Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supplementary Materials

NiOOH@Cobalt Copper Carbonate Hydroxide Nanorods as Bifunctional Catalysts for Highly Efficient Water and Hydrazine Oxidation

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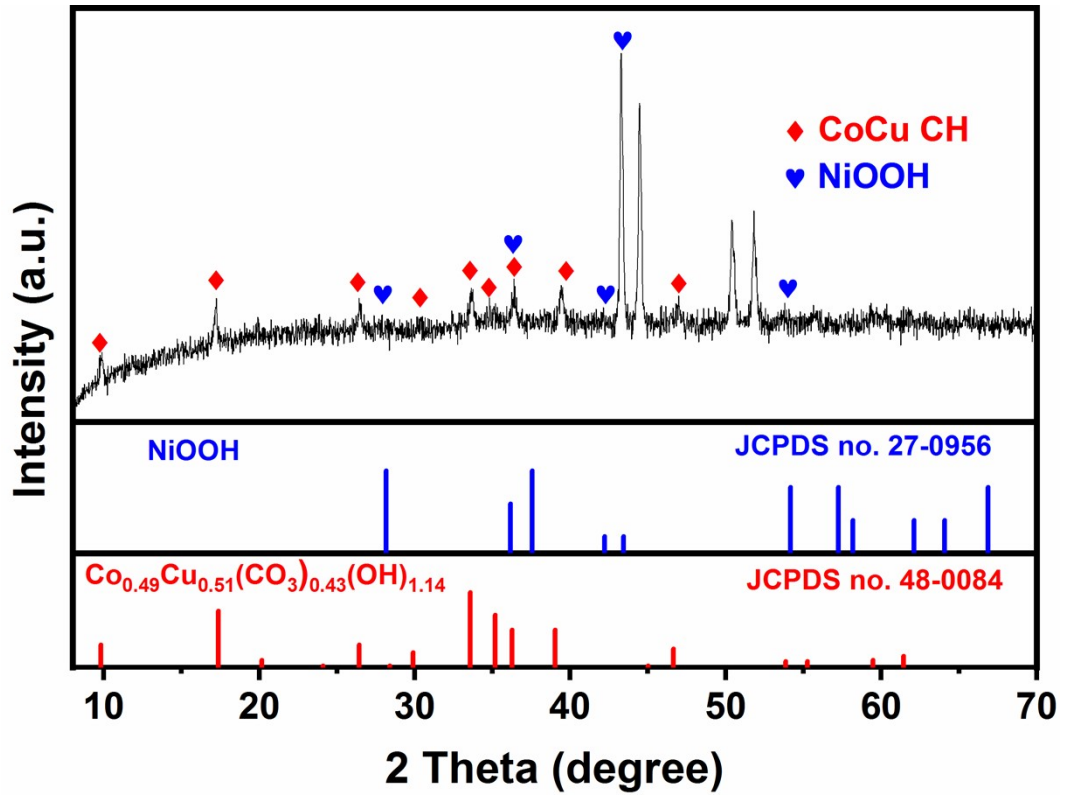

Figure S1 XRD pattern of NiOOH@CoCu CH powder with the deposition time of NiOOH prolonged to 30 min, and and the standard patterns of orthorhombic cobalt copper carbonate hydroxide (JCPDS no. 48-0084) and nickel oxide hydroxide (JCPDS no. 27-0956).

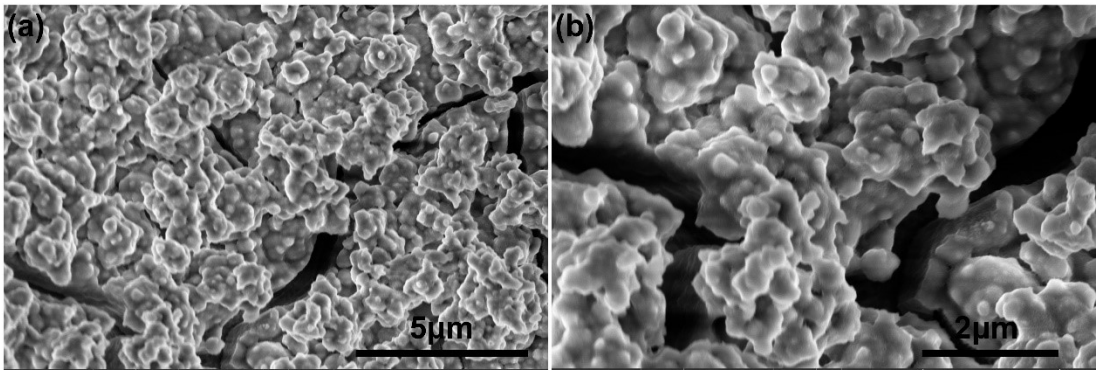

Figure S2 SEM images of NiOOH directly deposited on nickel foam (NiOOH/NF)

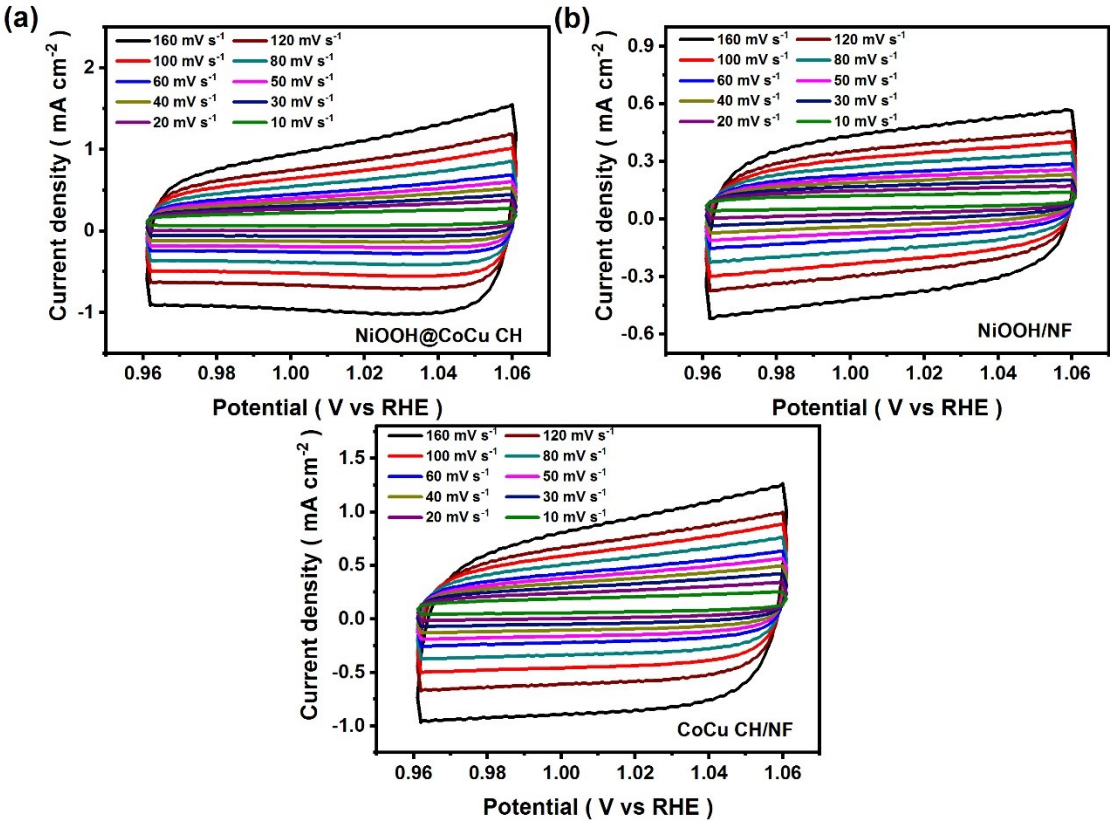

Figure S3 Electrochemical measurements for OER: cyclic voltammogram (CV) curves at different scan rates for OER: (a) NiOOH@CoCu CH, (b) NiOOH/NF and (c) CoCu CH/NF.

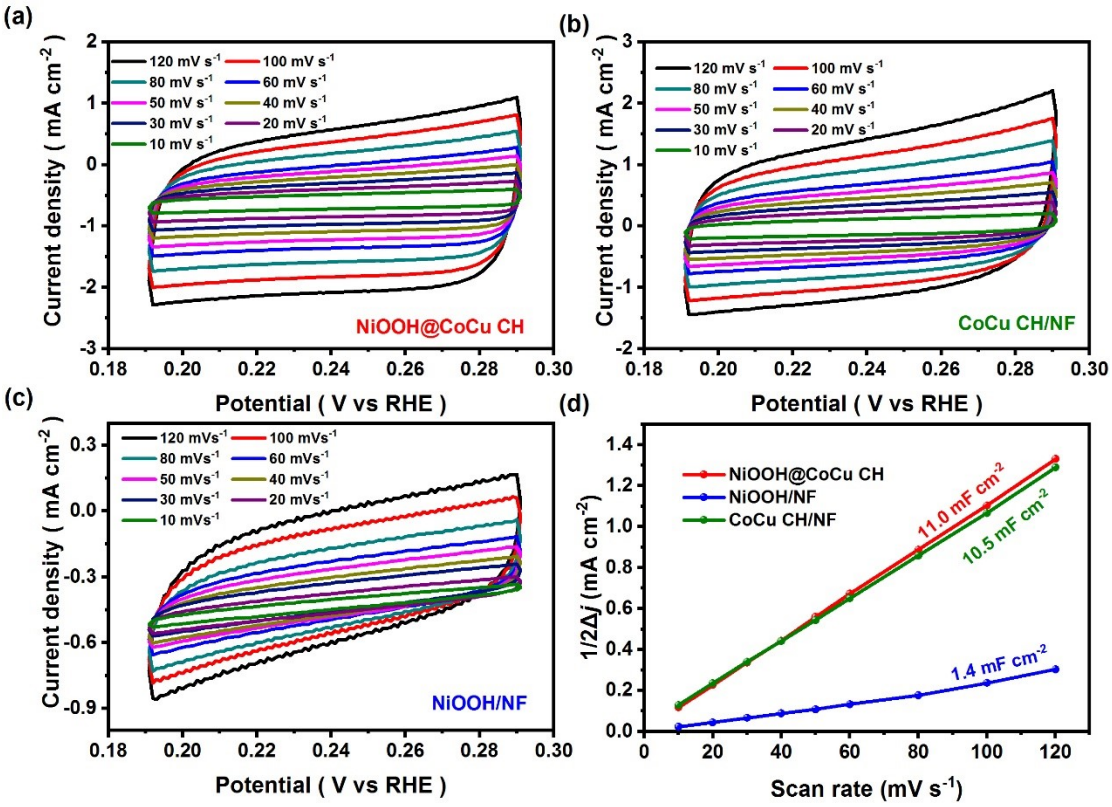

Figure S4 Electrochemical measurements for HER: CV curves of NiOOH@CoCu CH (a), CoCu CH/NF (b) and NiOOH/NF (b) at different scan rates. (d) Plots curve of 1/2 of the difference in the current density at 0.24 V vs RHE (1/2Δj) against scan rate, and the slopes enable the estimation of the electrochemical double layer capacitance (C_{dl}) values.

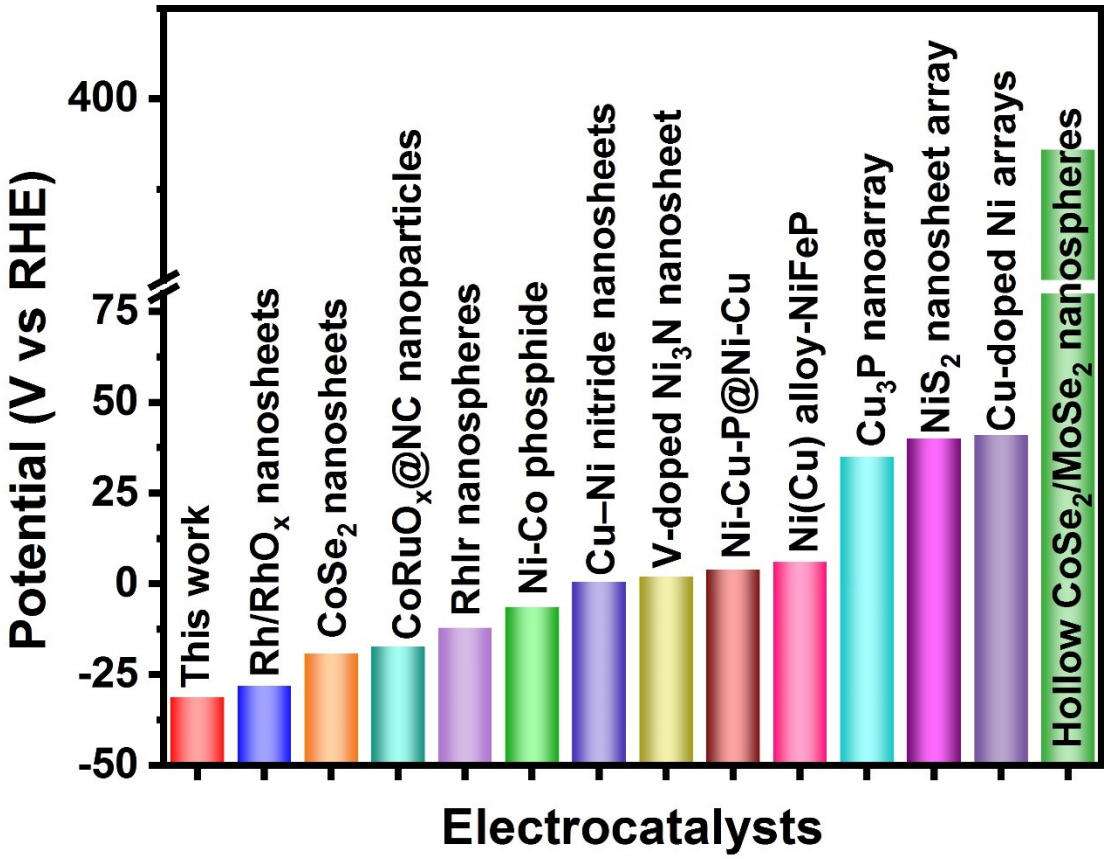

Figure S5 Comparison of HzOR performance of different electrocatalysts in tems of the potential to deliver a current density of 10 mA cm^{-2} in 1 M KOH with 0.5 M hydrazine.

Table S1 Electrocatalytic OER performance of NiOOH@CoCu CH compared with other transition metal oxides and hydroxides tested in 1 M KOH electrolyte.

Catalysts	Overpotential (j=10 mA cm^{-2}) (mV)	Tafel slope (mV dec^{-1})	Ref.
NiOOH@CoCu CH	263	43.2	This work
$Co(OH)_2$/NF	230	43	Electrochim. Acta, 2022, 411, 1400
Co_3Fe_1-LDH/rGO/ NF	250	43	Int. J. Hydrogen Energy, 2021, 46, 27529-27542
NiCo–$NiCoO_2$@Cu_2O on CF	327	118	Int. J. Hydrogen Energy, 2021, 46, 18936-18948
Cu@CoFe LDH	240	44.4	Nano Energy, 2017, 41, 327–336
Cobalt carbonate hydroxide mesostructure	320	38.8	Int. J. Hydrogen Energy, 2018, 43, 9635-9643
$CuCo_2O_4$@CQDs	290	64	Inorg. Chem., 2018, 57, 12, 7380–7389
$La(CrMnFeCo_2Ni)O_3$	325	51.2	Adv. Funct. Mater. 2021, 2101632
β-$NiMoO_4$	300	53	ACS Appl. Mater. Interfaces 2017, 9, 9640−96530
hierarchical $NiMoO_4$–$CoMoO_4$ nanotubes	300	64	J. Mater. Chem. A, 2015, 3, 22750–22758
$Co_{3-x}Fe_xO_4$	294	47.3	Dalton Trans., 2022,51, 3137-3145
MoO_2@MoS_2@Co_9S_8 nanorods	310	70	App. Surf. Sci., 2021, 543, 148804
Ir-doped $Co(OH)_2$ nanosheets	262	80.2	Dalton Trans., 2022,51, 1527-1532
Co–Fe Oxyphosphide Microtubes	280	53	Adv. Sci. 2019, 6, 1900576
$NiCo_2O_4$ nanosheet array	270	59.2	J. Catal., 2018, 357, 238–246
α-$Co(OH)_2$	320	58	ChemSusChem, 2019, 12, 5300-5309
CoO_x/CC	263	56.1	ACS Appl. Energy Mater. 2019, 2, 1977–1987

$Co_{2.3}Fe_{0.7}O_4$-NSs/CFP	359	34.3	ACS Appl. Mater. Interfaces 2018, 10, 46, 39809–39818
P/Mo-Co_3O_4@CC	265	59.4	Adv. Sci. 2020, 7, 1902830
$CuCo_2O_4$@CC	288	64.2	J. Colloid Interface Sci., 2020, 576, 476–485
$Co(OH)_2$@$Ni(OH)_2$/CC	330	223	Appl. Surf. Sci., 2019, 479, 1270–1276

Table S2 HER performance of trasition metal oxides and hydroxides in 1 M KOH

Catalysts	Overpotential (j=10 mA cm^{-2}) (mV)	Tafel slope (mV dec^{-1})	Ref.
NiOOH@CoCu CH	171	108	This work
NiO/Co_3O_4	169.5	119	Chem. Commun., 2019, 55, 6515-6518
NiFe LDH-Co_3O_4 nanowires	303	79	Catal. Sci. Technol., 2019, 9,2879-2887
$Co(OH)_2$/NF	190	70	Electrochim. Acta, 2022, 411, 1400
NiCoFe layered triple hydroxide nanosheets	180	78	Sustainable Energy Fuels, 2022,6, 474-483
NiFe LDH/FeOOH	181.8	None	Inorg. Chem. 2021, 60, 17371-17378
NiCu mixed metal oxid	200	120	Electrochim. Acta, 2021, 371, 137837
NiFe LDH/CeO_x	154	101	ACS Appl. Mater. Interfaces 2018, 10, 35145-35153
Cu@CoFe LDH	177	36.4	Nano Energy, 2017, 41, 327-336
Graphene-like sheets supported FeCo LDH	430	122	Chemosphere, 2022, doi: 10.1016/j.chemosphere. 2022.134251
$Ni(OH)_2$/Ni/Ti	197	88	ChemSusChem, 2018, 11, 948-958
S-doped NiCo LDH on a stainless steel	380	69	J. Electroanal. Chem., 2019, 833, 105-112
CoMn CH/NF	180	NA	J. Am. Chem. Soc., 2017, 139, 8320-8328
$CuCo_2O_4$@CQDs	331	65	Inorg. Chem., 2018, 57,

			12, 7380-7389
$CoCO_3$@NiFe LDH nanowires array	171	168.2	Mater. Lett., 2020, 277, 128285
MoO_2@MoS_2@Co_9S_8 nanorods	160	80	App. Surf. Sci., 2021, 543, 148804
Co–Fe Oxyphosphide Microtubes	220	62	Adv. Sci. 2019, 6, 1900576
$NiCo_2O_4$ nanosheet array	~200	71.2	J. Catal., 2018, 357, 238-246
Co_9S_8@NiCo LDH/NF	168	103	Sci. Bull., 2019, 64, 158-165
Fe_2O_3 nanocatalysts on N-doped carbon nanomateria	245	76.6	J. Power Sources, 2019, 426, 74–83

Table S3 Hydrazine oxidation-assisted hydrogen production peformance of different electrode couples in 1 M KOH with 0.5 M hydrazine

Catalysts	Current density (mA cm^{-2})	Cell voltage (V)	Ref.
NiOOH@CoCu CH	10	0.087	This work
	50	0.33	
CoP/Co nanoparticles	10	0.26	J Phys Chem Lett, 2021, 12: 4849-4856.
NiSe nanosheets on Ni Foam	50	0.47	ACS Appl. Mater. Interfaces, 2021, 13: 34457-34467
V-doped Ni_3N nanosheet on Ni foam	10	0.094	ACS Appl. Mater. Interfaces, 2021, 13: 3881-3890.
Ni(Cu) alloy anchored on amorphous NiFeP	10	0.147	J. Catal., 2019, 373: 180-189.
Copper–nickel nitride nanosheets	10	0.24	Adv. Energy Mater., 2019, 9: 1900390.
Cu_3P nanoarray	10	0.38	Inorg. Chem. Front., 2017, 4: 420-423.
NiS_2 nanosheet array on Ti mesh	10	0.34	Mater. Today Energy, 2017, 3: 9-14.
$CoSe_2$ nanosheets	10	0.164	Angew. Chem. Int. Ed. Engl., 2018, 57: 7649-7653.
hollow $CoSe_2$/$MoSe_2$ nanospheres	10	0.85	Chem. Eng. J., 2021, 404: 126529.

Cu-doped Ni arrays	10	0.07	J. Mater. Chem. A, 2020, 8: 21084-21093.
Rh/RhO_x nanosheets	10	0.068	J. Mater. Chem. A, 2022, doi: 10.1039/D1031TA09391F.
RhIr mesoporous nanospheres	10	0.13	J. Mater. Chem. A, 2021, 9: 18323-18328.
Ni-Cu-P@Ni-Cu nano-micro dendrite	10	0.125	Electrochim. Acta, 2021, 382: 138335.
nickel-cobalt phosphide grown on Ni foam	10	0.127	Int. J. Hydrogen Energy, 2020, 45: 27000-27011.
CoRuOx@NC nanoparticles	10	0.079	ACS Sustainable Chem. Eng, 2020, 8: 12089-12099.
CoP nanoparticles embedded into N-doped carbon nanotubes grafted on carbon polyhedron	10	0.89	ACS Sustainable Chem. Eng, 2019, 7: 10044-10051.
ruthenium single atoms anchored onto of WS_2	10	0.14	Adv. Funct. Mater., 2022, 2109439.