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MDPI

Supplementary Materials

Nitrogen-Doped Porous Carbon Derived from Biomass Used as Trifunctional Electrocatalyst toward Oxygen Reduction, Oxygen Evolution and Hydrogen Evolution Reactions

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Measurement of the Number of Electron and Koutecky-Levich (K-L) plot

The linear sweep voltammetry (LSV) technique was conducted with an RDE loaded with as-prepared samples at different rotation rates to investigate the electrode kinetics toward ORR. The overall electron transfer number (n) per oxygen molecule in a typical ORR process on different electrodes can be calculated using the Koutecky-Levich (K-L) equation as follows.

$$1/j = 1/j_k + 1/0.62nFC(D)2/3\omega 1/2v\text{-}1/6) \quad (1)$$

where j and j_K are the measured and kinetic-limited current density respectively. j_K is assumed to be a constant at a certain potential. F is the Faraday constant; n is the number of electrons transferred per oxygen molecule; D is the diffusion coefficient of O_2 in 0.1M KOH; C is the bulk concentration of O_2 (1.2 x 10-3 mol/liter); ν is the kinematic viscosity of electrolyte (0.01 cm2 /s); ω is the rotation in rpm; and k is the electron transfer rate constant. From the corresponding K-L plots, the data exhibited good linearity. Then, n can be calculated as

$$n = 4\frac{I_d}{I_d + I_r/N} \quad (2)$$

where I_r is the ring current, I_d is the disk current, and N is the current collection efficiency of the Pt ring, which was determined to be 0.41.

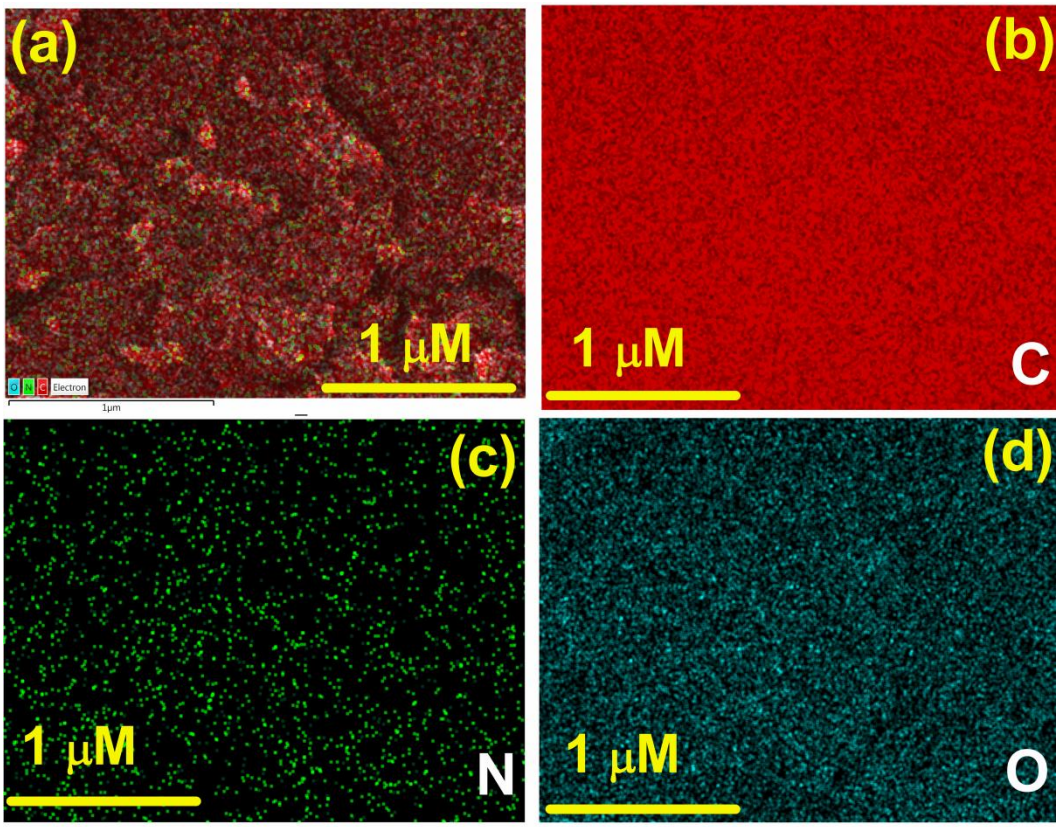

Figure S1. (**a**–**d**) SEM image elemental mapping of C, N, and O for N-PC.

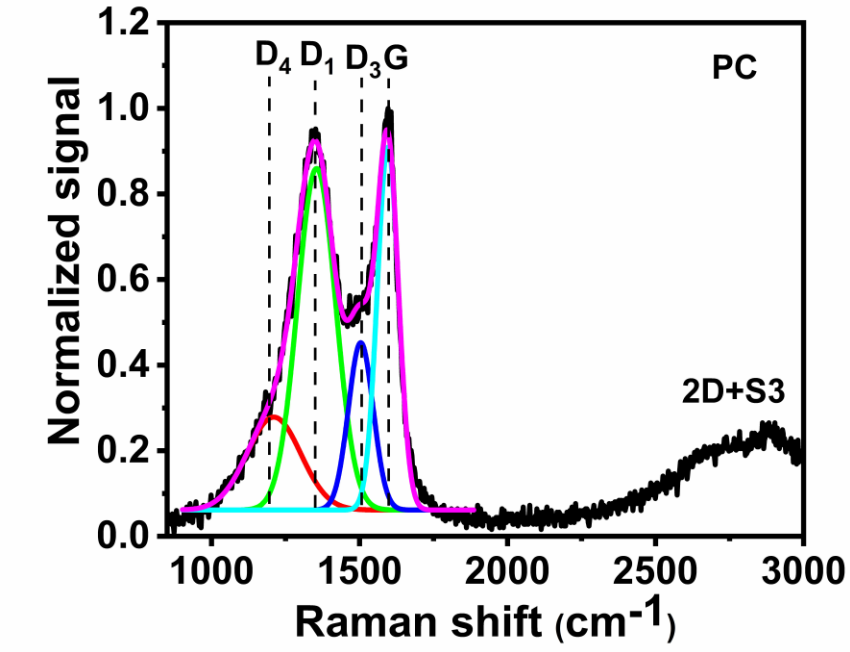

Figure S2. Raman spectrum of PC with a deconvolution of the *D*/*G* spectral region.

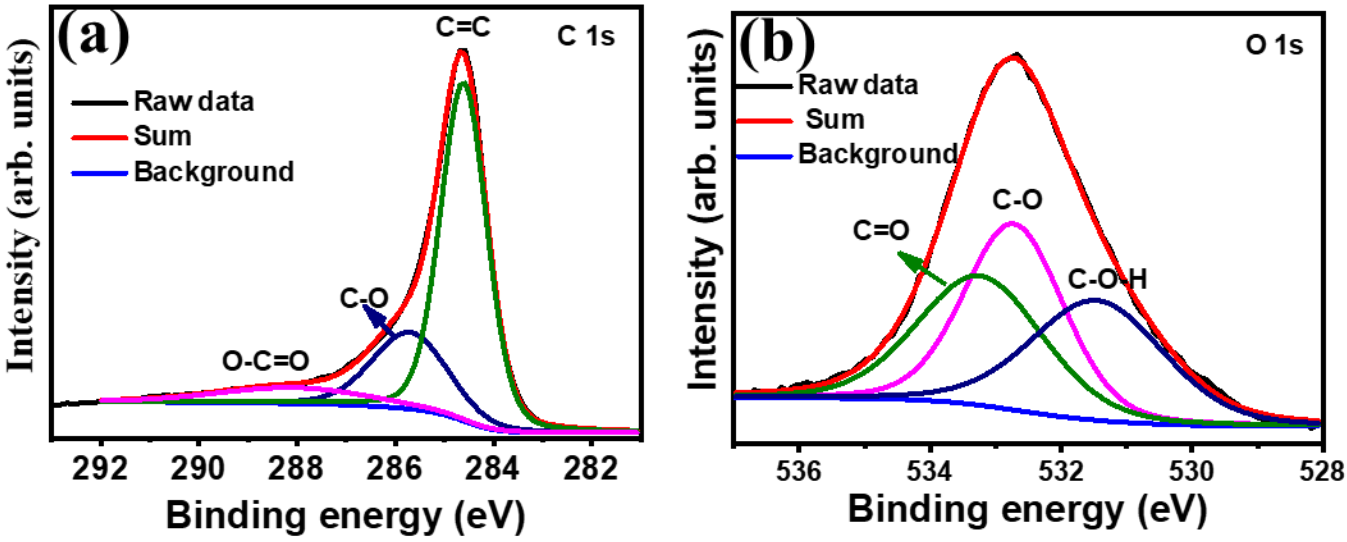

Figure S3. Deconvoluted XPS spectra of (a) C 1s and (b) O 1s for PC.

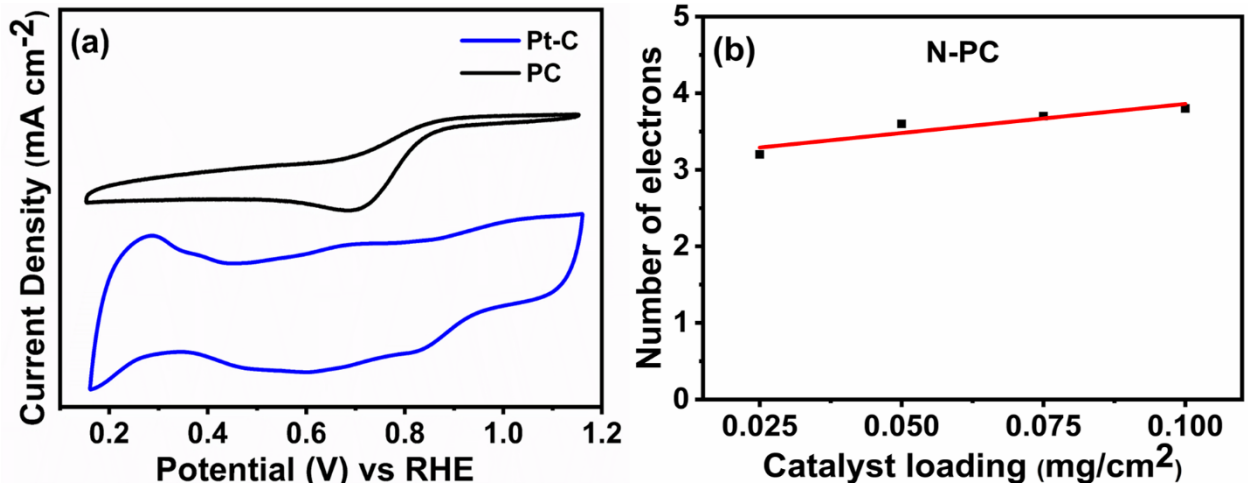

Figure S4. (**a**) CV curves of PC and Pt-C in O_2 saturated (**b**) Effect of the catalyst loading on the number of electrons transferred.

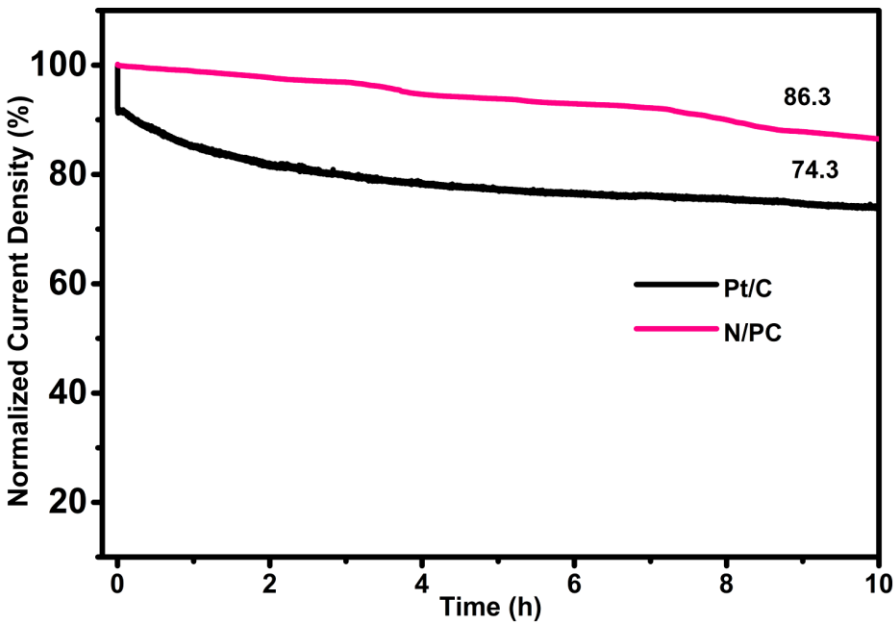

Figure S5. Long term durability of N-PC and Pt-C in 0.1 M KOH.

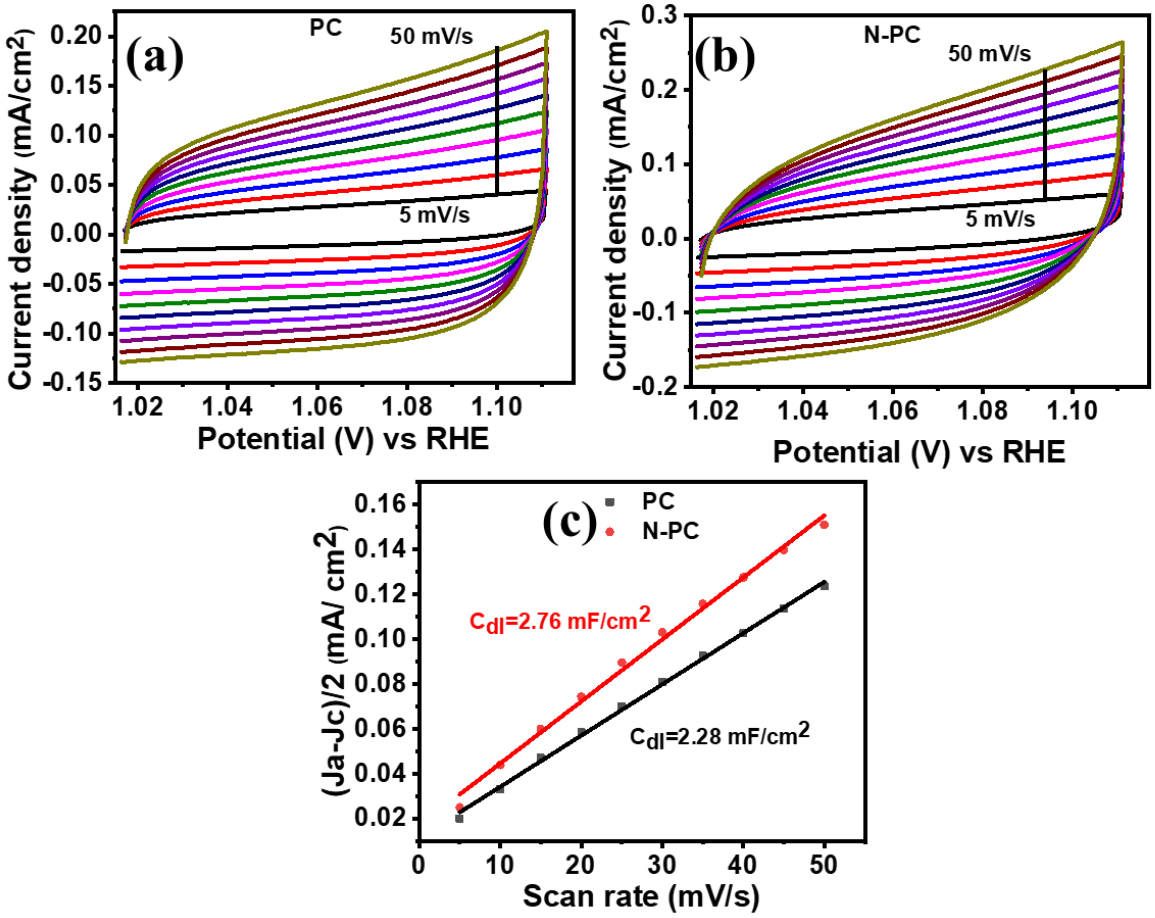

Figure S6. CV curves of (**a**) PC and (**b**) N-PC with different scan rate from 5–25 mV S^{-1}; (**c**) linear fit of ΔJ/2 Vs scan rate.

Table S1. Comparison of ORR performance for N-PC with other Bio-derived activated carbon.

The precursor for Carbon source	Sample Name	Onset potential vs RHE (V)	Electrolyte	References
Golden shower	N/PC	0.83	0.1M KOH	This work
Banana peel	BPPC-MO50	0.9259	0.1M KOH	[1]
Banana peel	N-BPDC-H_3PO_4-1000	0.92	0.1M KOH	[2]
wastesoybean dregs	3D-NCN	0.82	0.1M KOH	[3]
Kidney bean	KB 350Z900	0.90	KOH	[4]
Orange peel	Pt/OP-AC	0.84	HClO4	[5]
Soybean	Fe/CeSOYB	0.84	1 M KOH	[6]

Table S2. Comparison of OER performance for N-PC@Ni with other N-doped carbon materials.

Sample Name	Overpotential at 10 mA cm-2 (mV)	Electrolyte	References
N/PC@Ni	314	1 M KOH	This work
N/C	380	KOH-pH-13	[7]
N-CCs	460	0.1 M NaOH	[8]
NPMC	390	0.1 M KOH	[9]
Fe/N-CNSs	498	0.1 M KOH	[10]
NMWNT	320	1 M NaOH	[11]
N-GRW	360	1M KOH	[12]
Ni foam/N-NTs/Ni(OH)	254	1M KOH	[13]
N-doped CNTs	370	1M KOH	[14]
NCF-900	340	1 M KOH	[15]

Table S3. Comparison of HER performance for N-PC@Ni with other N-doped carbon materials.

Sample Name	Overpotential at 10 mA cm-2 (mV)	Electrolyte	References
N/PC@Ni	179	1 M KOH	This work
NMWNT	235	0.1 M NaOH	[11]
C_3N_4@NG	240	0.5 M $H2SO_4$	[17]
N,P-graphene-1	422	0.5 M $H2SO_4$	[18]
Co-N-GA	232	1.0 M KOH	[19]
SHG	230	0.1 M KOH	[20]
Ni-NC700	301	0.1 M KOH	[21]
FeNi+NPC	340	0.1 M KOH	[16]
N,S-CN	380	1 M KOH	[22]
FeCo+NPC	450	0.1 M KOH	[16]

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