Electronic Supplementary Information

One-step hydrothermal synthesis of cobalt-vanadium based nanocomposites as bifunctional catalysts for overall water splitting

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Additional figures.

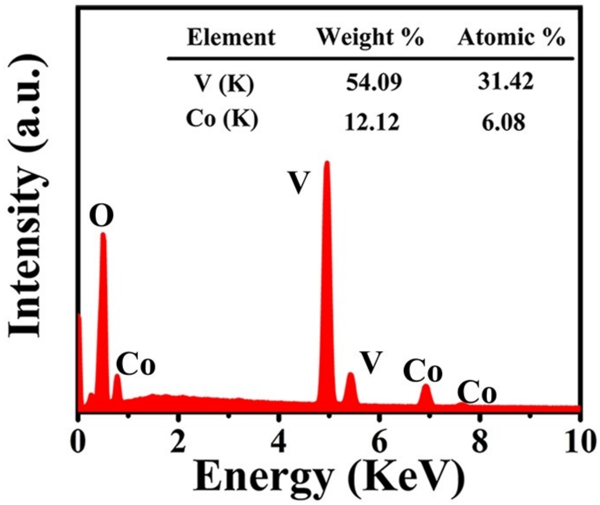

Fig. S1. EDS patterns of $Co_{0.2}$-VOOH, inset shows the corresponding element ratio.

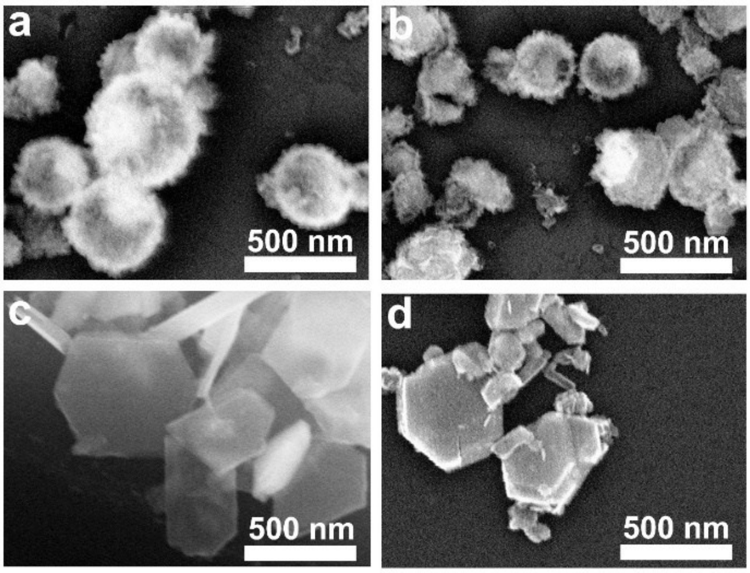

Fig. S2. The morphology adjustment with the different content of cobalt doping. SEM images of (a) pure VOOH, (b) $Co_{0.1}$-VOOH, (c) $Co_{0.2}$-VOOH, and (d) $Co_{0.3}$-VOOH.

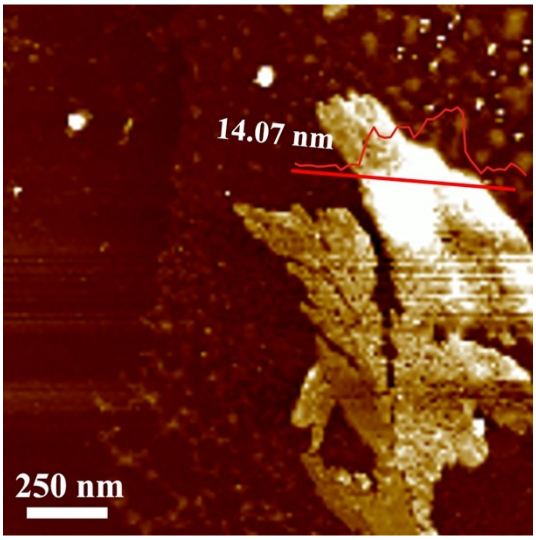

Fig. S3. AFM image of $Co_{0.3}$-VOOH and corresponding height profile.

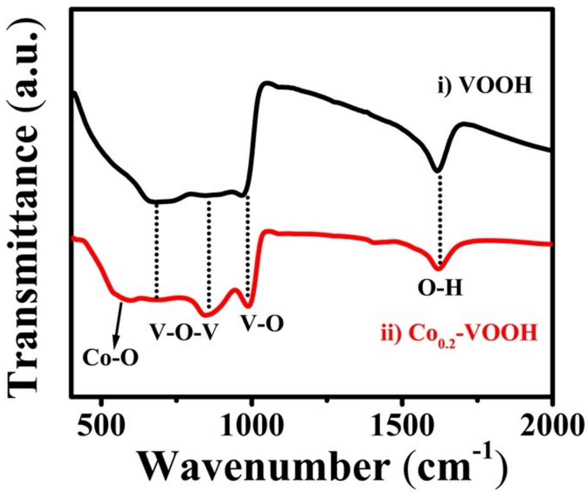

Fig. S4. FT-IR spectra of VOOH and $Co_{0.2}$-VOOH.

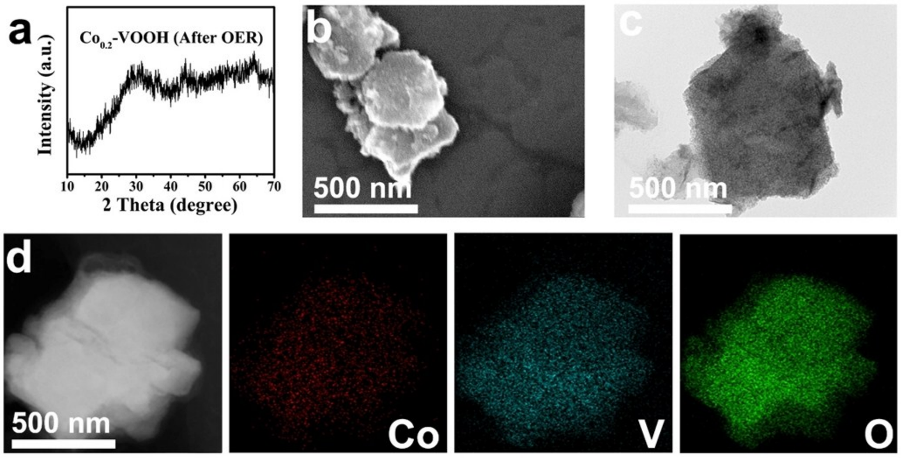

Fig. S5. (a) XRD pattern, (b) SEM image, (c) TEM image, (d) elemental maps of the $Co_{0.2}$-VOOH electrocatalyst after long-time OER process.

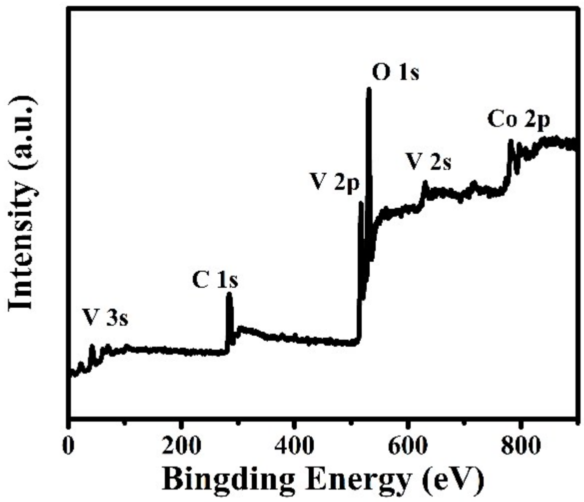

Fig. S6. XPS spectrum of the $Co_{0.2}$-VOOH electrocatalyst after long-time OER process.

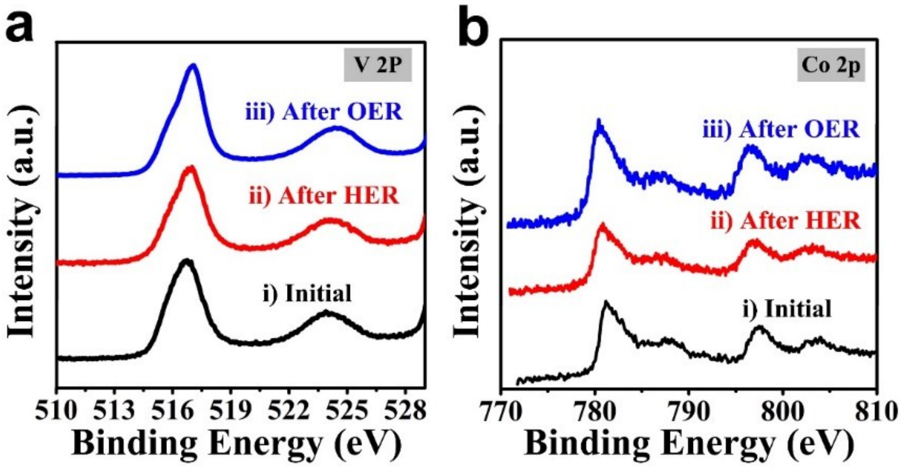

Fig. S7. High-resolution XPS spectra of a) V 2p and b) Co 2p for $Co_{0.2}$-VOOH after OER and HER process, respectively.

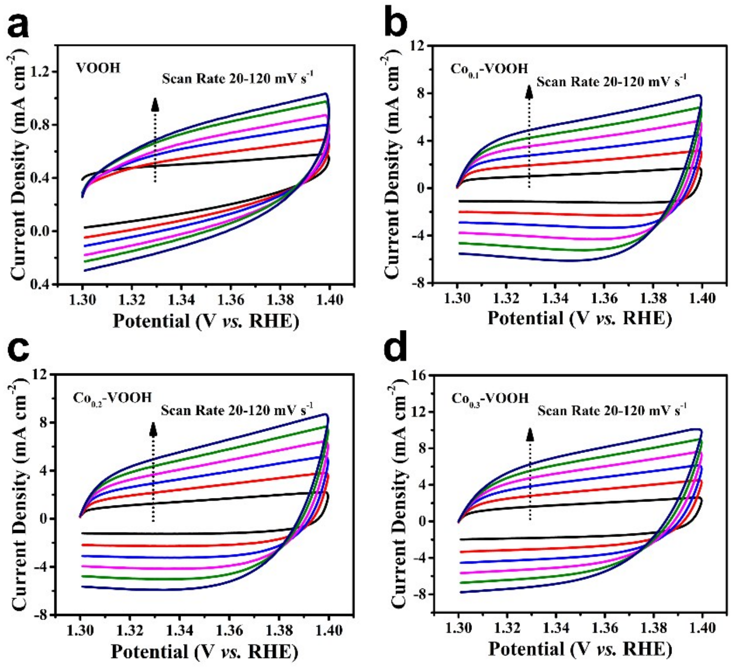

Fig. S8. Cyclic voltammograms of a) pure VOOH, b) $Co_{0.1}$-VOOH, c) $Co_{0.2}$-VOOH, and d) $Co_{0.3}$-VOOH with various scan rates in 1.0 M KOH.

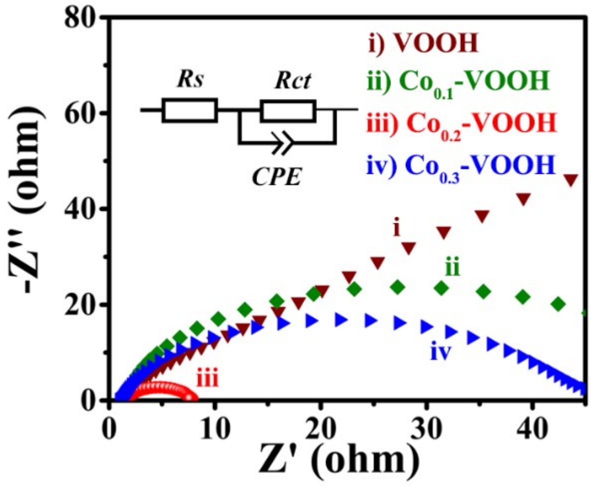

Fig. S9. Nyquist plots of various catalysts toward OER. Inset: relevant equivalent electric circuit.

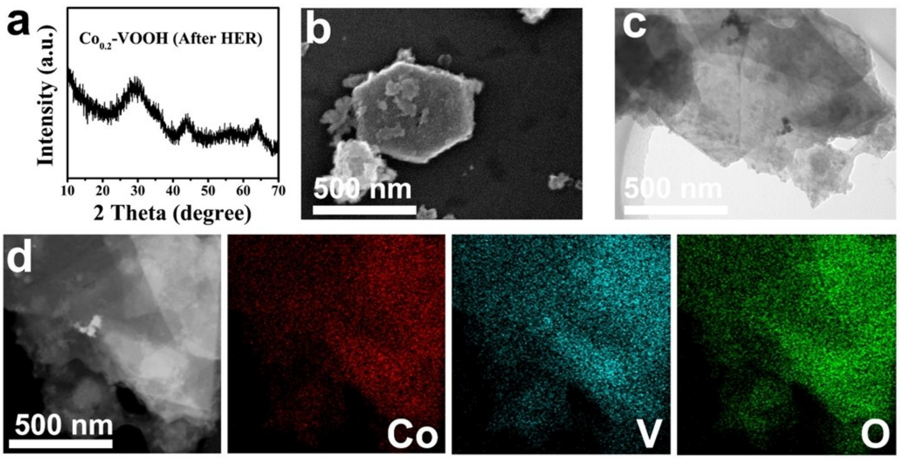

Fig. S10. a) XRD pattern, b) SEM image, c) TEM image, d) elemental maps of the $Co_{0.2}$-VOOH electrocatalyst after long-time HER process.

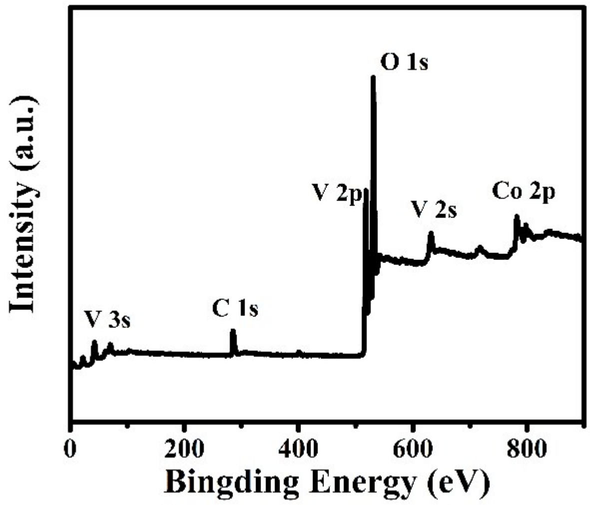

Fig. S11. XPS spectrum of the $Co_{0.2}$-VOOH electrocatalyst after long-time HER process.

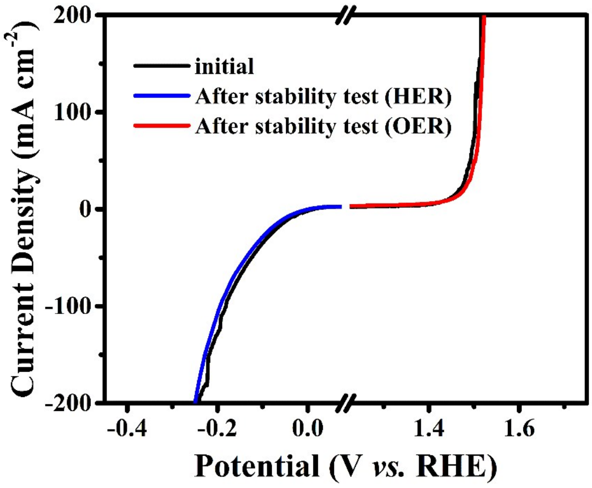

Fig. S12. Polarization curves of $Co_{0.2}$-VOOH before and after the overall water splitting stability test.

Table S1. Mass ratios of V and Co of various catalysts obtained from ICP-OES.

Catalyst	V (wt%)	Co (wt%)	Molar radio
VOOH	34.72	-	-
$Co_{0.1}$-VOOH	33.96	3.69	1:0.09
$Co_{0.2}$-VOOH	33.91	8.15	1:0.21
$Co_{0.3}$-VOOH	33.29	11.63	1:0.30

Table S2. Comparison of the OER performance for the $Co_{0.2}$-VOOH catalyst in this work with reported non-noble OER electrocatalysts in 1.0 M alkaline medium.

Catalyst	Substrate	Catalyst loading (mg cm^{-2})	Tafel Slope (mV dec^{-1})	Overpotential at 10 mA cm^{-2} (mV)	Ref.
$Co_{0.2}$-VOOH	Carbon cloth	0.5	30.8	210	This work
Mo-doped CoP	Carbon cloth	2.5	56	305	1
$CoO/Co(OH)_2$	Carbon cloth	-	142	340	2
$(Ni_{0.33}Co_{0.67})S_2$ NWs	Carbon cloth	-	78	334	3
$CoNi/CoNiO_2$@NC	Carbon cloth	2	63	181	4
CoMnP	Glassy carbon	0.284	61	330	5
$Ni_{0.75}V_{0.25}$ LDH	Glassy carbon	0.143	50	318	6
Ni_2P NPs	Glassy carbon	0.14	47	290	7
Co_3O_4	Glassy carbon	0.35	62	408	8
$Co(OH)_2$	Glassy carbon	0.35	58	360	9
$NiPS_3$@NiOOH	Glassy carbon	0.382	80	225*	10
MoO_2	Ni foam	2.9	54	260	11
Fe_xN	Ni foam	4	44.5	238	12
NiSe	Ni foam	2.8	64	250	13
VOOH	Ni foam	0.8	68	270	14
CoFePO	Ni foam	2.187	51.7	274.5	15
NiFe-NS	Ni foam	0.07	40	302	16
$Fe(PO_3)_2$	Ni foam	8	51.9	177	17
Fe doped CoP	Ti foil	1.03	67	230	18
Co-P film	Cu foil	2.6	47	345	19

* The value is estimated from the curves displayed in the references.

Table S3. Comparison of the HER performance for the $Co_{0.2}$-VOOH catalyst in this work with reported non-noble HER electrocatalysts in 1.0 M alkaline medium.

Catalyst	Substrate	Catalyst loading (mg cm^{-2})	Tafel Slope (mV dec^{-1})	Overpotential at 10 mA cm^{-2} (mV)	Ref.
$Co_{0.2}$-VOOH	Carbon cloth	0.5	58.2	130	This work
V-doped WS_2	Carbon cloth	-	85	134	20
Fe-doped CoP	Carbon cloth	-	69	98	21
Ni-Co-P	Carbon cloth	0.27	69	57	22
CNTs@$CoS_xSe_{2(1-x)}$	Carbon cloth	0.81	96	225	23
Fe-doped Co_9S_8	Carbon cloth	95.3	83	95.3	24
c-$CoSe_2$	Carbon cloth	-	85	190	25
CP/CTs/Co-S	Carbon paper	0.32	131	190	26
Co@NG	Carbon paper	1	112	220	27
NiCoP/rGO	Carbon fiber	0.15	124.1	209	28
Ni-Co-P	Glassy carbon	0.286	60	150	29
Ni@NC-800	Glassy carbon	0.8	160	205	30
MoC/Mo_2C	Glassy carbon	0.14	42	120	31
VOOH	Ni foam	0.8	104	164	14
$Ni_{2.5}Co_{0.5}Fe$	Ni foam	0.3	93	275	32
Janus Co/CoP	Ni foam	0.22	73.8	193	33
Ni_3FeN/rGO	Ni foam	0.5	90	94	34
CoO_x@CN	Ni foam	0.42	115	232	35
Co_3O_4 microtube	Ni foam	-	98	190*	36
$Ni_{0.9}Fe_{0.1}$/NC	Ni foam	2	111	231	37
NiFe/$NiCo_2O_4$	Ni foam	-	88	105	38
Cu@NiFe LDH	Cu foam	2.2	58.9	116	39

* The value is estimated from the curves displayed in the references.

Table S4. Comparison of the bifunctional water splitting activity of the $Co_{0.2}$-VOOH catalyst in this work with other reported bifunctional electrocatalysts in 1.0 M alkaline medium.

Catalyst	Substrate	Catalyst loading (mg cm^{-2})	Current density (j mA cm^{-2})	Voltage at the corresponding j (V)	Ref.
$Co_{0.2}$-VOOH	Carbon cloth	0.5	10	1.57	This work
			100	1.74	
			200	1.80	
Mo-doped CoP	Carbon cloth	2.5	10	1.56	1
			100	1.6*	
CNTs@$CoS_xSe_{2(1-x)}$	Carbon cloth	0.81	10	1.74	23
Ni-$NiFe_2O_4$	Carbon cloth	-	10	1.57	40
CP/CTs/Co-S	Carbon paper	0.32	10	1.743	26
VOOH	Ni foam	0.8	10	1.62	14
			100	1.82*	
NiCoP	Ni foam	1.6	10	1.58	41
			100	1.82	
			200	1.98	
Ni@NC-800	Ni foam	0.8	10	1.60	30
			20	1.64	
Ni_3Se_2	Ni foam	8.87	10	1.612	42
Ni_2P NPs	Ni foam	0.14	10	1.63	7
Cu@CoS_x	Cu foam	3.9	10	1.5	43
			100	1.8*	
Ni-Mo alloy	Cu foil	4.2	10	1.59	44
			100	1.9*	
Fe doped CoP	Ti foil	1.03	10	1.6	18
			60	1.73*	
Ni_5P_4	Ni foil	0.35	10	1.7*	45

*The value is estimated from the curves displayed in the references.

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