Electronic Supplementary Material (ESI) for Sustainable Energy & Fuels.

Supporting Information

Bifunctional catalytic activity of a Ni-Co layered double hydroxide for the electro-oxidation of water and methanol

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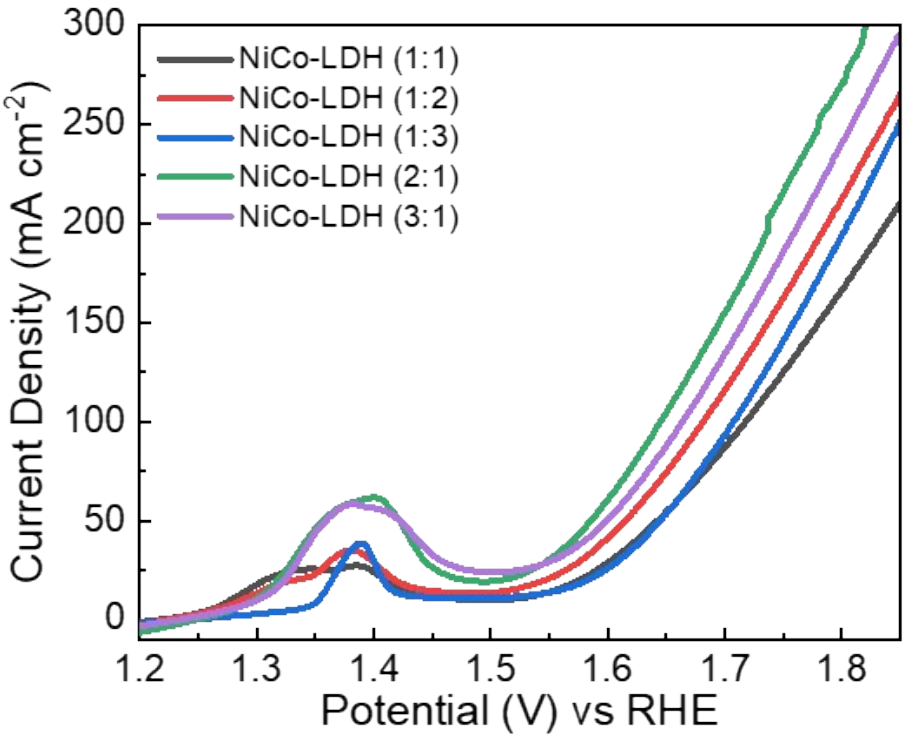

Figure S1 OER polarization curves of NiCo-LDH with different molar ratio

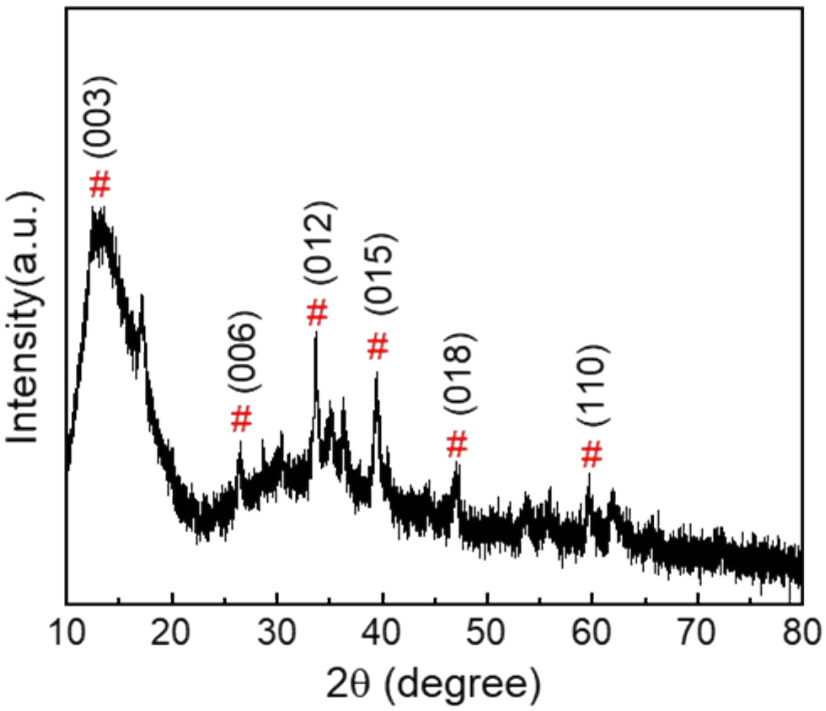

Figure S2 XRD spectra of the powder sample of NiCo-LDH

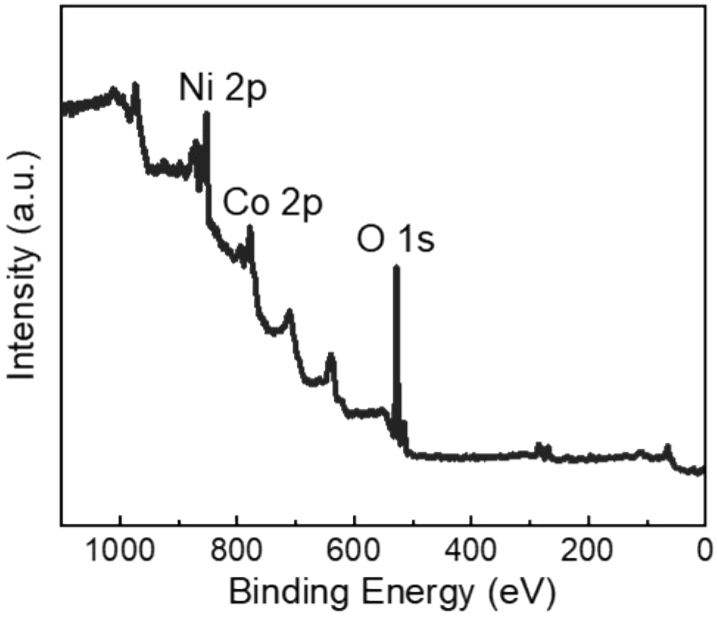

Figure S3 High-resolution XPS survey spectrum of NiCo-LDH nanowires

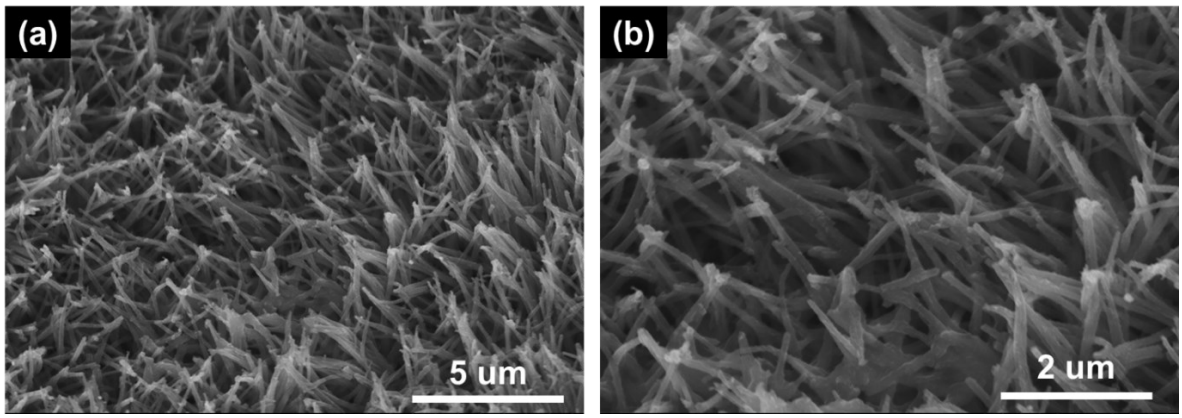

Figure S4 FE-SEM images of NiCo-LDH nanowires after 50 h stability

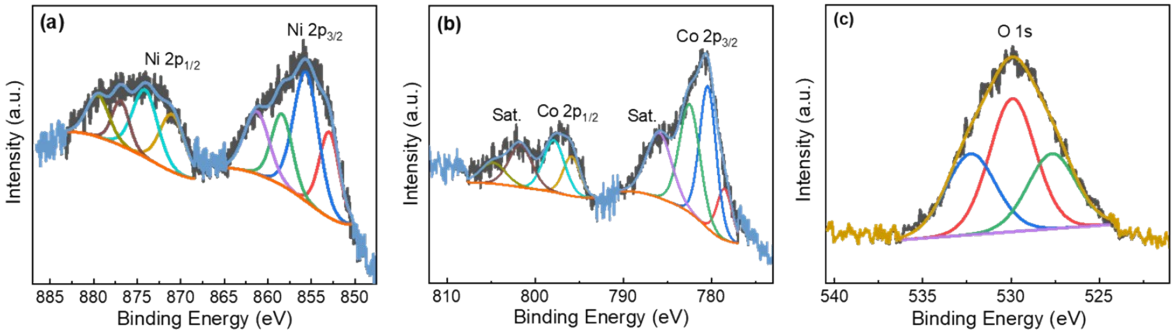

Figure S5 XPS spectra of NiCo-LDH nanowires (a) spectrum of Ni 2p (b) spectrum of Co 2p (c) spectrum of O 1s after 50 h stability in 1 M KOH

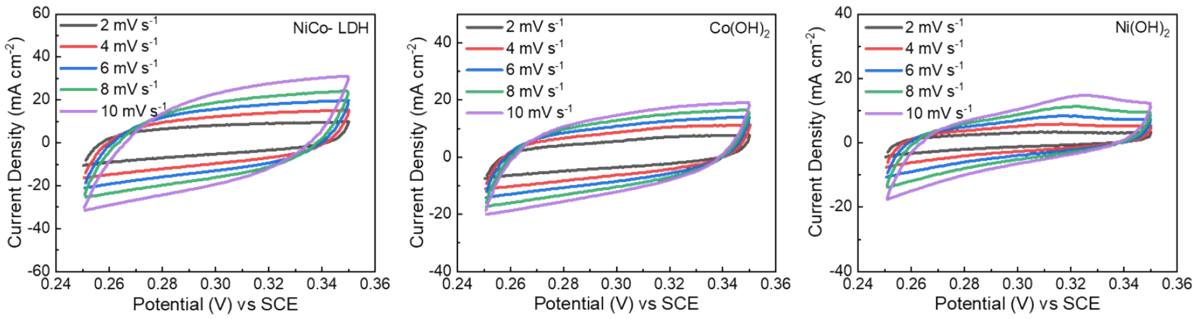

Figure S6 CV curves of NiCo-LDH, $Co(OH)_2$, and $Ni(OH)_2$ in 1 M KOH at different scan rates

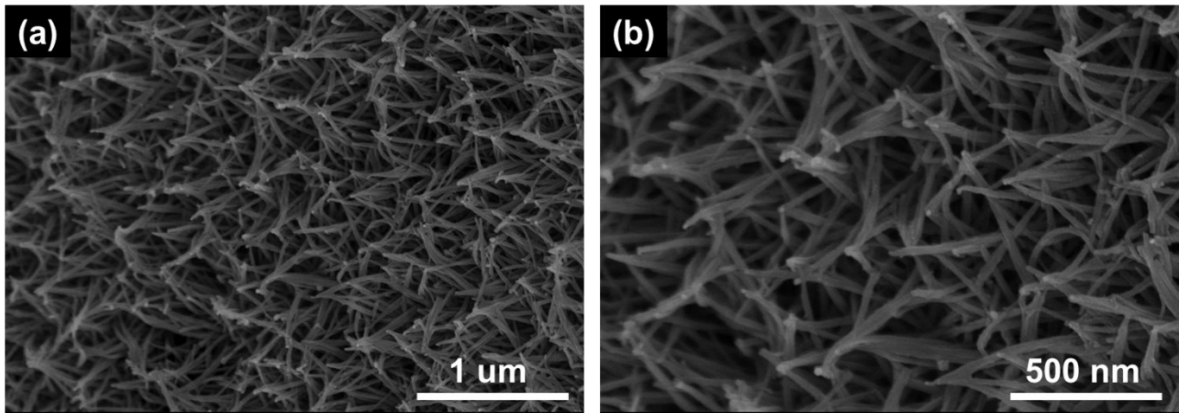

Figure S7 FE-SEM images of NiCo-LDH nanowires after 2000 s stability for MOR in 1M KOH with 0.5 M methanol

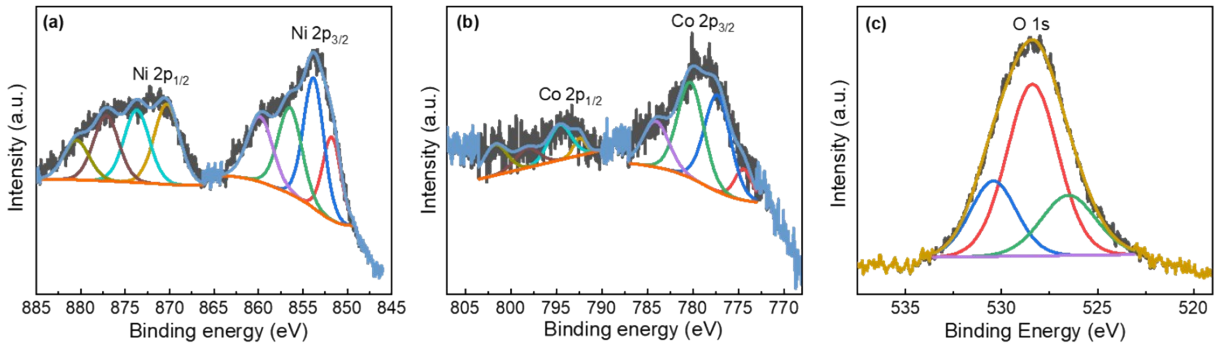

Figure S8 XPS spectra of NiCo-LDH nanowires (a) spectrum of Ni 2p (b) spectrum of Co 2p (c) spectrum of O 1s after 2000 s stability in 1 M KOH with 0.5 M methanol

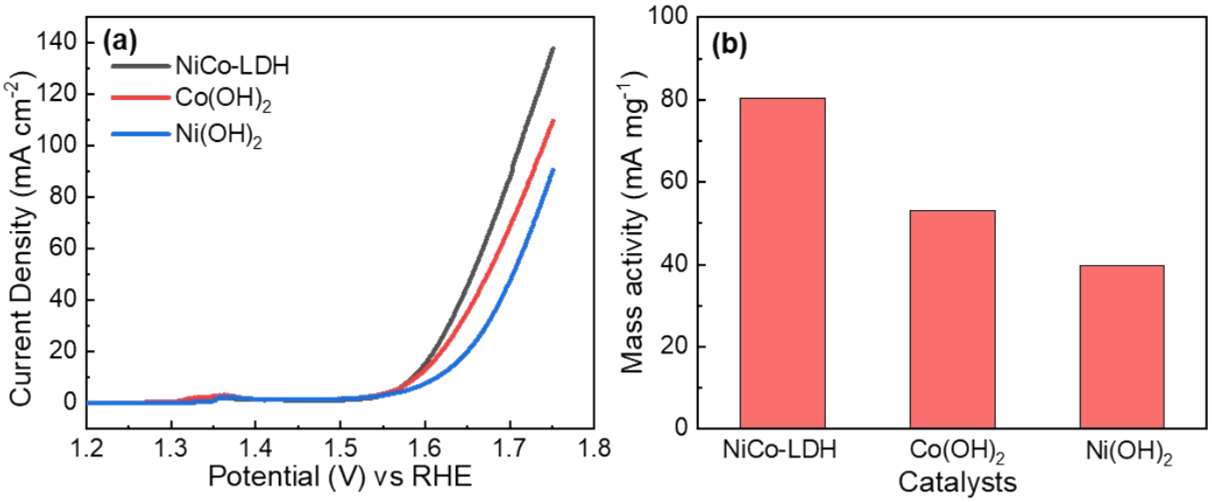

Figure S9 (a) OER polarization curves of NiCo-LDH, $Co(OH)_2$, and $Ni(OH)_2$ deposited on glassy carbon electrode. (b) Corresponding mass activities of NiCo-LDH, $Co(OH)_2$, and $Ni(OH)_2$ deposited on glassy carbon electrode at potential of 1.7 V.

Preparation of NiCo-LDH, $Co(OH)_2$, and $Ni(OH)_2$ on glassy carbon electrode

The NiCo-LDH or $Co(OH)_2$ or $Ni(OH)_2$ also deposited onto a glassy carbon electrode (GC). To prepare NiCO-LDH on the GC electrode, 5 mg of NiCo-LDH was dispersed in 1 mL of a mixed solution containing 495 µL of ethanol, 490 µL of water, and 15 µL of 5 Wt.% Nafion solution. The mixture was then sonicated to form a homogeneous catalyst ink. Then the catalyst ink was drop casted on the surface of the 0.07 cm^{-2} GC electrode and dried in air. The amount of NiCo-LDH loaded onto the GC electrode was approximately 1.1 mg cm^{-2}. The same procedure was applied to deposit $Ni(OH)_2$ and $Co(OH)_2$.

Figure S9 (a) shows the OER polarization curve obtained with NiCo-LDH, $Co(OH)_2$, and $Ni(OH)_2$ deposited onto the GC electrode. The mass activity values of NiCo-LDH, $Co(OH)_2$, and $Ni(OH)_2$ are 80.34, 53.04, and 39.80 mA mg^{-1} respectively (**Figure S9 (b)**).

Table S1 Comparison of OER performances with previously reported NiCo-based electrocatalysts

Catalyst	η (mV) at 10 mA·cm^{-2}	Tafel slope (mV·dec^{-1})	Electrolyte	ref
Ni-Co Nanowire	302	43.6	1 M KOH	S1
NiCo-LDH nanoarrays	307	64	1 M KOH	S2
NiCo-LDH nanosheets arrays	271	72	1 M KOH	S3
$Ni_xCo_{2x}(OH)_{6x}$@ graphene	280	67	1 M KOH	S4
NiOOH–$NiCr_2O_4$ nanosheets	271 (20 mA·cm^{-2})	104	1 M KOH	S5
NiO/$NiCo_2O_4$ Nanocrystals	264	79.4	1 M KOH	S6
NiCo/$NiCoO_x$-FeOOH	278	47.5	1 M KOH	S7
NiCoFe-LDH	280	34	1 M KOH	S8
$Ni_xCo_{1-x}(OH)_2$ nanoplate	270	59	1 M KOH	S9
U-NiO/$NiCo_2O_4$	387	49	0.1 M KOH	S10
C-NiO/$NiCo_2O_4$	430	44	0.1 M KOH	S10
NiO/$NiCo_2O_4$ nanosheets	360	61	1 M NaOH	S11
$NiCo_2O_4$	430	139	1 M NaOH	S11
NiO/$NiCo_2O_4$ nanocrystals	264	79.3	1 M KOH	S12
$NiCo_2O_4$ on stainless steel	530	49	0.1 M NaOH	S13
$NiCo_2O_4$ nanoframes (Cu_2O)	265	82	1 M KOH	S14
$NiCo_2O_4$ nanowires	460	90	1 M KOH	S15
MOF-NiO/ $NiCo_2O_4$	410	49	0.1 M KOH	S16
NiCo-LDH	270 (20 mA cm^{-2})	82	1 M KOH	This work

Table S2 Comparison of current densities, scan rate and applied potential with previously reported NiCo-based electrocatalyst for MOR in 1 M KOH

Electrocatalyst	Methanol Concentration/mol L^{-1}	Scan Rate/mV s^{-1}	Applied Voltage	Current Density/mA cm^{-2}	Ref
$NiCo_2O_4$ nanosheet	0.5	10	0.6 V vs. SCE	111	17
NiO nanosheet @ nanowire	0.5	10	1.62 V vs. RHE	89	18
$NiCo_2O_4$ nanocloth	0.5	10	0.6 V vs. SCE	134	17
NiO nanosheets	0.5	50	0.7 V vs. Ag/AgCl	85.3	19
$NiCo_2O_4$/carbon xerogel	0.5	50	0.6 V vs. Ag/AgCl	98	20
Ni/Graphene	0.75	50	0.728 V vs. Ag/AgCl	147.108	21
$NiMoO_4$/C	2.0	50	0.8 V vs Hg/HgO	49	22
Mesoporous $NiCo_2O_4$	0.5	10	0.6 V vs.Hg/HgO	125	23
Co_3O_4/ $NiCo_2O_4$	0.5	10	0.6 V vs. Hg/HgO	140	24
NiCo-LDH	0.5	10	0.5 V vs. SCE	761	This work

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