Supporting information

Tubular $Cu(OH)_2$ Arrays Decorated by Nanothorny Co-Ni Bimetallic Carbonate Hydroxide Supported on Cu Foam: a 3D Hierarchical Core-shell Efficient Electrocatalyst for Oxygen Evolution Reaction

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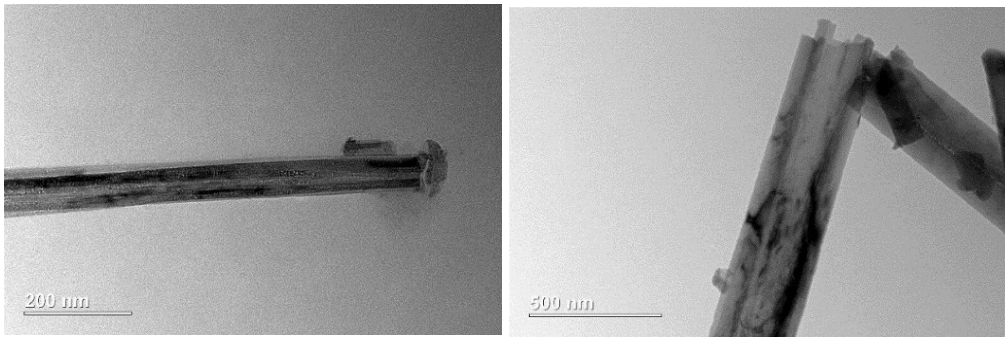

Figure S1 TEM images of $Cu(OH)_2$ NTs.

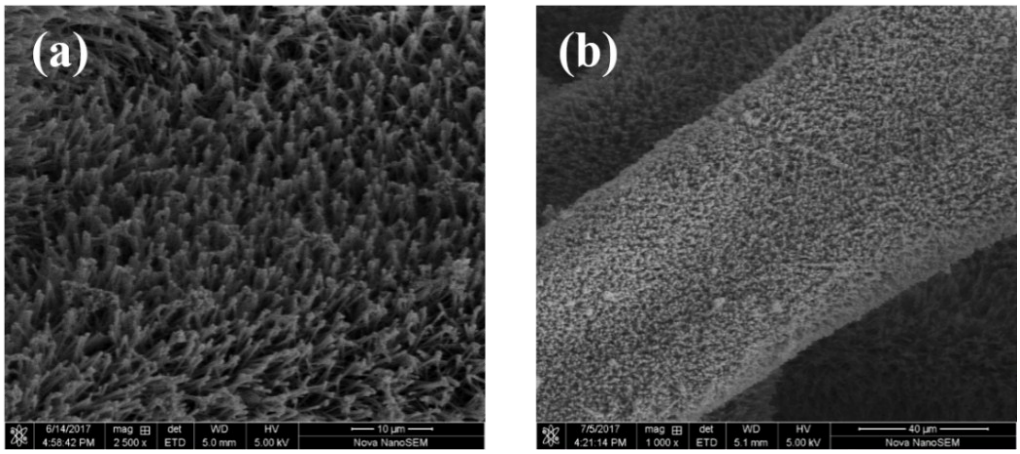

Figure S2 Low-magnification SEM of $Cu(OH)_2$@CoNiCH NTs/CF.

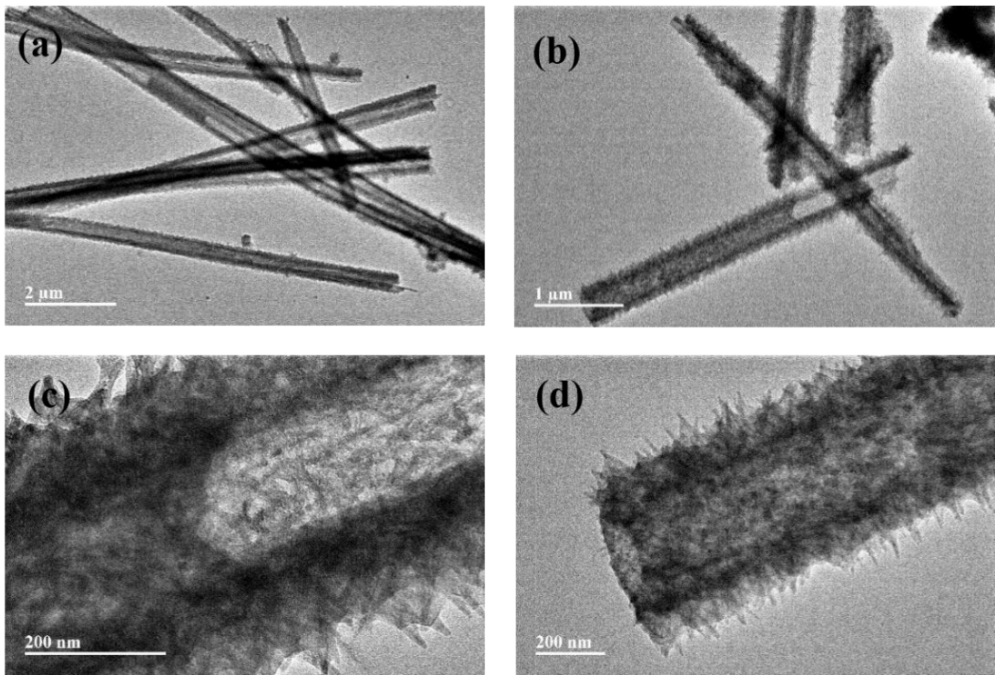

Figure S3 Low and high magnification TEM images of $Cu(OH)_2$@CoNiCH NTs.

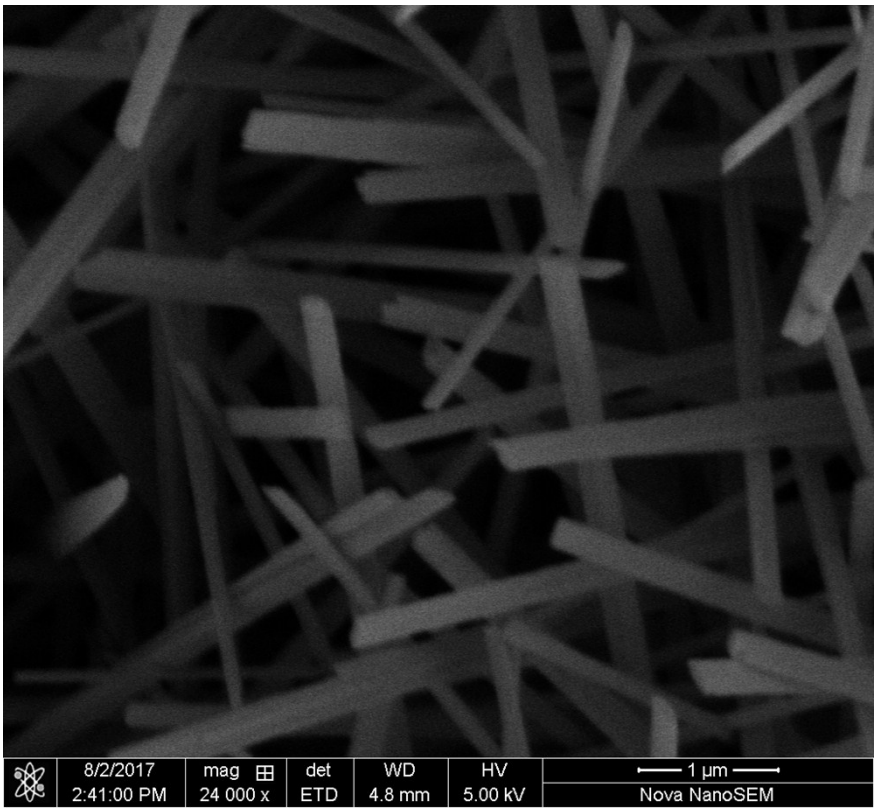

Figure S4 Low-magnification SEM of $Cu(OH)_2$ NWs/CF.

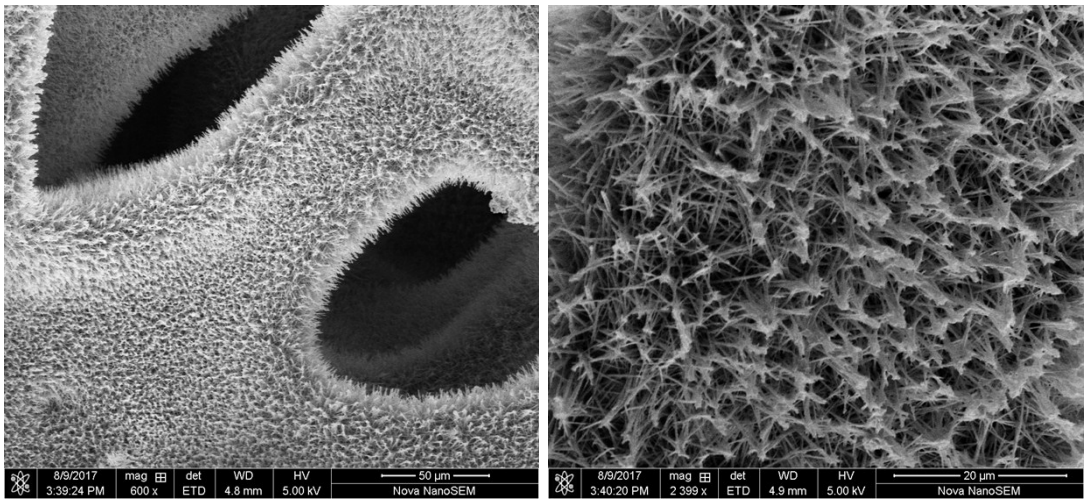

Figure S5 Low-magnification SEM of $Cu(OH)_2$@CoNiCH NWs/CF.

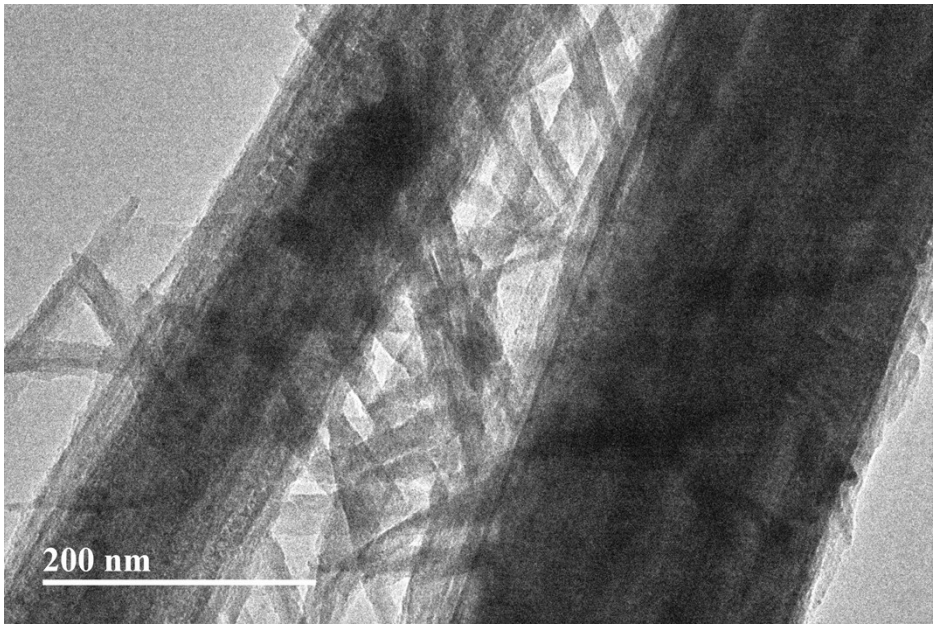

Figure S6 Low-magnification TEM of $Cu(OH)_2$@CoNiCH NWs.

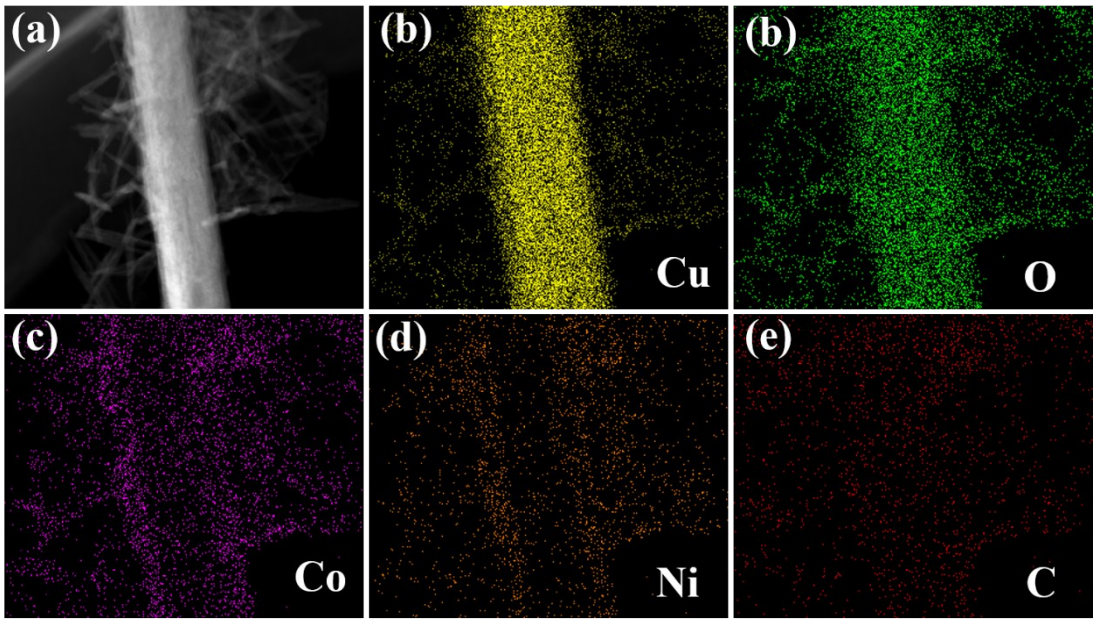

Figure S7 STEM EDS element mapping of $Cu(OH)_2$@CoNiCH NWs: (a)HAADF image of the EDS mapping area, (b-g) element mapping of Cu, O, Co, Ni and C elements.

For comparison, Cu and O elements evenly distributing on the whole individual construction proves that the solid $Cu(OH)_2$ nanowire core, and strong signals of Co and Ni in the walls mainly shows that CoNi nanothorn shell were distributed on the surface. (Figure S7)

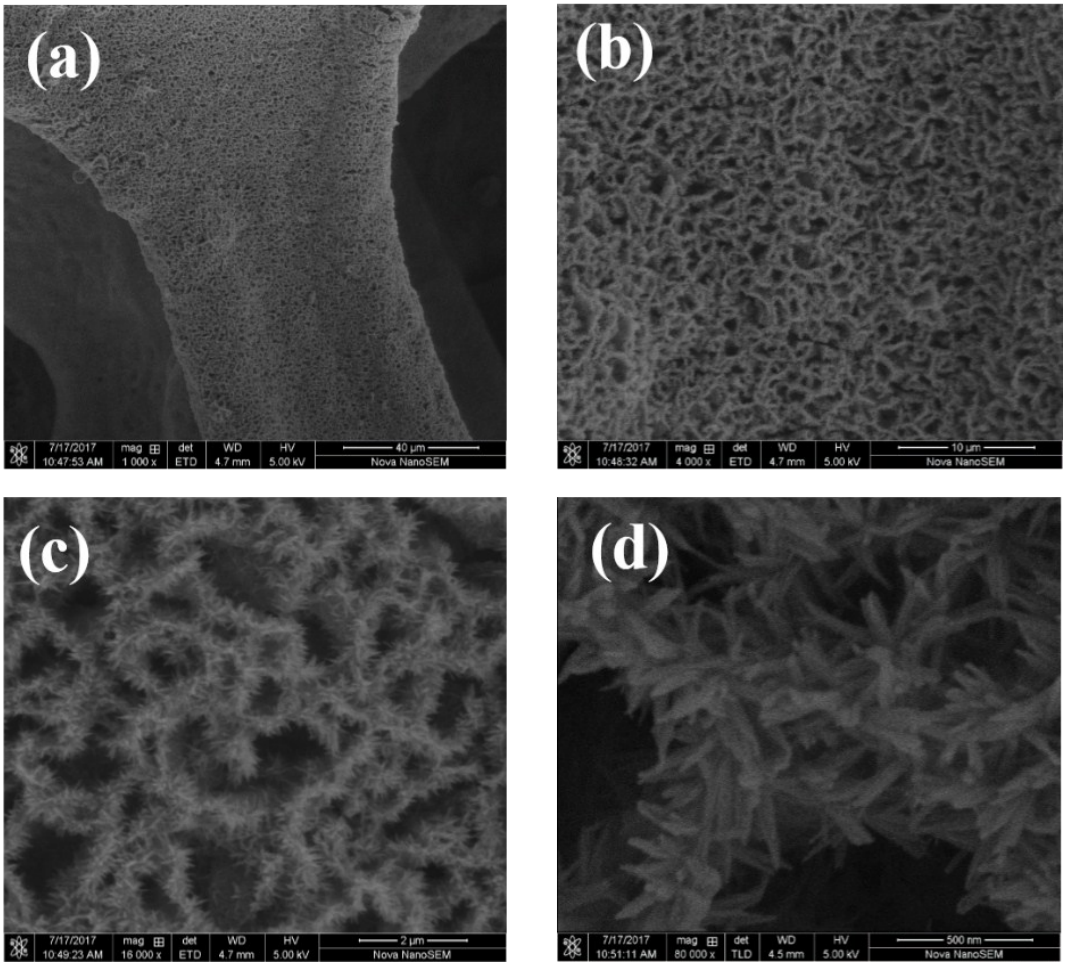

Figure S8 SEM of the CoNiCH NRs/CF.

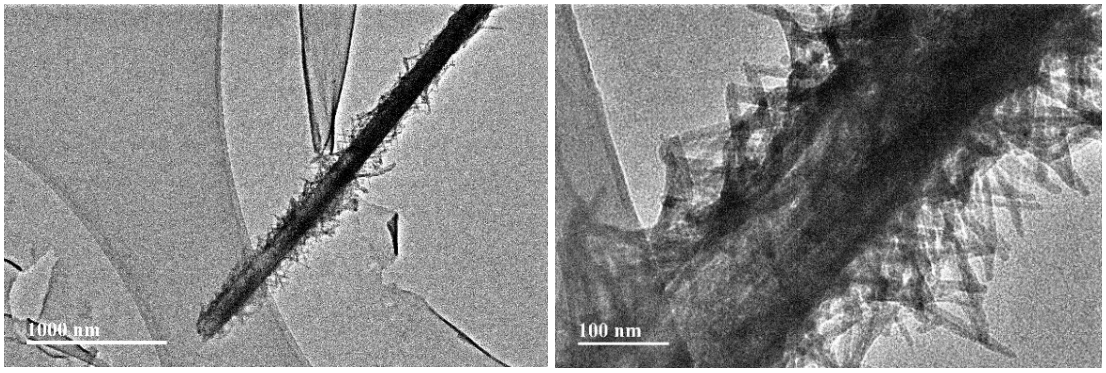

Figure S9 TEM of $Cu(OH)_2$@CoCH NTs.

Figure S10 EDS content of $Cu(OH)_2$@CoNiCH NTs.

As shown in Figure S10, the atomic ratio of Co/Ni of $Cu(OH)_2$@CoNiCH NTs is approximately 1.93 according to the EDS result.

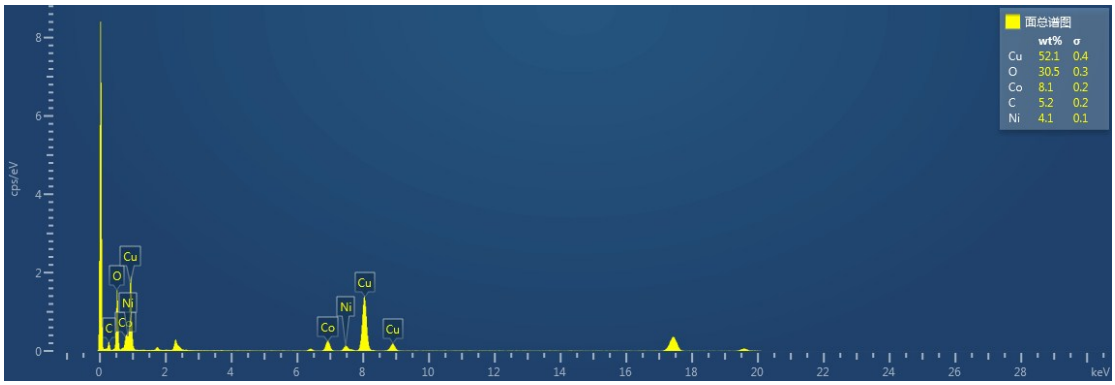

Figure S11 EDS content of $Cu(OH)_2$@CoNiCH NWs.

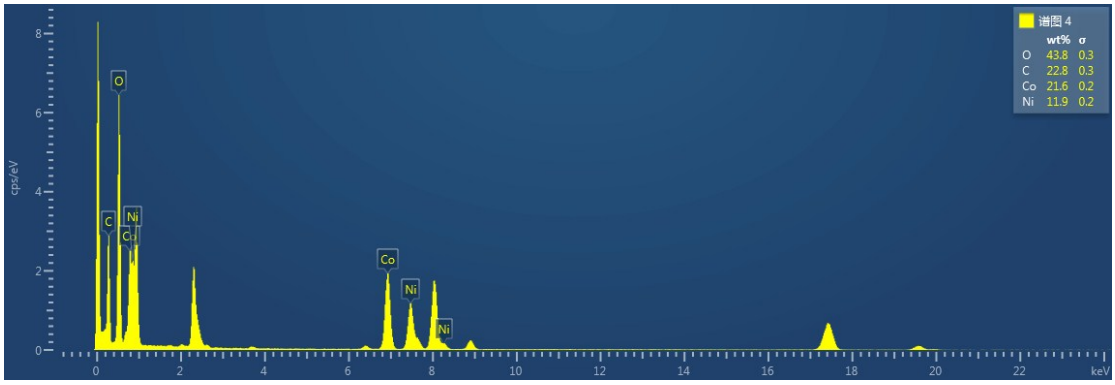

Figure S12 EDS content of CoNiCH NRs.

Table S1 The molar ratios of Co/Ni in prepared samples determined by ICP, EDS, XPS

Samples	Co/Ni molar ratios		
	ICP	EDS	XPS
$Cu(OH)_2$@CoNiCH NTs	1.90	1.93	1.91
$Cu(OH)_2$@CoNiCH NWs	1.91	1.98	1.92
CoNiCH NRs	1.89	1.82	1.91

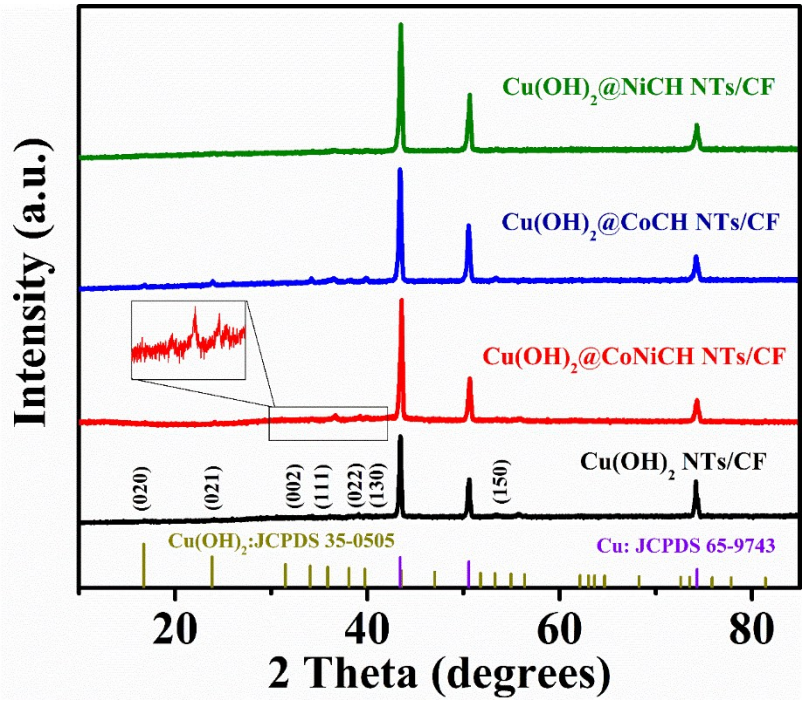

Figure S13 XRD of $Cu(OH)_2$@CoNiCH NTs/CF, $Cu(OH)_2$@CoCH NTs/CF, $Cu(OH)_2$@NiCH NTs/CF and $Cu(OH)_2$ NTs/CF.

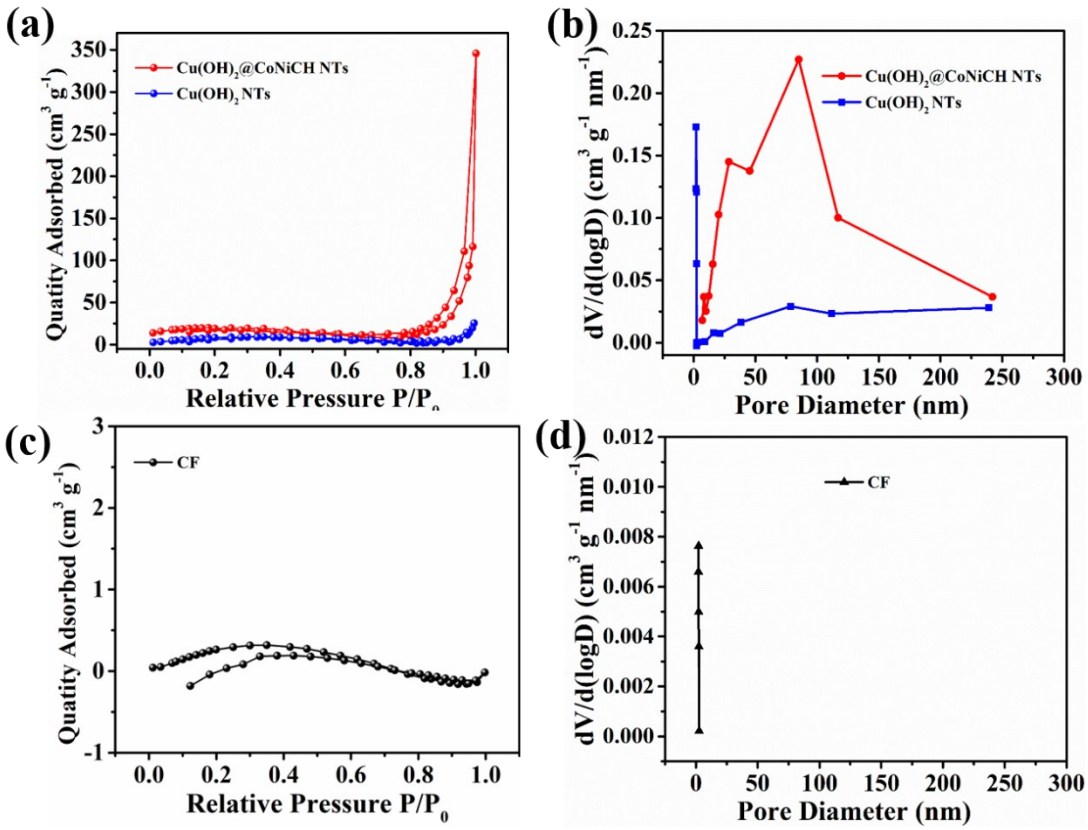

Figure S14 (a-b) BET of $Cu(OH)_2$@CoNiCH NTs and $Cu(OH)_2$ NTs, (c-d) BET of bare Cu foam.

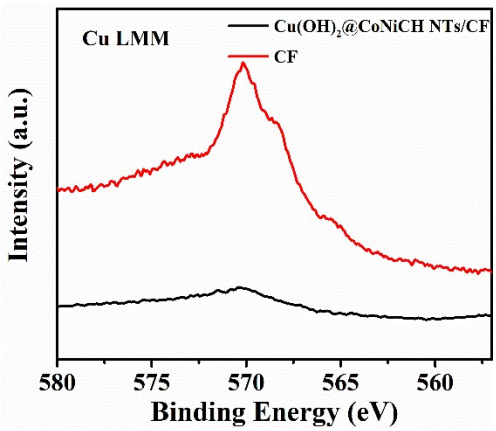

Figure S15 Cu LMM of $Cu(OH)_2$@CoNiCH NTs/CF and bare CF.

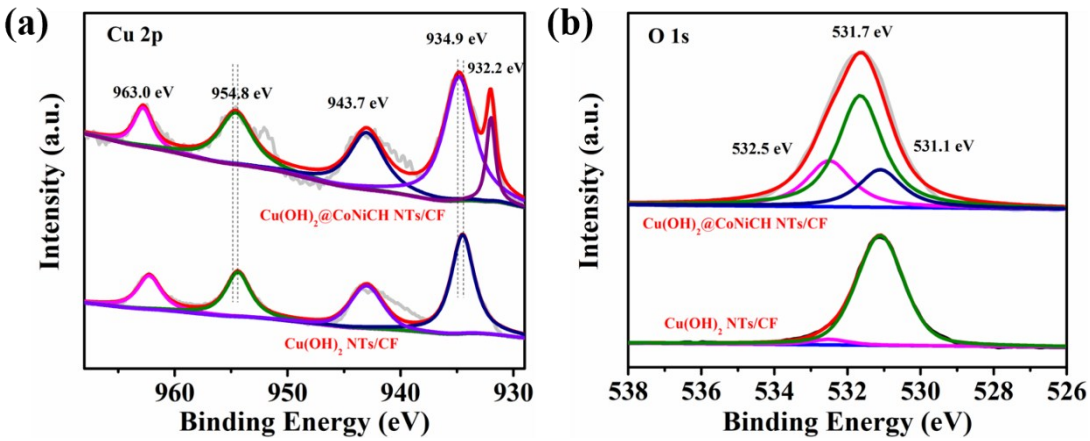

Figure S16 XPS spectra (Cu 2p and O 1s) comparison of the $Cu(OH)_2$@CoNiCH NTs/CF and $Cu(OH)_2$ NTs/CF.

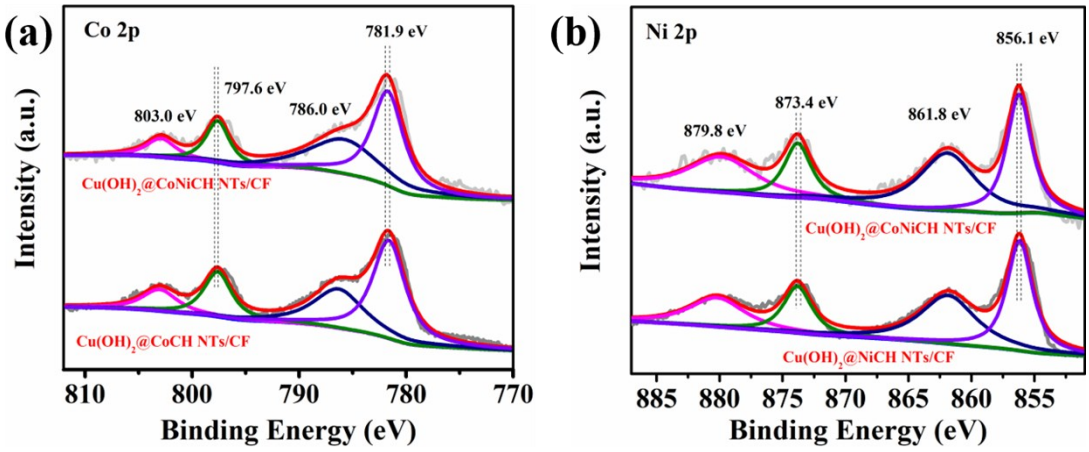

Figure S17 (a) XPS spectra (Co 2p) comparison of the $Cu(OH)_2$@CoNiCH NTs/CF and $Cu(OH)_2$@CoCH NTs/CF, (b) XPS spectra (Ni 2p) comparison of $Cu(OH)_2$@CoNiCH NTs/CF and $Cu(OH)_2$@NiCH NTs/CF

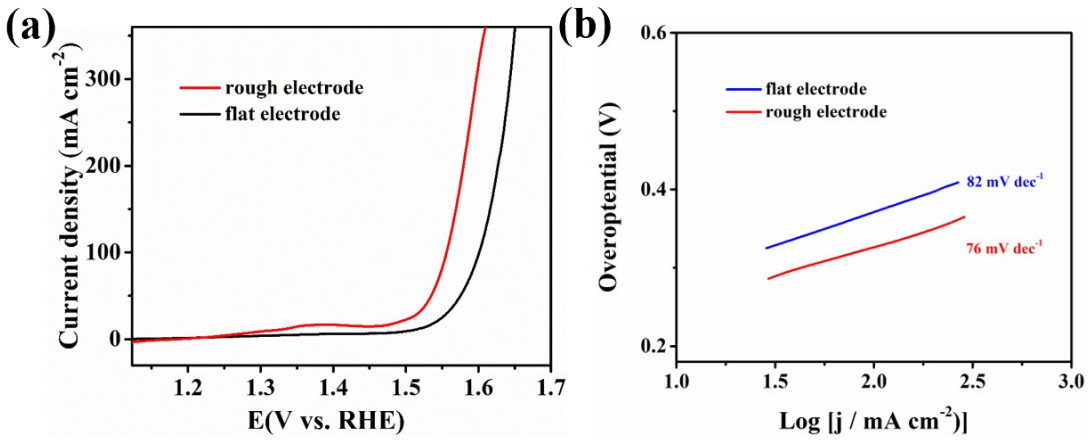

Figure S18 a) Polarization curves and b) Tafel plots of flat $Cu(OH)_2$@CoNiCH NTs /Cu foil and rough $Cu(OH)_2$@CoNiCH NTs/CF.

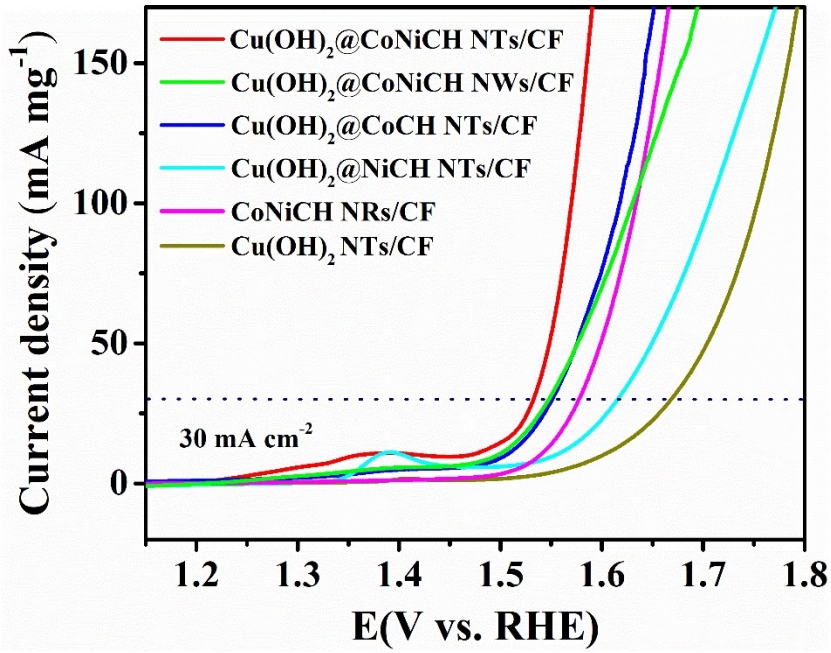

Figure S19 Mass-normalized polarization curves of the active materials loaded on CF.

Table S2 Mass-normalized overpotential of the active materials loaded on CF

Active materials	Mass (mg)	η (mV) (j = 30 mA mg^{-1})	η (mV) (j = 100 mA mg^{-1})
$Cu(OH)_2$@CoNiCH NTs/CF	1.54	303	340
$Cu(OH)_2$@CoNiCH NWs/CF	1.82	319	401
$Cu(OH)_2$@CoCH NTs/CF	1.63	321	388
$Cu(OH)_2$@NiCH NTs/CF	1.52	386	477
CoNiCH NRs/CF	0.96	349	404
$Cu(OH)_2$ NTs/CF	0.64	439	524

Table S3 Comparison of the 3D $Cu(OH)_2$@CoNiCH NTs/CF with recently reported materials

Catalyst	Mass (mg)	Overpotential at current density			Ref.
		10 mA cm^{-2}	50 mA cm^{-2}	100 mA cm^{-2}	
$Cu(OH)_2$@CoNiCH NTs/CF	1.54 mg cm^{-2}	85	305	326	**This work**
Co_1Mn_1 carbonate hydroxide nanosheets/NF	5.6 mg cm^{-2}	-	322	349	**J. Am. Chem. Soc.** 2017, 139 (24), 8320-8328
CCS CoNi core-shell nanowires/carbon fiber	0.3 mg cm^{-2}	302	-	-	**Adv. Energy Mater.** 2017, 7 (1), 1601492
CoO–MoO_2 Nanocages	0.5 mg cm^{-2}	312	-	-	**Adv. Funct. Mater.** 2017, 27 (34), 1702324
FeCoOOH/Graphene	0.2 mg cm^{-2}	330	-	-	**Adv. Energy Mater.** 2017, 7 (14), 1602148
NiFe LDH nanosheets/Cu nanowire	-	310	-	460	**Energy Environ. Sci.**, 2017, 10, 1820-1827.
Dendritic Nanostructured Copper Oxide	-	290	-	-	**Angew. Chem. Int. Ed.** 2017, 129 (17), 4870-4874
NiFe LDH/NF	-	240	~350	~460	**Science** 2014, 345, 1593
$Ni(OH)_2$-TCNQ microarray	5.6 mg cm^{-2}		322	354	**ACS Catal.**, 2018, 8, 651-655
CoO/Co composite	0.255 mg cm^{-2}	350	-	-	**ACS Energy Lett.** 2017, 2 (5), 1208–1213

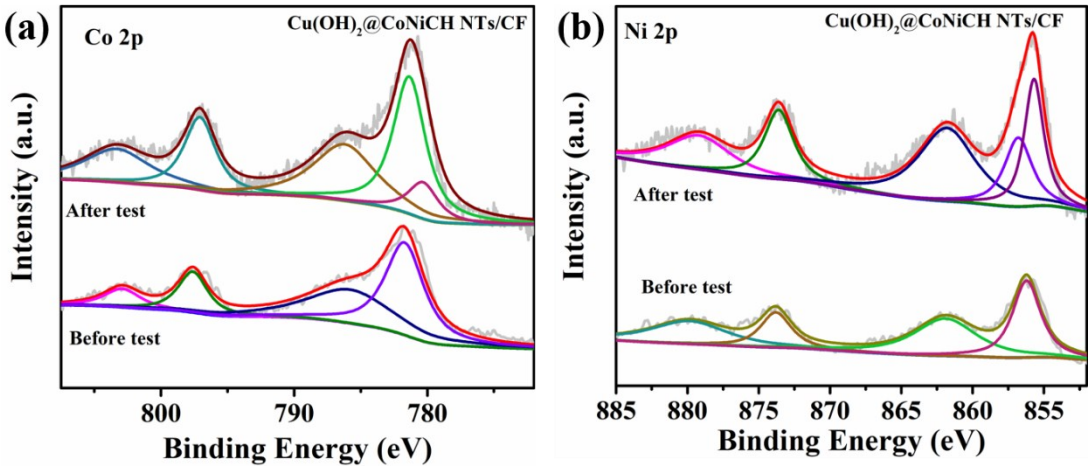

Figure S20 The XPS spectra comparison of $Cu(OH)_2$@CoNiCH NTs/CF before and after LSV tests.

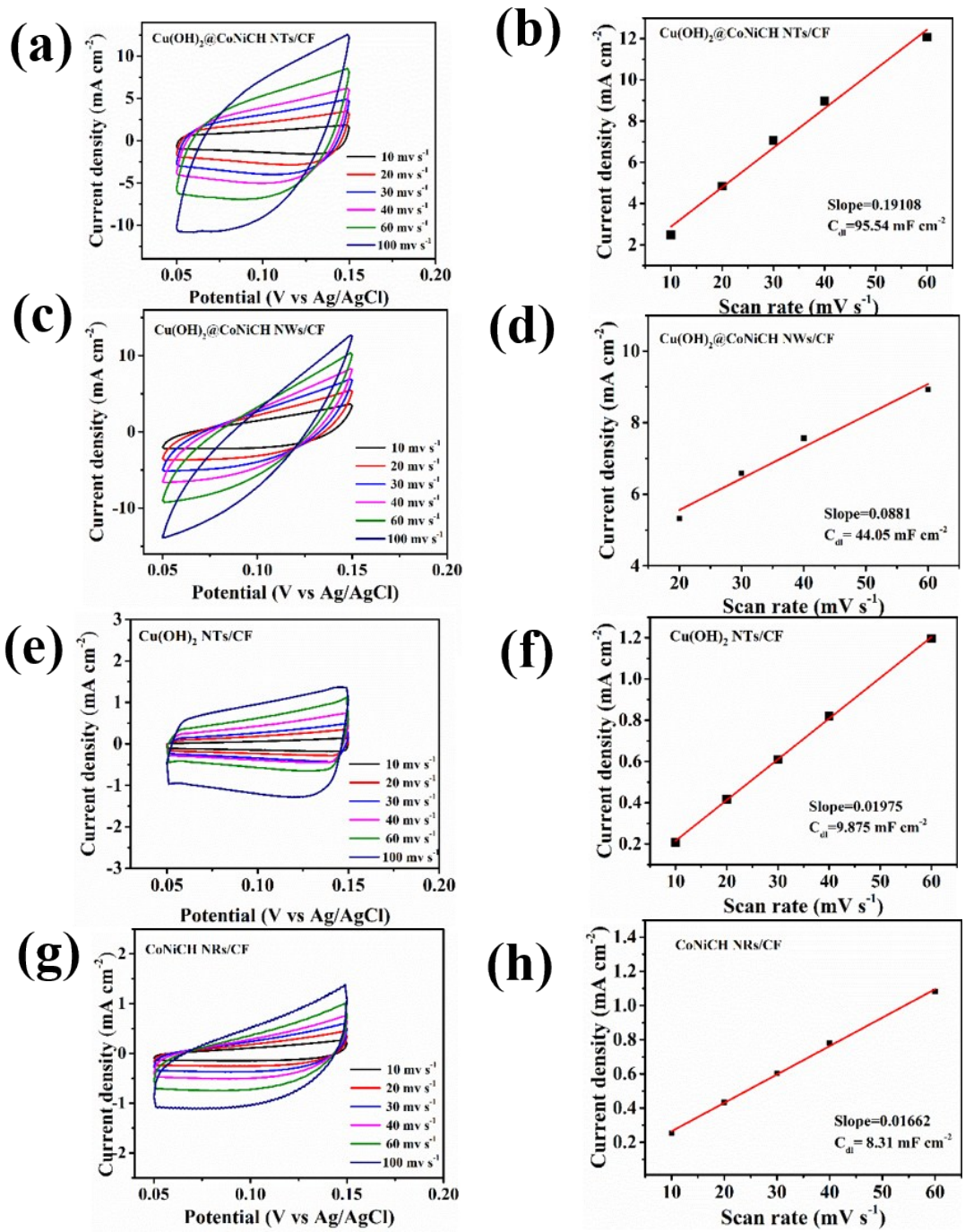

Figure S21 ECSAs and corresponding C_{dl} of the (a) $Cu(OH)_2$@CoNiCH NTs/CF, (b) $Cu(OH)_2$@CoNiCH NWs/CF, $Cu(OH)_2$ NTs/CF, (d) CoNiCH NRs/CF.

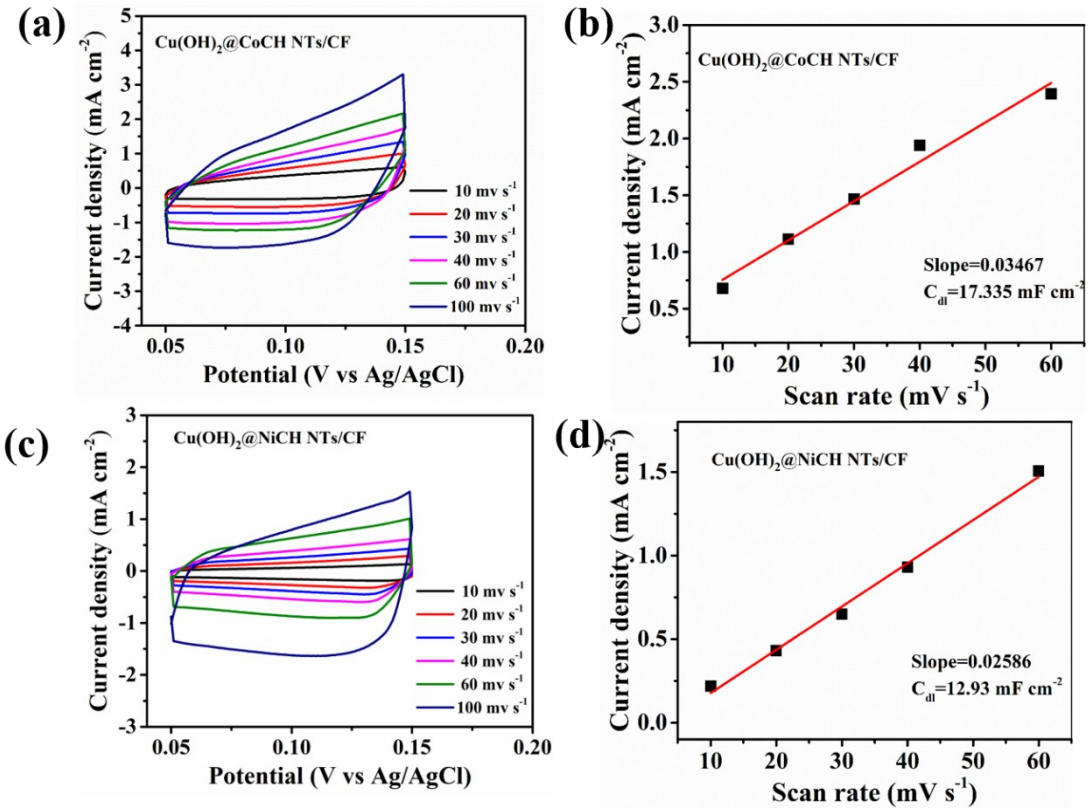

Figure S22 ECSA and corresponding C_{dl} of $Cu(OH)_2$@CoCH NTs/CF, $Cu(OH)_2$@NiCH NTs/CF

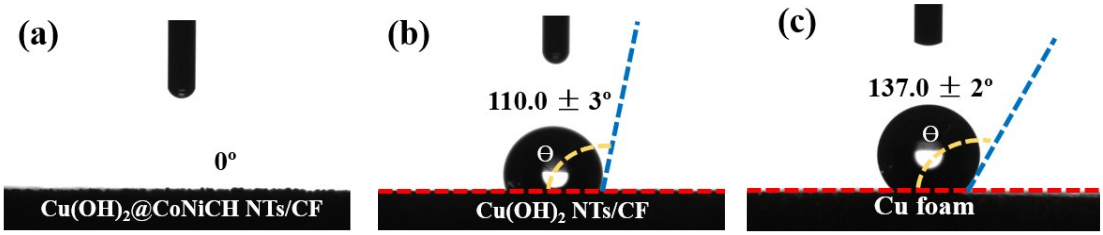

Figure S23 Contact angle images of (a) $Cu(OH)_2$@CoNiCH NTs/CF (b) $Cu(OH)_2$ NTs/CF and (c) Cu foam