Electronic Supplementary Information for

Wood-derived hierarchically porous monolithic carbon matrix embedded with Co nanoparticles as an advanced electrocatalyst for water splitting

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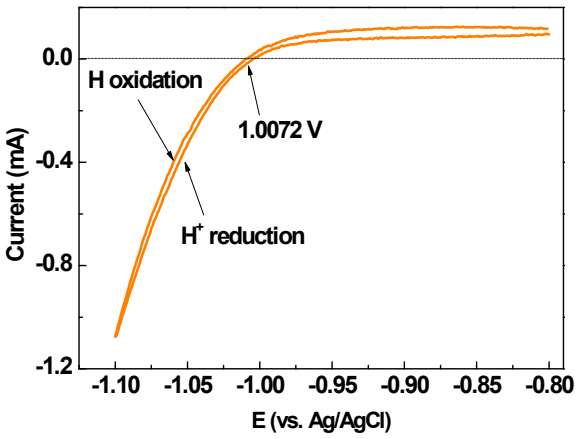


Fig. S1 The cyclic voltammograms (CV) of Pt wire working electrode in the high purity hydrogen saturated 1 M KOH electrolyte solution. The CV scans were run at a scan rate of 5 mV s^{-1}, and the average of the two potentials at which the current crossed zero was taken to be the thermodynamic potential for the hydrogen electrode reactions.

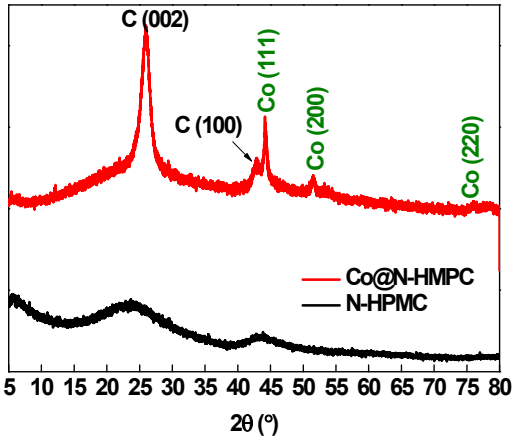


Fig. S2 XRD patterns of Co@N-HPMC and N-HPMC.

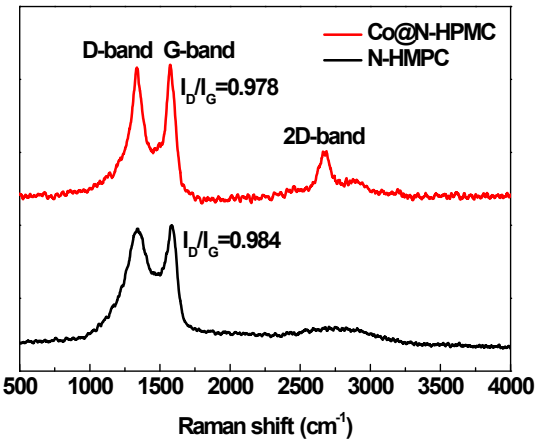


Fig. S3 Raman spectra of Co@N-HPMC and N-HPMC.

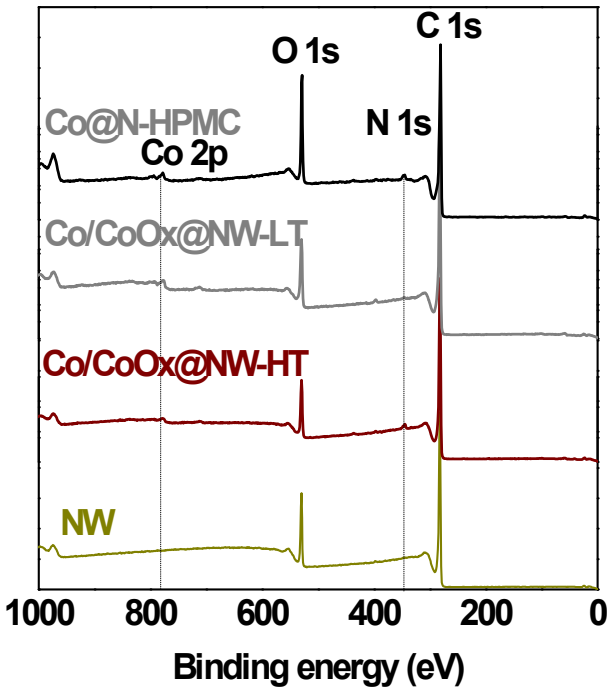


Fig. S4 XPS spectra of NW, Co/CoO_x@NW-HT, Co/CoO_x@NW-LT, and Co@N-HPMC.

Table S1 The content variation of diffrent Co species calculated based on the fitting results of XPS analysis.

Sample	Co^0	Co^{3+}	Co^{2+}	Co-N_x
Co/CoO_x@NW	24.6%	34.3%	41.1%	0%
Co/CoO_x@NW-LT	26.1%	19.8%	54.1%	0%
Co@N-HPMC	5.2%	0%	55.1%	39.7%
Co@N-HPMC after HER stability test	4.7%	0%	59.9%	35.4%
Co@N-HPMC after OER stability test	6.9%	35.9%	42.3%	14.9%

Table S2 ICP-OES analysis of Co@N-HPMC.

Sample	Electrode area (cm^2)	Mass (g)	Concentration of Co (mg kg^{-1})	Loading of Co in Co@N-HPMC (mg cm^{-2})
Co@N-HPMC	1.0	0.0162	19490.1	0.32

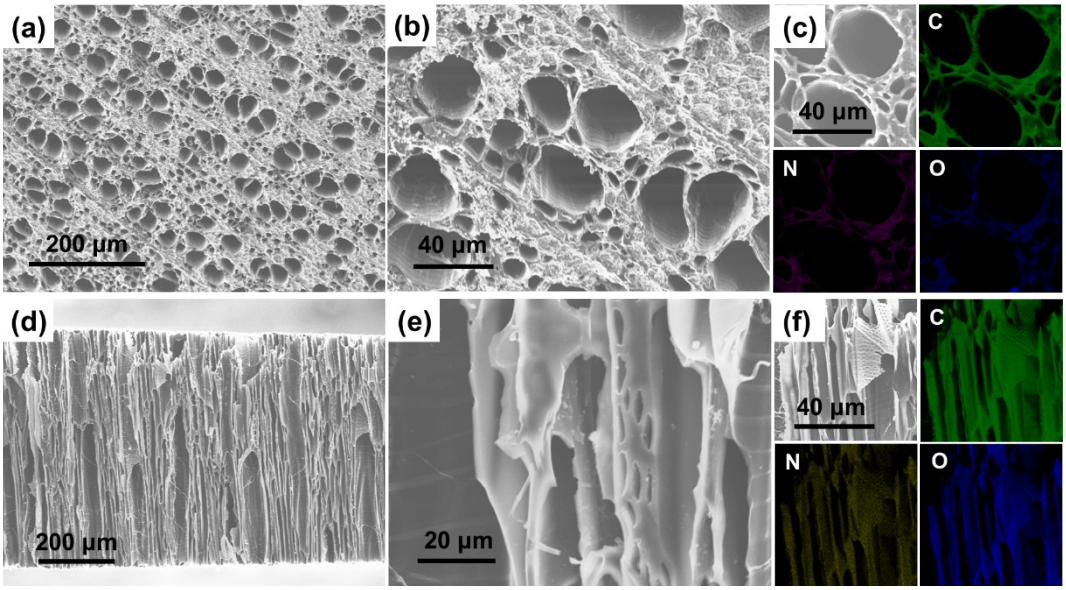


Fig. S5 (a, b) Top-view SEM images of N-HPMC and (c) corresponding EDX elemental maps. (d, e) Side-view SEM images of N-HPMC and (f) corresponding EDX elemental maps.

Table S3 HER activities of various non-noble metal electrocatalysts in 1.0 M KOH solution.

Samples	Overpotential (mV) at 10 mA cm^{-2}	Catalyst Loading (mg cm^{-2})	Self-supported	Reference
Co@HPMC	**128**	**0.32**	**Yes**	**This work**
Co-NCNT/CC	78	3.4	Yes	S1
$Co_{6.25}Fe_{18.75}Ni_{75}O_x$	84	4	Yes	S2
Co@NC-Ti	106	11.2	Yes	S3
CoFe/NF	110	0.42	Yes	S4
CoP/CC	131	1.5	Yes	S5
$Co(OH)_2$/NCNTs/NF	170	0.72	Yes	S6
$NiCo_2N$/NF	180	-	Yes	S7
Co-MoS_2	48	4	No	S8
Co_4Ni_1P NTs	129	0.19	No	S9
Co_2P-N-C	139	0.4	No	S10
FeCo	149	1	No	S11
H-$Co_{0.85}Se$|P	150	2.1	No	S12
Cu@CoFeLDH	171	2.4	No	S13
Co/NS	173	12	No	S14
Co@BCN	183	21.23	No	S15
Co@NCN-800	200	0.285	No	S16
Co/N–C	210	4.5±0.1	No	S17
Co@Co_3O_4-NC	221	0.4	No	S18
FeCo@NCNTsNH	275	0.32	No	S19
N-Co@G	337	0.285	No	S20
Co-NRCNTs	370	0.280	No	S21

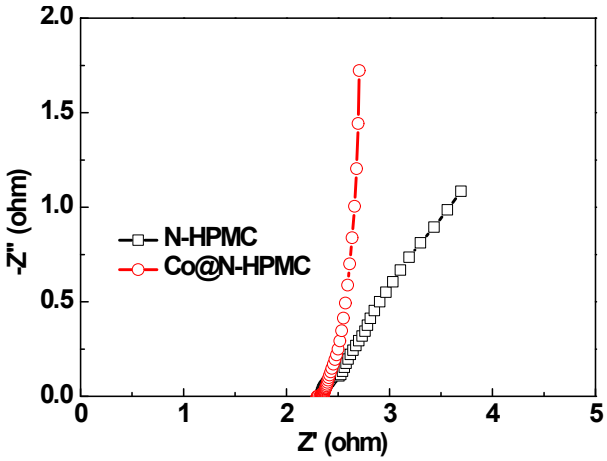


Fig. S6 Nyquist plots of N-HPMC and Co@N-HPMC recorded in 1.0 M KOH at open cicuit potential. The The N-HPMC has a small semicircles in the low-frequency range of the Nyquist plots than Co@N-HPMC, indicating that the charge-transfer-related resistance (R_{ct}) of N-HPMC is smaller than Co@HPMC, which is due to the fact that the presence of surface oxides on Co nanoparticles will interrupt the electron transfer within N-HMPC matrix.

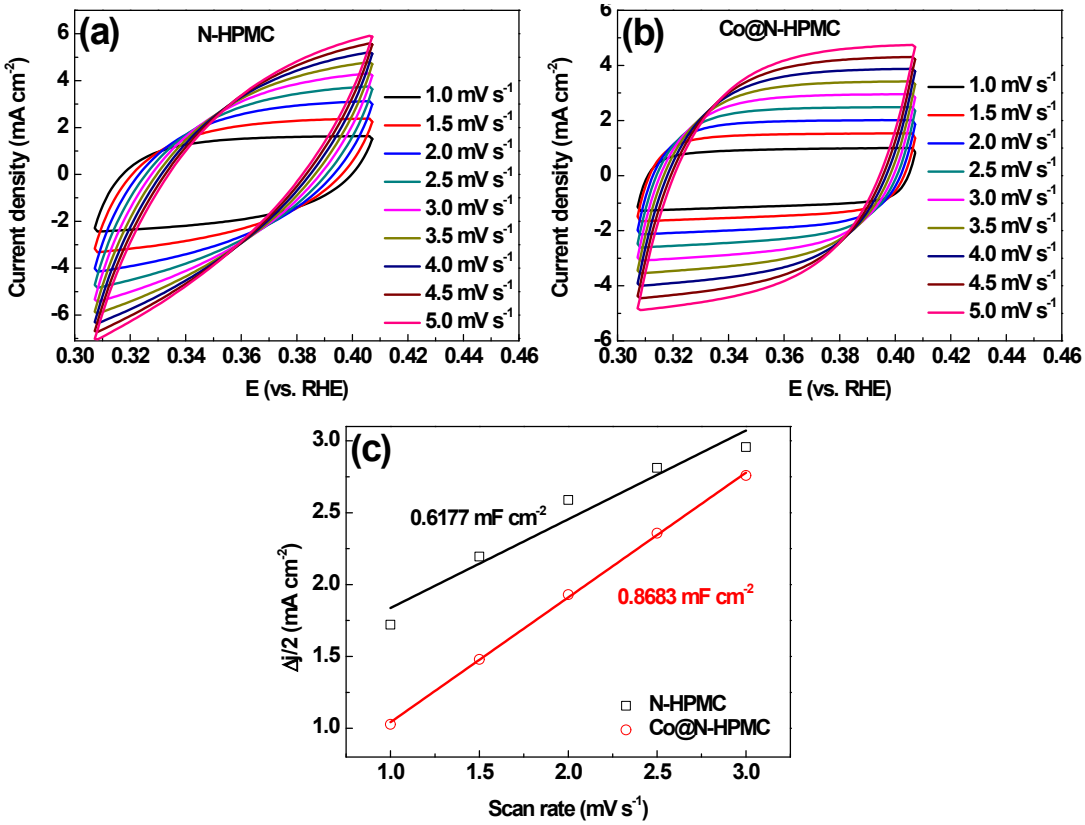


Fig. S7 CV curves of the (a) N-HPMC and (b) Co@N-HPMC at various scan rates. (c) Comparison of C_{dl} for N-HPMC and Co@N-HPMC.

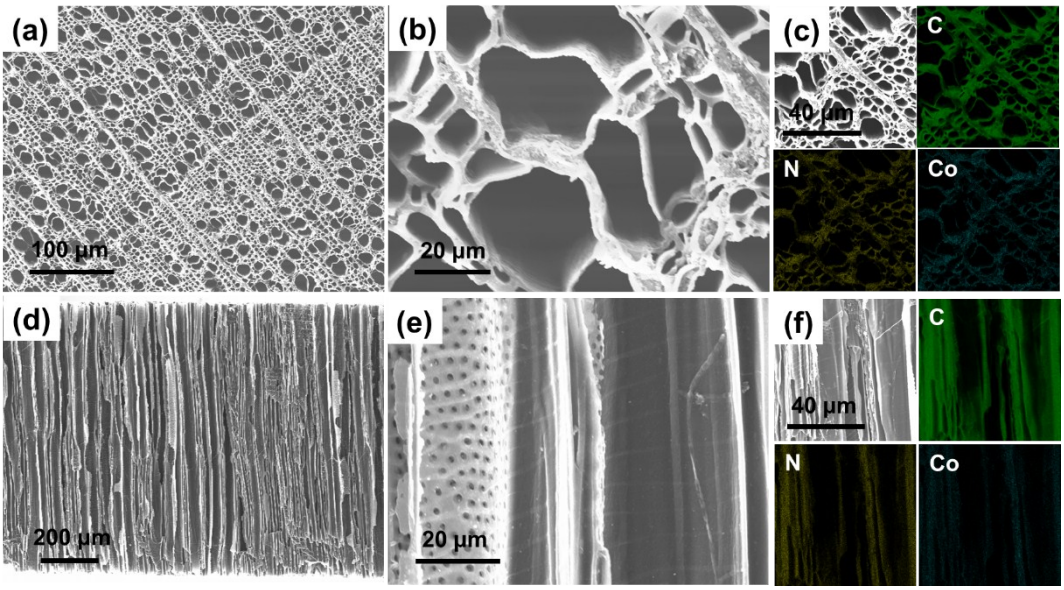


Fig. S8 (a, b) Top-view SEM images of Co@N-HPMC after HER stability test and (c) corresponding EDX elemental maps. (d, e) Side-view SEM images of Co@N-HPMC after HER stability test and (f) corresponding EDX elemental maps.

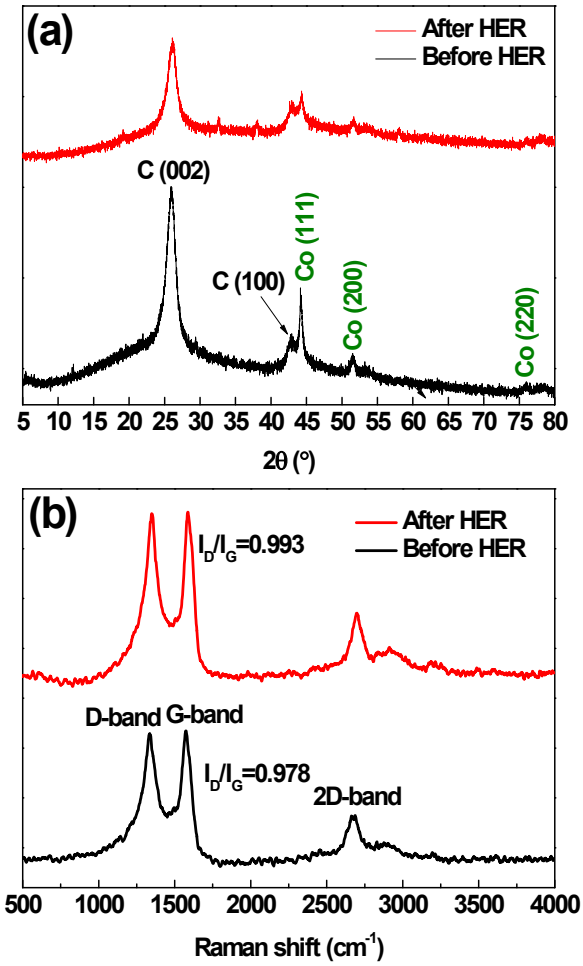


Fig. S9 (a) XRD patterns and (b) Raman spectra of Co@N-HPMC before and after HER stability test.

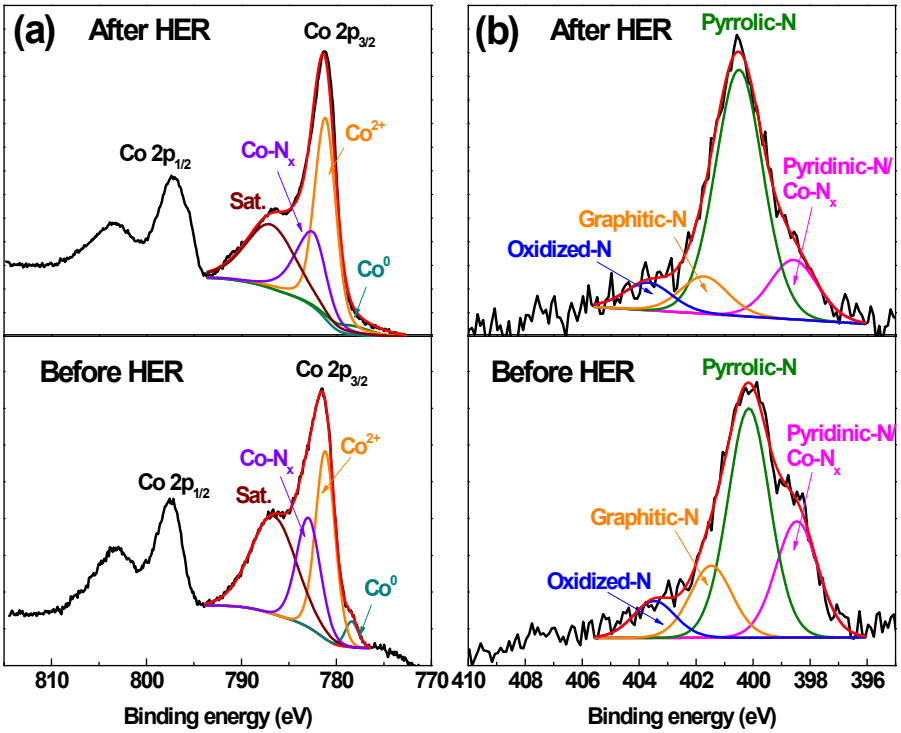


Fig. S10 High-resolution XPS spectra of (a) Co 2p and (b) N 1s for Co@N-HPMC before and after HER stability test.

Table S4 OER activities of various non-noble metal electrocatalysts in 1M KOH.

Samples	Overpotential (mV) at j=10 mA cm^{-2}	Catalyst Loading (mg cm^{-2})	Self-supported	Reference
Co@HPMC	**297**	**0.32**	**Yes**	**This work**
$Co_{6.25}Fe_{18.75}Ni_{75}O_x$	186	4	Yes	S2
CoFe/NF	220	0.42	Yes	S4
$Co(OH)_2$/NCNTs/NF	270	0.72	Yes	S6
$NiCo_2N$/NF	290	-	Yes	S7
Co_1Mn_1CH/NF	294	-	Yes	S22
CoP/CC	300	1.5	Yes	S5
Cu@CoFe LDH	240	2.4	No	S13
CoFeBO/NS	240	2.0	No	S14
Co_4Ni_1P	245	0.19	No	S12
Co-MoS_2	260	4	No	S8
$Co_{0.9}S_{0.58}P_{0.42}$	266	-	No	S23
FeCoNi	288	1	No	S11
Mn-Co oxyphosphide	320	0.25	No	S24
CoS_2/N,S-GO	380	0.25	No	S25
Co@Co_3O_4-NC	391	0.4	No	S18
Co@N–C	400	0.45±0.1	No	S17

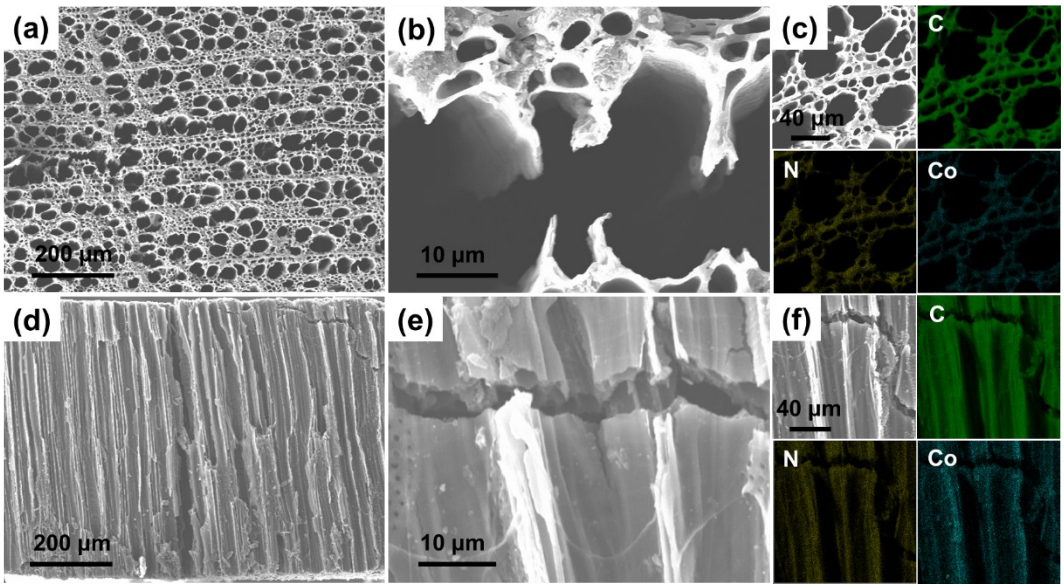


Fig. S11 (a, b) Top-view SEM images of Co@N-HPMC after OER stability test and (c) corresponding EDX elemental maps. (d, e) Side-view SEM images of Co@N-HPMC after OER stability test and (f) corresponding EDX elemental maps.

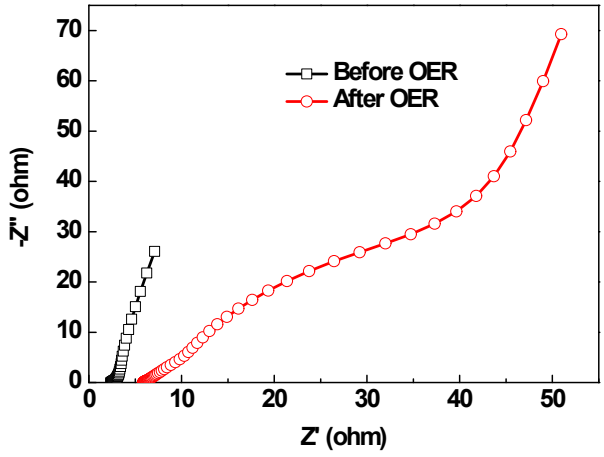
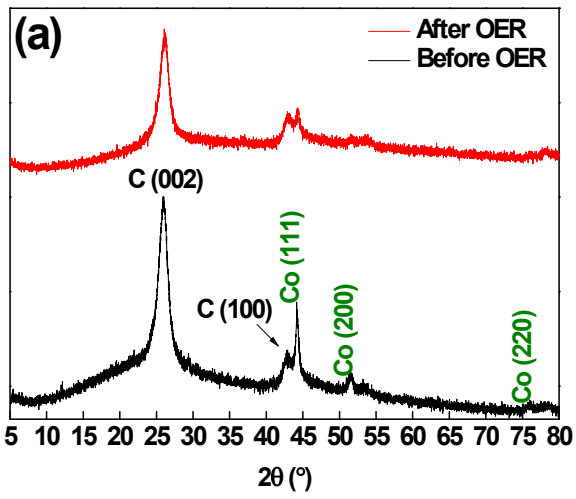


Fig. S12 Nyquist plots of the Co@N-HPMC before and after OER meaured at open circuit potential.



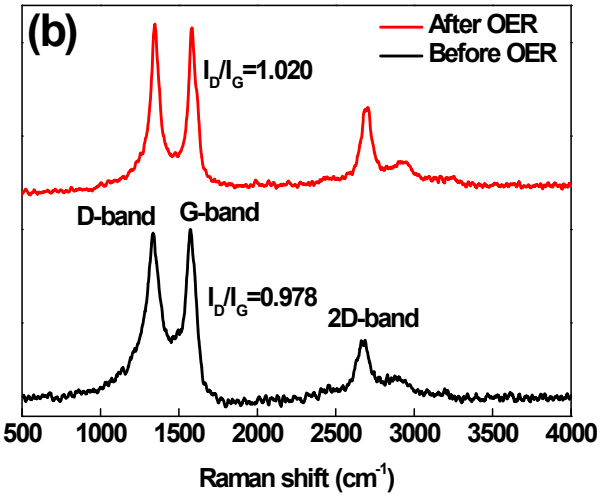


Fig. S13 (a) XRD patterns and (b) Raman spectra of Co@N-HPMC before and after OER stability test.

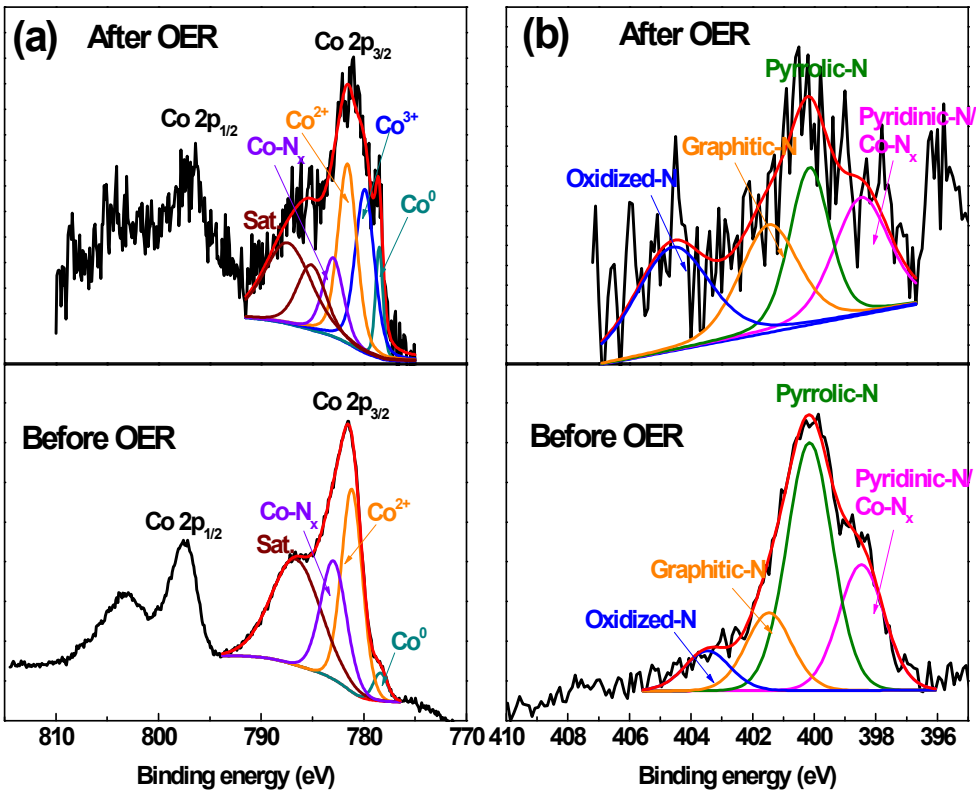


Fig. S14 High-resolution XPS spectra of (a) Co 2p and (b) N 1s for Co@N-HPMC before and afte OER stability test.

Table S5 Comparison of two electrodes water splitting with different bifunctional electrocatalysts

Electrode configuation Cathode‖Anode	Overpotential (V) at j=10 mA cm^{-2}	Catalyst Loading (mg cm^{-2})	Self-supported	Reference
Co@HPMC‖Co@HPMC	1.77	0.32	Yes	This work
CoFe/NF‖CoFe/NF	1.45	0.42	Yes	S4
$Co_{6.25}Fe_{18.75}Ni_{75}O_x$‖$Co_{6.25}Fe_{18.75}Ni_{75}O_x$	1.583	0.19	Yes	S2
CoSe film‖CoSe film	1.65	3.8	Yes	S26
CoP/CC‖CoP/CC	1.68	1.5	Yes	S5
$NiCo_2N$/NF‖$NiCo_2N$/NF	1.7	-	Yes	S7
$Co(OH)_2$/NCNTs/NF‖$Co(OH)_2$/NCNTs/NF	1.72	0.72	Yes	S6
CoFeBO/NS‖Co/NS‖CoFeBO/NS‖Co/NS	1.51	12/2	No	S14
Co_4Ni_1P NTs‖Co_4Ni_1P NTs	1.59	0.19	No	S11
$Co_{0.9}S_{0.58}P_{0.42}$‖$Co_{0.9}S_{0.58}P_{0.42}$	1.59	-	No	S23
EG/H-$Co_{0.85}$Se|P‖EG/H-$Co_{0.85}$Se|P	1.64	2.1	No	S12
$NiCo_2O_4$‖$NiCo_2O_4$	1.65	1.0	No	S27
FeCo‖FeCoNi	1.678	1	No	S11
Cu@CoFeLDH‖Cu@CoFeLDH	1.681	2.4	No	S13
Co_3O_4 NCs/carbon‖Co_3O_4NCs/carbon	1.91	0.35	No	S28

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