Electronic Supplementary Information

Improving the electrocatalytic performance of sustainable Co/Carbon materials for oxygen evolution reaction by ultrasound and microwave assisted synthesis

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Fig. S1 Picture of the combined MW/US apparatus.

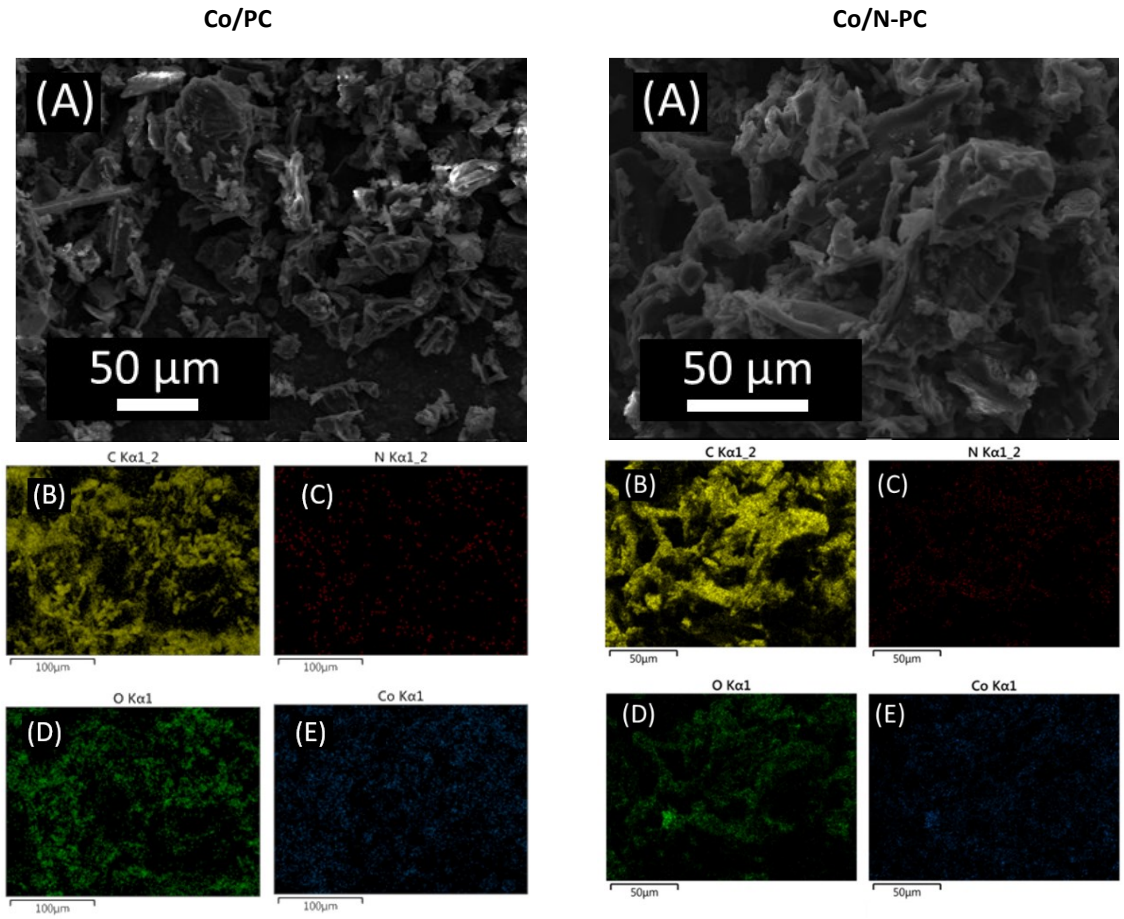

Fig. S2 Mapping analysis of the Co/PC (left panel) and Co/N-PC (right panel) composites: (A) SEM image; (B) Carbon; (C) Oxygen; (D) Nitrogen and (E) Cobalt.

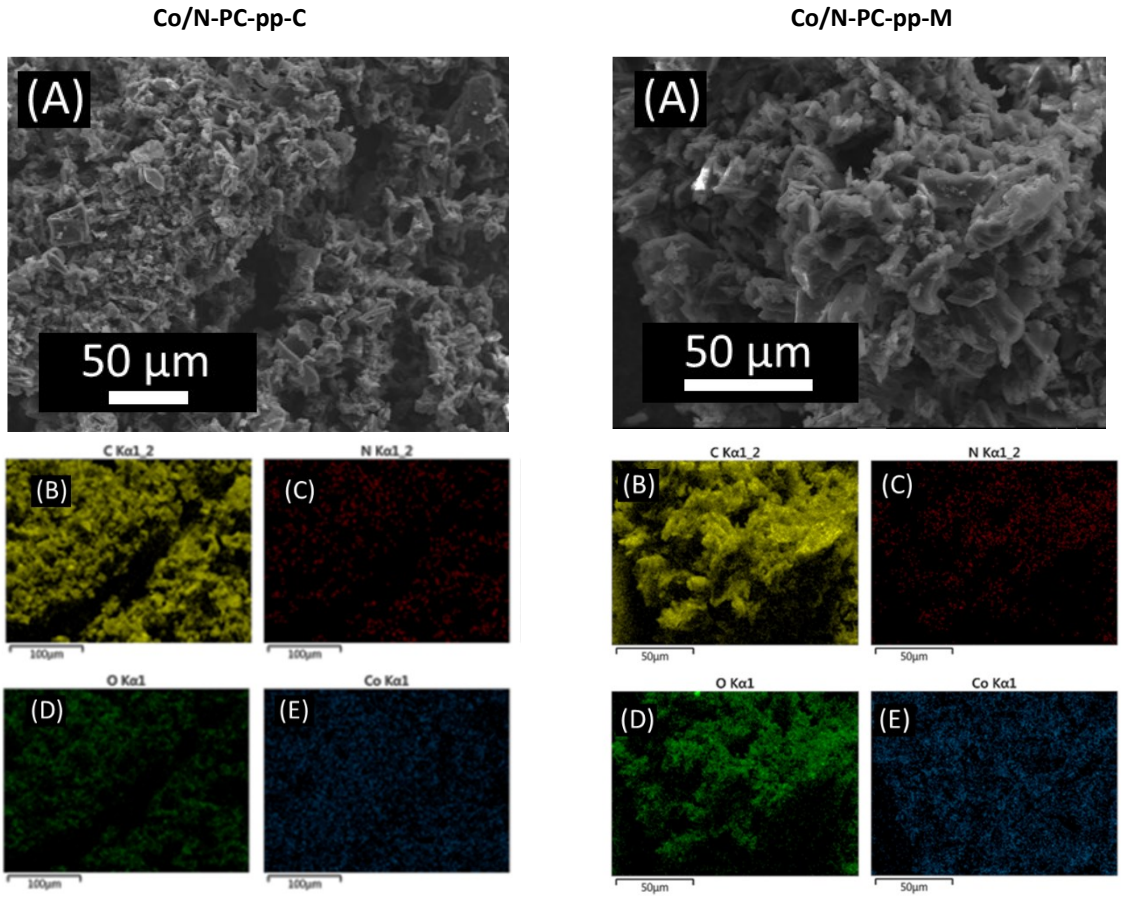

Fig. S3 Mapping analysis of the Co/N-PC-pp-C (left panel) and Co/N-PC-pp-M (right panel) composites: (A) SEM image; (B) Carbon; (C) Oxygen; (D) Nitrogen and (E) Cobalt.

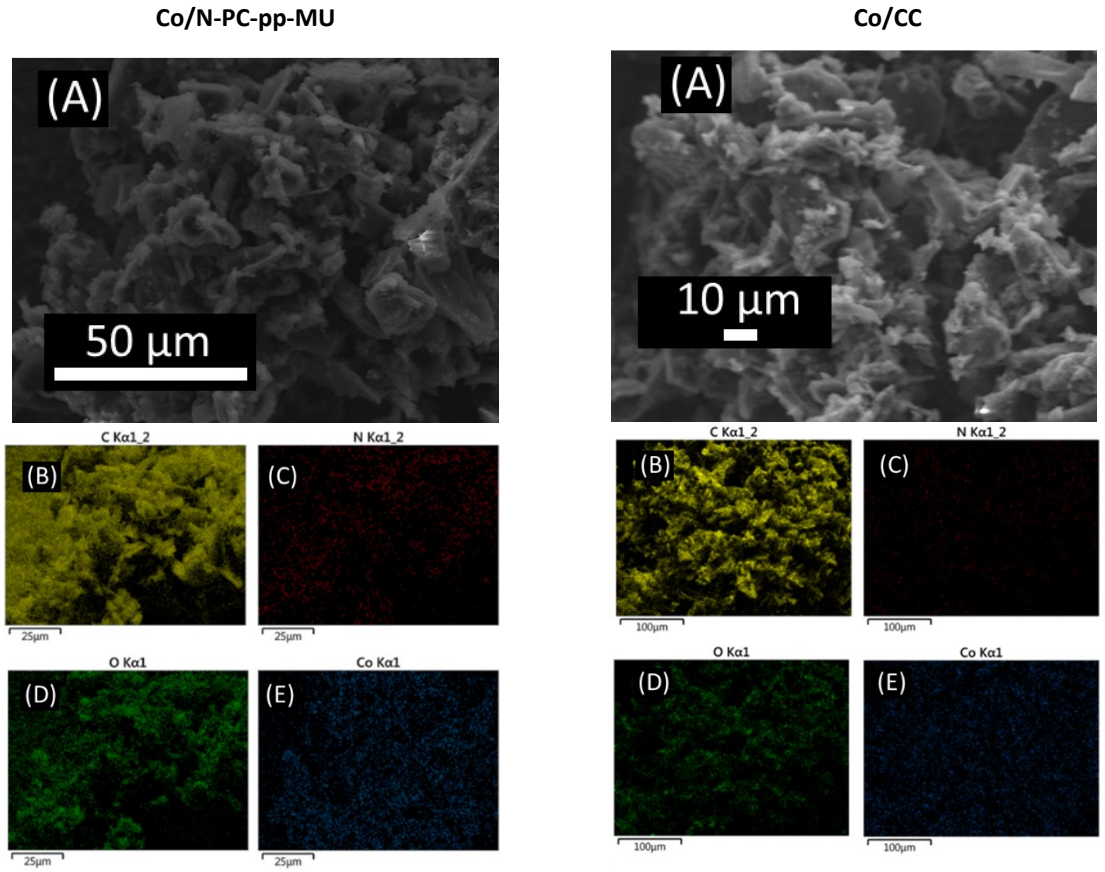

Fig. S4 Mapping analysis of the Co/N-PC-pp-MU (left panel) and Co/CC (right panel) composites: (A) SEM image; (B) Carbon; (C) Oxygen; (D) Nitrogen and (E) Cobalt.

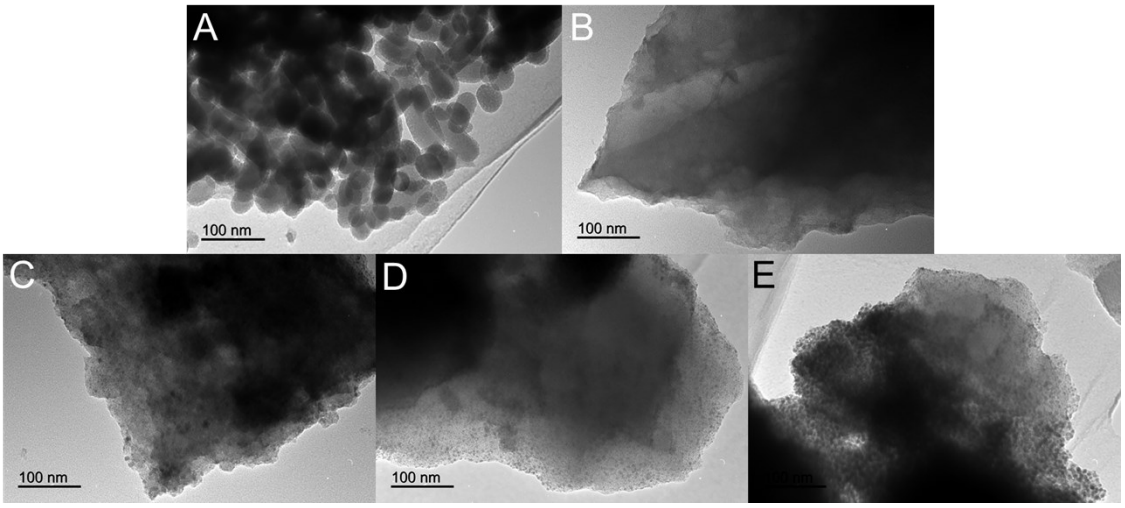

Fig. S5. Representative TEM images of Co/CC (A), N-PC (B), Co/N-PC-pp-M (C), Co/N-PC-pp-U (D) and Co/N-PC-pp-MU (E) samples.

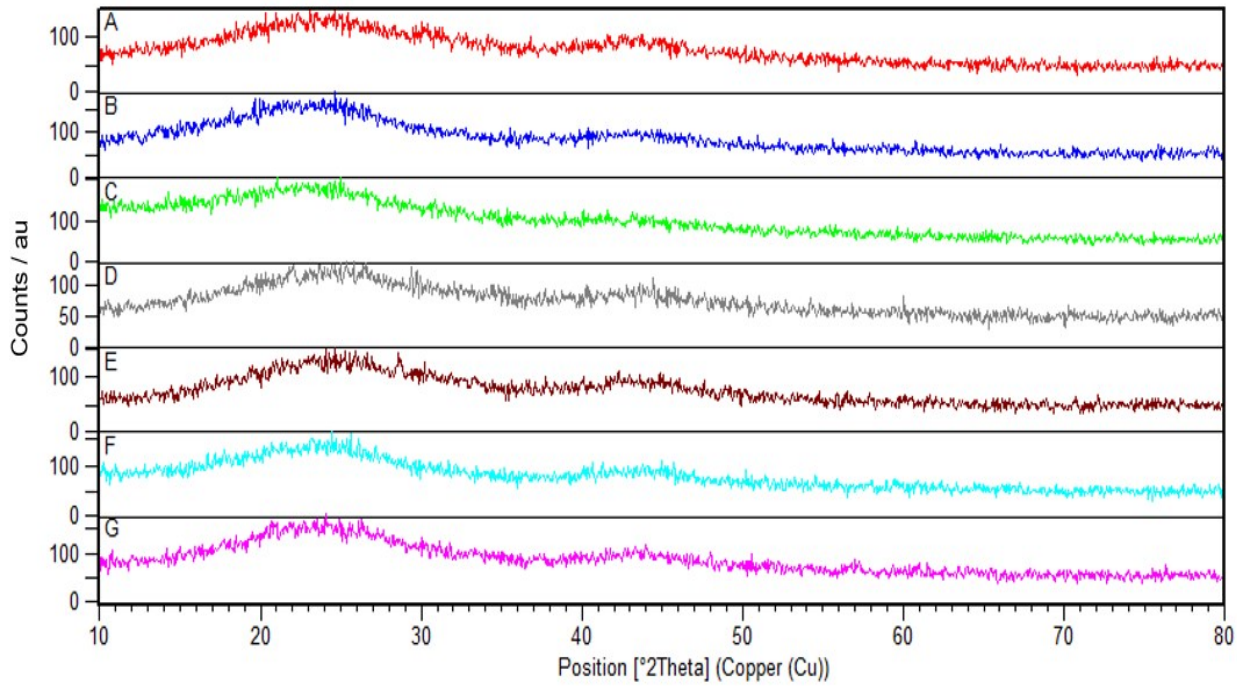

Fig. S6 XRD patterns of the different samples: (A) Co/PC; (B) Co/N-PC; (C) Co/N-PC-pp-C; (D) Co/N-PC-pp-M; (E) Co/N-PC-pp-U, (F) Co/N-PC-pp-MU and (G) Co/CC.

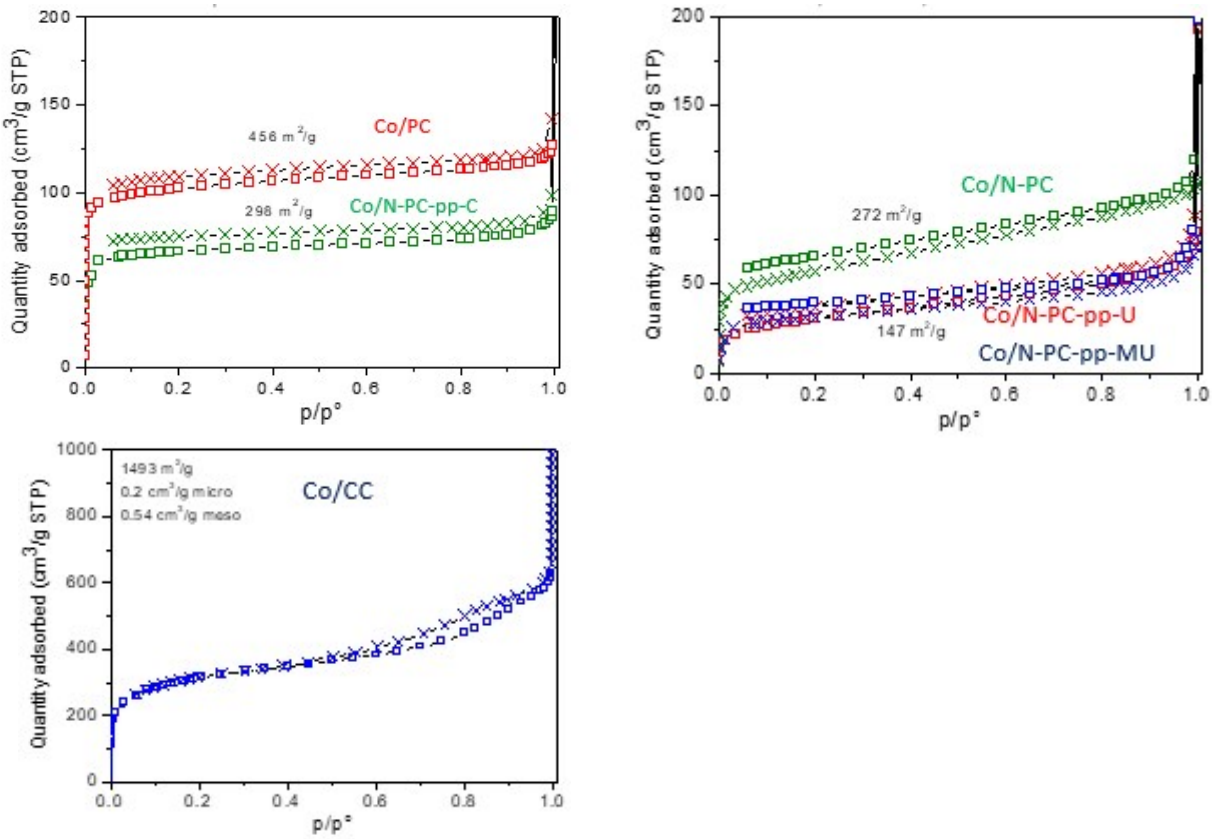

Fig. S7 N_2 adsorption-desorption isotherms of the different samples.

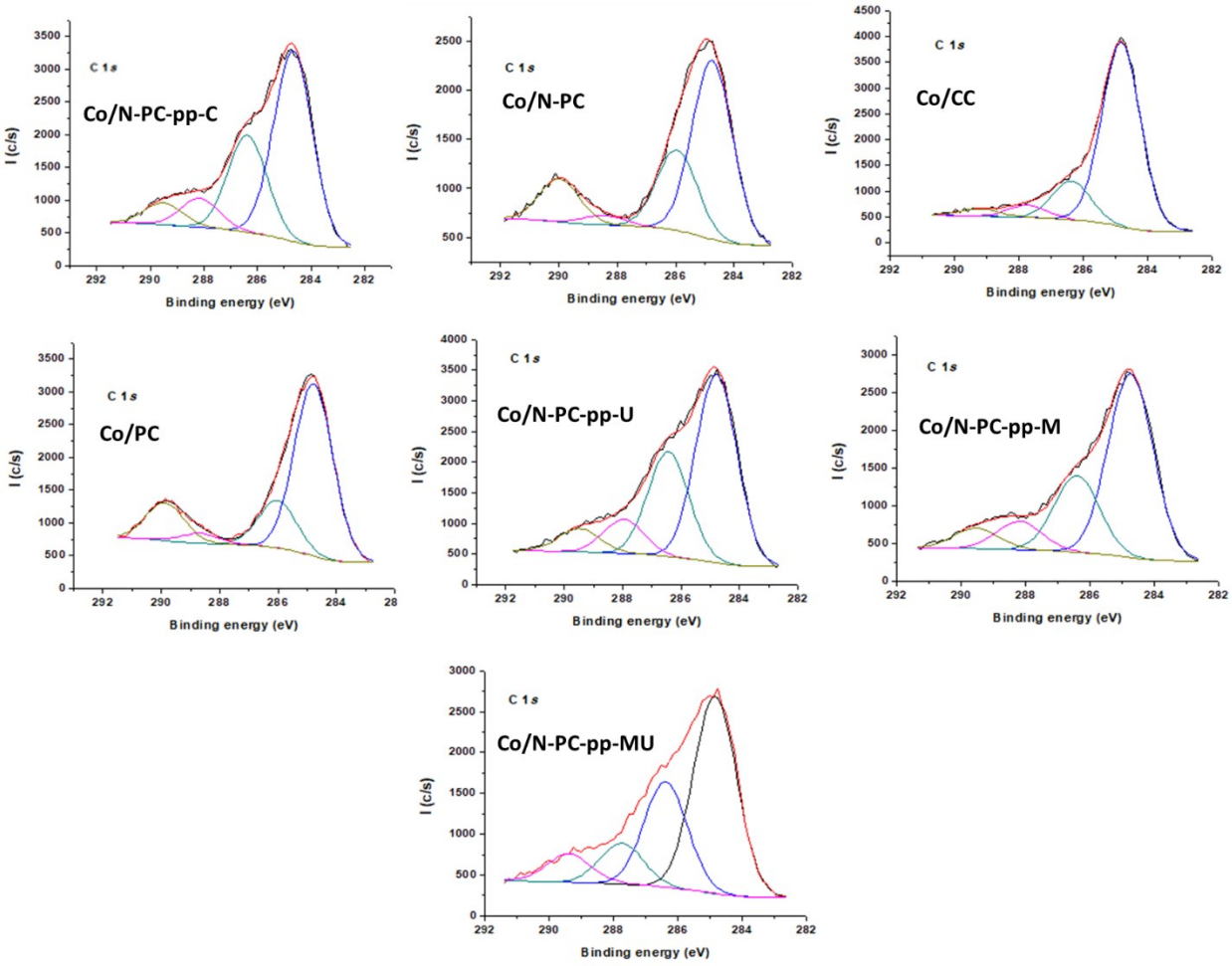

Fig. S8 HR-XPS C 1s core level spectra for Co/CC, Co/PC, Co/N-PC and Co/N-PC-pp-C, Co/N-PC-pp-U, Co/N-PC-pp-M and Co/N-PC-pp-MU samples.

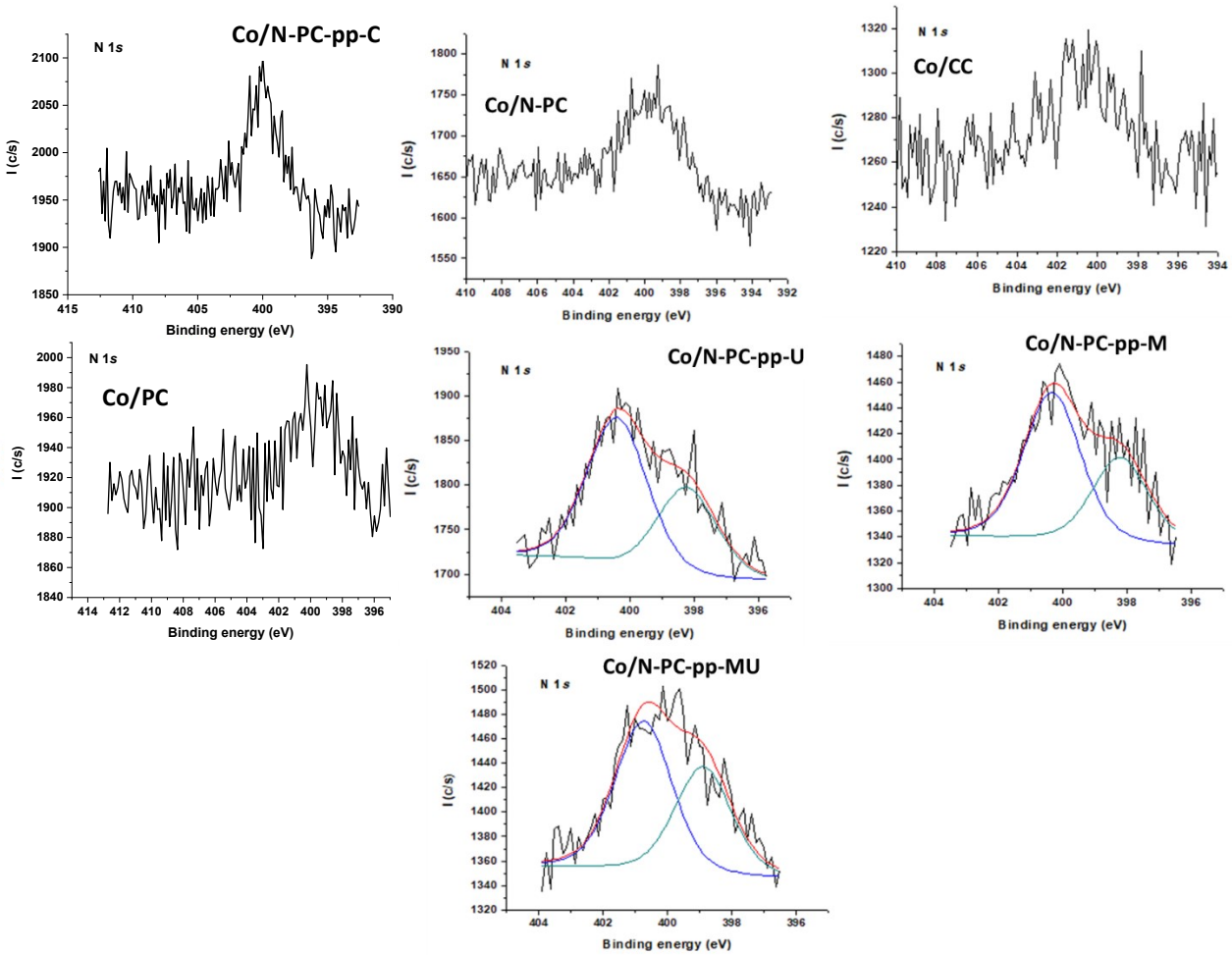

Fig. S9 HR-XPS N 1s core level spectra for Co/CC, Co/PC, Co/N-PC and Co/N-PC-pp-C, Co/N-PC-pp-U, Co/N-PC-pp-M and Co/N-PC-pp-MU samples.

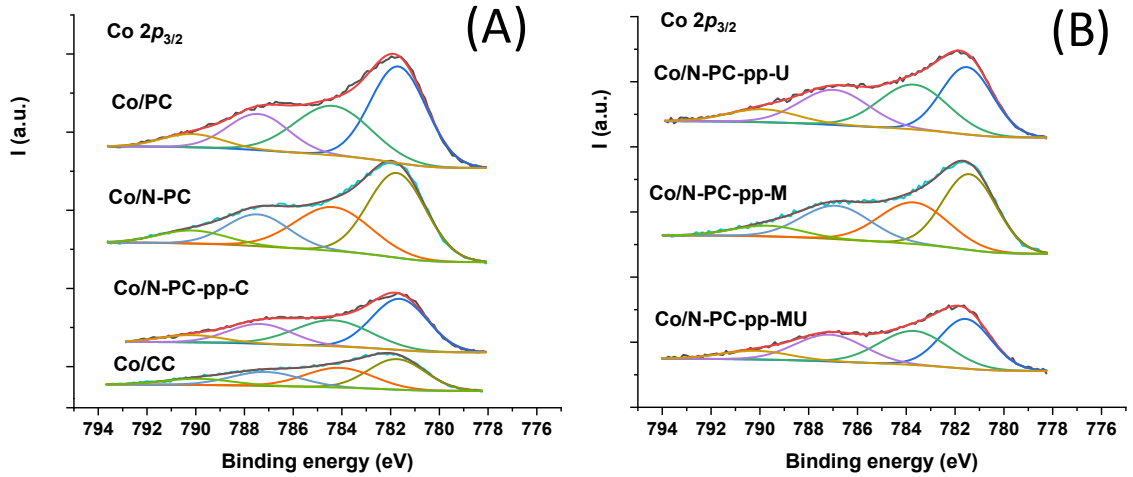

Fig. S10 (A,B) Deconvoluted XPS spectra of the Co $2p_{3/2}$ region for the different samples.

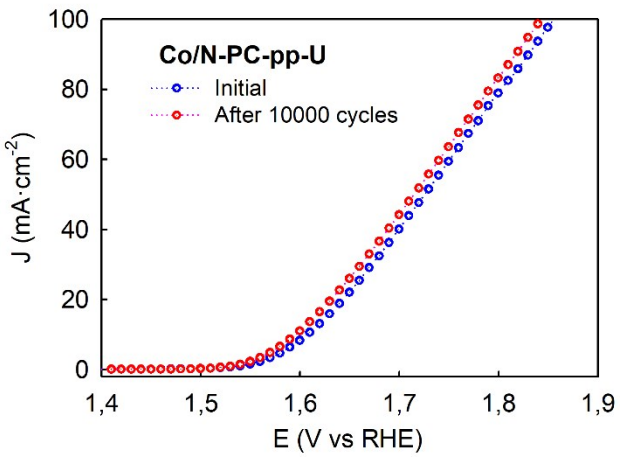

Fig. S11. LSV curves of Co/N-PC-pp-U sample before and after performing 10000 cycles of cyclic voltammetry at the same OER conditions.

Table S1. List of the amount of final product obtained (in mg) with the different synthetic procedures.

Sample	Amount final product (mg)
Co/CC	299
Co/PC	254
Co/N-PC	307
Co/N-PC-pp-C	274
Co/N-PC-pp-M	306
Co/N-PC-pp-U	318
Co/N-PC-pp-MU	323

Table S2. Co $2p_{3/2}$ spectral fitting parameters and Δ (Co $2p_{3/2}$-Co $2p_{1/2}$) (in eV).

Sample	Peak 1	Peak 2	Peak 3	Peak 4	Δ (Co $2p_{3/2}$-Co $2p_{1/2}$)
Co/CC	781.8(39%)	784.1(30%)	787.1(21%)	789.9(10%)	-
Co/PC	781.7(44%)	784.4(31%)	787.4(18%)	790.1(7%)	16.0
Co/N-PC	781.8(44%)	784.4(30%)	787.5(18%)	790.1(8%)	16.1
Co/N-PC-pp-C	781.6(44%)	784.4(30%)	787.4(19%)	790.0(7%)	16.1
Co/N-PC-pp-M	781.4(41%)	783.7(29%)	786.9(23%)	789.7(7%)	16.0
Co/N-PC-pp-U	781.5(35%)	783.7(31%)	787.0(24%)	789.9(10%)	16.1
Co/N-PC-pp-MU	781.6(35%)	783.7(32%)	787.1(25%)	790.2(8%)	16.3

Table S3. Comparison of the OER electrocatalytic parameters of the Co/N-PC with the state-of-the-art Co-based carbon catalysts.

Catalysts	Onset potential (V)	η_{10} (mV)	Tafel slope (mV · dec^{-1})	Co% wt	Ref.
Co@Co_3O_4/NC	1.58	410	80	-	[S1]
Co@C-600	1.45	277	46	3.9[a]	[S2]
Co_3O_4/rGO	1.57	346	47	10	[S3]
Co–N/PC@CNT-700	1.48	400	89	-	[S4]
Co@CNT/MSC	1.64	547	155	-	[S5]
Co_9S_8/C NSs	1.50	434	119	-	[S6]
Co/N-PC-pp-MU	1.57	520	92	3.40[b]	This work

[a]XPS analysis.

[b] ICP-MS analysis.

Table S4. OER electrocatalytic parameters obtained for Co/N-PC-pp-M at different temperatures.

Co/N-PC-pp-M				
Working Temperature (°C)	**Onset potential (V)**	**Overpotential (mV) at 10 mA·cm^{-2}**	**Maximum current density (mA·cm^{-2})**	**Tafel slope (mV·dec^{-1})**
R.T.	1.57	526	27.1	78
60	1.55	440	70.0	74
80	1.52	380	106.1	69

Table S5. OER electrocatalytic parameters obtained for Co/N-PC-pp-U at different temperatures.

Co/N-PC-pp-U				
Working Temperature (°C)	**Onset potential (V)**	**Overpotential (mV) at 10 mA·cm^{-2}**	**Maximum current density (mA·cm^{-2})**	**Tafel slope (mV·dec^{-1})**
R.T.	1.56	497	32.0	94
60	1.54	428	76.6	61
80	1.51	365	126.2	58

Table S6. Comparison of OER electrocatalytic properties of Co-modified materials at 80 °C.

Catalysts	**Onset potential (V)**	**η_{10} (mV)**	**Tafel slope (mV · dec^{-1})**	**Activation energy (kJ·mol^{-1})**	**Ref.**
$LaCoO_3$ perovskite	1.57	470	73.2	47	[S7]
Co_3O_4	1.48	275	61	-	[S8]
Co/N-PC-pp-U	1.54	350	58	9.97	This work

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