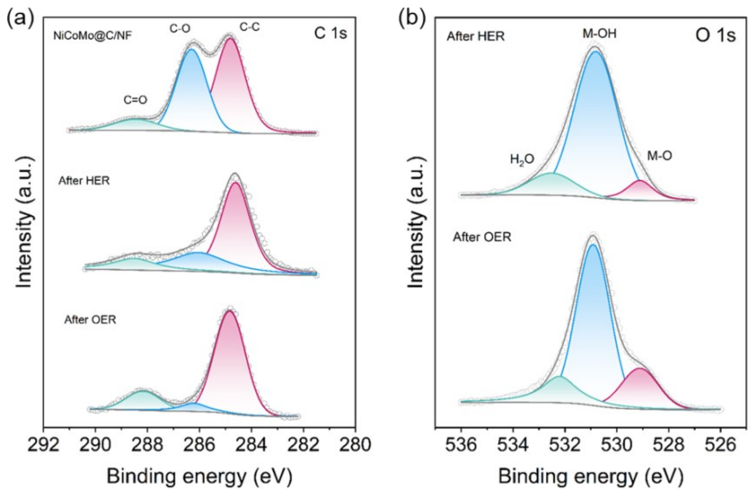

Fig. S19 XPS spectra of NiCoMo@C/NF before and after stability testing for HER and OER: (a) C 1s; (b) O 1s.

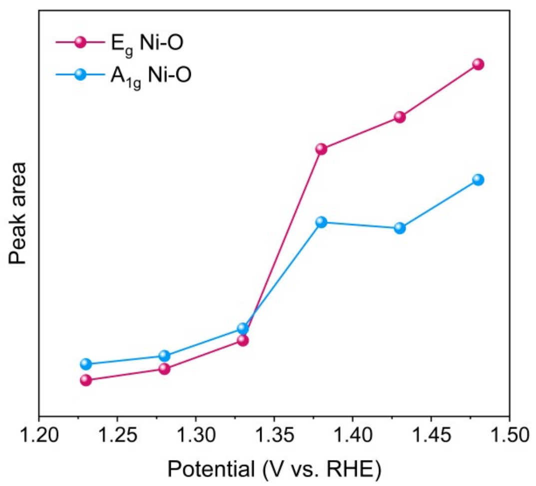

Fig. S20 Plot of the Ni-O characteristic peak area versus potential.

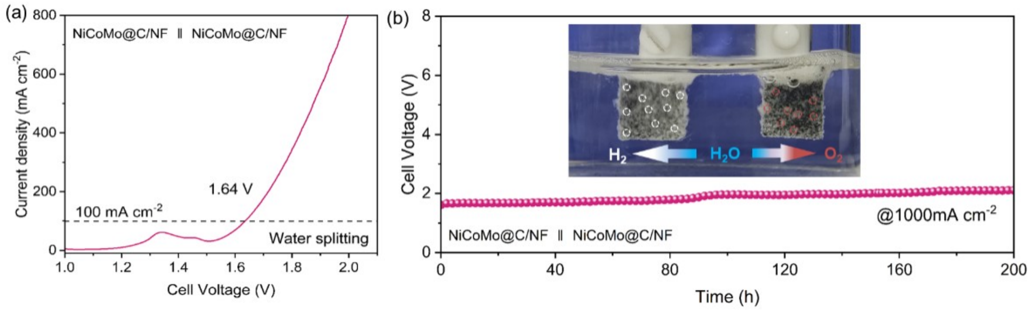

Fig. S21 (a) LSV curve of NiCoMo@C/NF || NiCoMo@C/NF for overall water splitting in 1.0 M KOH; (b) Long-term stability of NiCoMo@C/NF || NiCoMo@C/NF at 1000 mA cm^{-2}. The inset shows the process of overall water splitting on the NiCoMo@C/NF electrode.

Table S1. Comparisons of overpotentials and Tafel slopes for NiCoMo@C/NF at 10 mA cm^{-2} with other reported electrocatalysts for HER in alkaline solutions.

Electrocatalysts	Overpotential (mV)	Tafel slope (mV dec^{-1})	Test conditions	References
NiCoMo@C/NF	59	32.4	1.0 M KOH (with 95% IR compensation)	This work
Ni-Co-B-P	166	55.6	1.0 M KOH	1
Mn-Co-P@Ni-Co-NF	75	79	1.0 M KOH	2
Co-Ni-NF	68	131	0.1 M KOH (with 90% IR compensation)	3
NiCo-MOFs	125	78	N_2-saturated 1.0 M KOH	4
Ni_1Co_2-LDH/Ni/NiO-CNFs	152	50.5	1.0 M KOH	5
Ni-Co/CC	62	63.5	1.0 M KOH	6
Ni-Co/N@CW	143	105	1.0 M KOH (with 90% IR compensation)	7
NCMO@NC	92	115	1.0 M KOH + 1.0 M CH_3OH	8
Cu-Zn-Ni-Co	67	97.7	1.0 M KOH	9
NiCo(CrV)	87	96	1.0 M KOH	10
$NiCo_2S_4/ReS_2$	85	78.3	1.0 M KOH	11
GO/Ni-Co/CW	70	70.8	1.0 M KOH	12
MOF/NiCo	98	48	1.0 M KOH (with 90% IR compensation)	13

NiCo-SAD-NC	61	31.5	1.0 M KOH	14
Mo-NiCo	235.8	161.1	1.0 M KOH (with 90% IR compensation)	15
$Co_1Mo_1Ni_{0.5}Pi$	96	145.3	1.0 M KOH	16

Table S2. Comparisons of overpotentials for NiCoMo@C/NF at at 1000 mA cm^{-2} with other reported electrocatalysts for HER in 1.0 M KOH at room temperature.

Materials	Overpotential @1000 mA cm^{-2} (mV)	References
NiCoMo@C/NF	289	This work
$Ni-WO_3/NF$	~300	17
FeCoNiCrMn HEA/NM	425	18
Fe-rich MEA	343.6	19
$Mn@Ni_3N-Co_3N$	~350	20
NiCoMoO	566	21
$ac-NiCo(OH)_2/NF$	510	22
$Fe-CoP@Fe-Ni_2P/NF$	310	23
FeMoS@CoFe LDH	376	24
$NiCo/V_2O_3/C$	396	25
$Cu-FeOOH/Fe_3O_4$	349	26

Table S3. Comparisons of overpotentials for NiCoMo@C/NF at 10 mA cm^{-2} with other reported electrocatalysts for OER.

Electrocatalysts	Overpotential (mV)	Electrolyte	References
NiCoMo@C/NF	214	1.0 M KOH (with 95% IR compensation)	This work
NiCo	288	1.0 M KOH	27
EP-NiCo/EGR	300	1.0 M KOH (with 90% IR compensation)	28
NiFeCr/NF	233	1.0 M KOH (with 90% IR compensation)	29
CoNi-$Ti_3C_2T_x$	241	N_2-saturated 1.0 M KOH	30
NiCo-CAT MOF	307	1.0 M KOH	31
NiCo(CrV)	320	1.0 M KOH	10
NiFeB	319	N_2-saturated 1.0 M KOH (with 85% IR compensation)	32
NiCo-$NiCoO_2$@NC	318	O_2-saturated 1.0 M KOH	33
Ni-60-V_2O_5@NC	300	1.0 M KOH	34
NF@NiMoCo	277	O_2-saturated 1.0 M KOH	35
(Ni, Cu)O@C	330	1.0 M KOH (with 90% IR compensation)	36

Table S4. Comparisons of overpotentials for NiCoMo@C/NF at 1000 mA cm^{-2} with other reported electrocatalysts for OER in 1.0 M KOH at room temperature.

Materials	Overpotential @1000 mA cm^{-2} (mV)	References
NiCoMo@C/NF	354	This work
Ni-WO_3/NF	~550	17
FeCoNiCrMn HEA/NM	560	18
ac-$NiCo(OH)_2$/NF	364	22
NiCoMoO	631	21
$Fe_{0.125}Ni_{0.375}Mo_{0.5}$ NFs	426	37
NiFe LDH-CeW@NFF	353.8	38
$Fe_xNi_{2-x}P_4O_{12}$/RGO	380	39
CrO^{2-}-NiFe LDH/Cr_2O_3	355	40
Fe-NiCo-LDH	400	41

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