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Facile pyrolysis approach of folic acid-derived high graphite N-doped porous carbon materials for the oxygen reduction reaction

Xuexia Liu[a, b], Shuaihui Li[b], Limin Liu[b], Zhijun Wang[b, *]

[a] College of Chemistry, Nanchang University, Nanchang, Jiangxi 330088, China

[b] School of chemistry and Chemical Engineering, Jinggangshan University, Ji'an, Jiangxi 343009, China

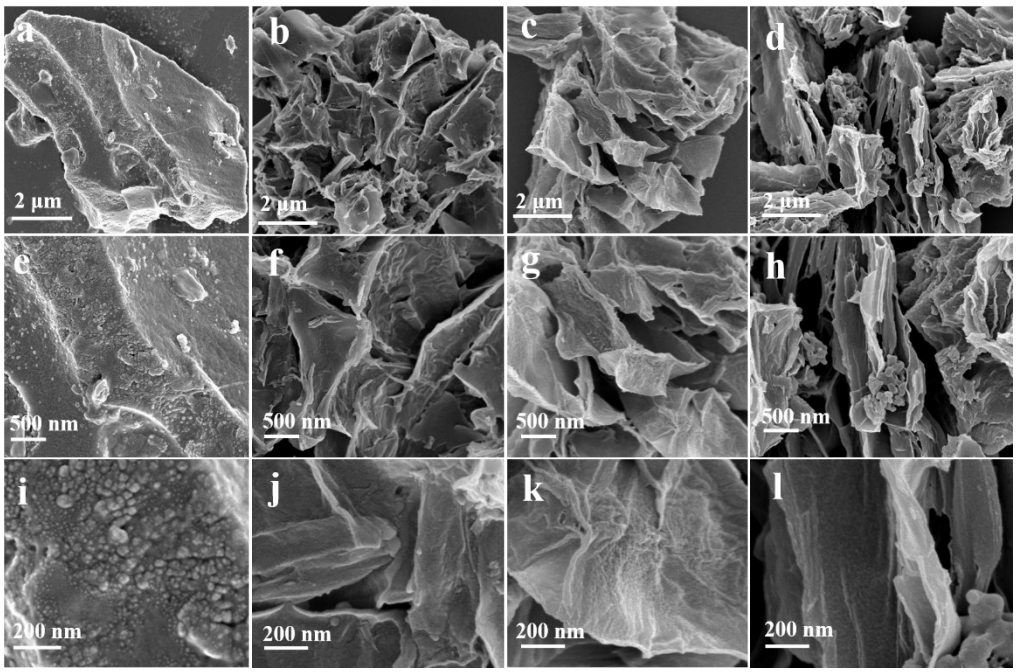

Fig. S1 Scanning electron microscopy (SEM) images of (a, e and i) dC-750, (b, f and j) m-NC-650, (c, g and k) m-NC-850 and (d, h and l) m-NC-950.

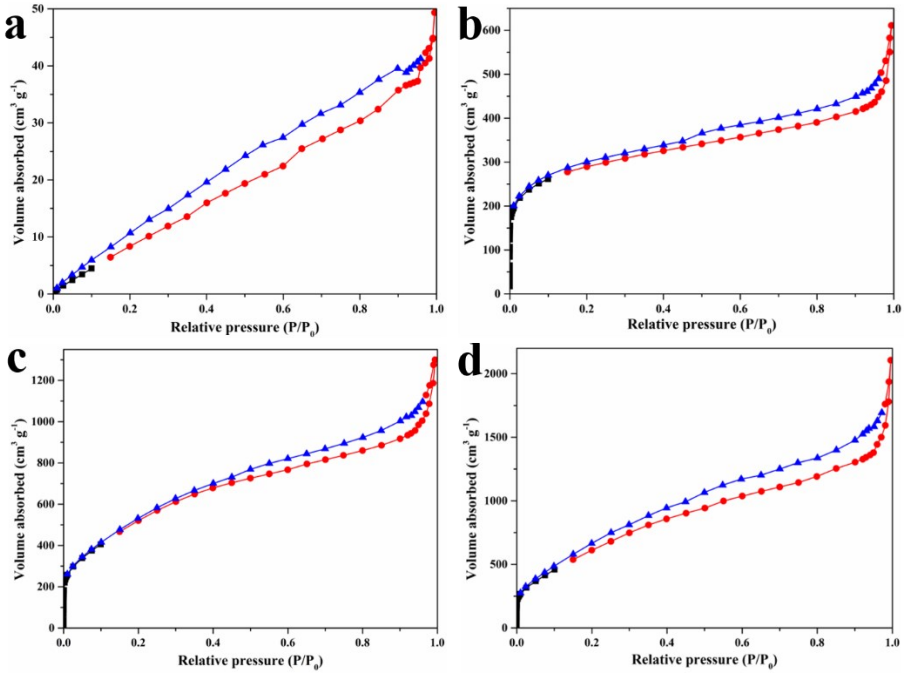

Fig. S2 Nitrogen adsorption/desorption isotherms of (a) dC-750, (b) m-NC-650, (c) m-NC-850 and (d) m-NC-950.

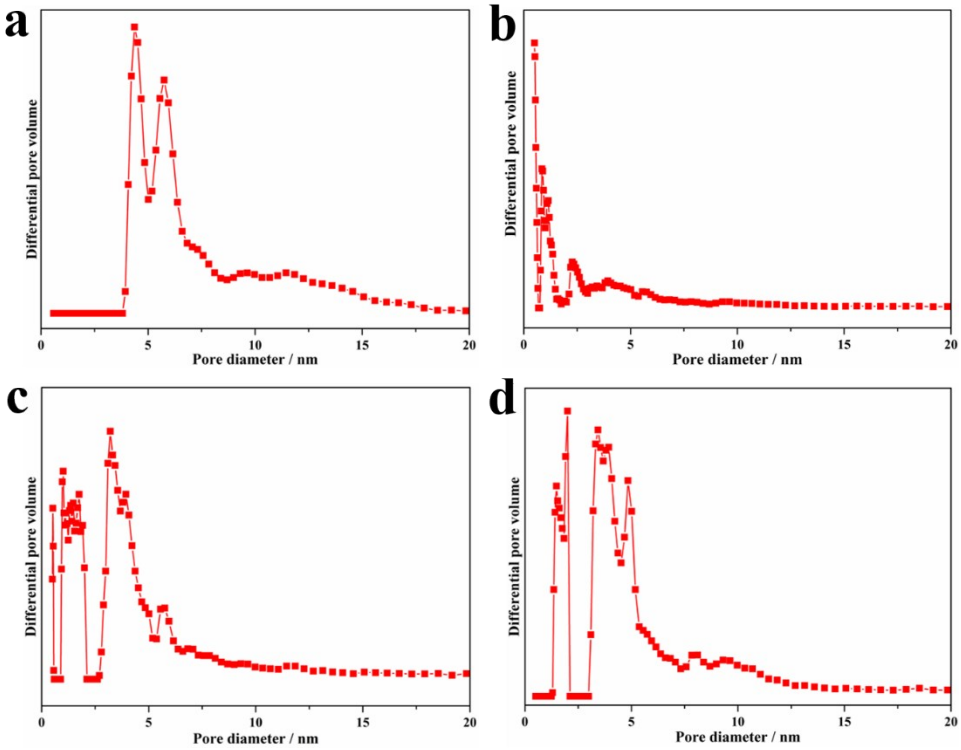

Fig. S3 Pore-size distribution curves of (a) dC-750, (b) m-NC-650, (c) m-NC-850 and (d) m-NC-950.

Table S1 Pore characteristics of dC-750 and m-NC-T.

Sample	S_{BET} ($m^2\ g^{-1}$)	$S_{langmuir}$ ($m^2\ g^{-1}$)	S_{mic} ($m^2\ g^{-1}$)	S_{mes} ($m^2\ g^{-1}$)	V_{pore} ($m^3\ g^{-1}$)	D_{aver} (nm)
dC-750	58.36	253.40	0.00	58.36	0.059	4.367
m-NC-650	1044.01	1429.62	658.76	385.25	0.672	0.504
m-NC-750	1441.08	2213.75	652.27	788.81	1.024	0.524
m-NC-850	1955.80	3228.70	448.75	1507.05	1.522	3.204
m-NC-950	2378.79	4180.74	0.00	2378.79	2.207	2.000

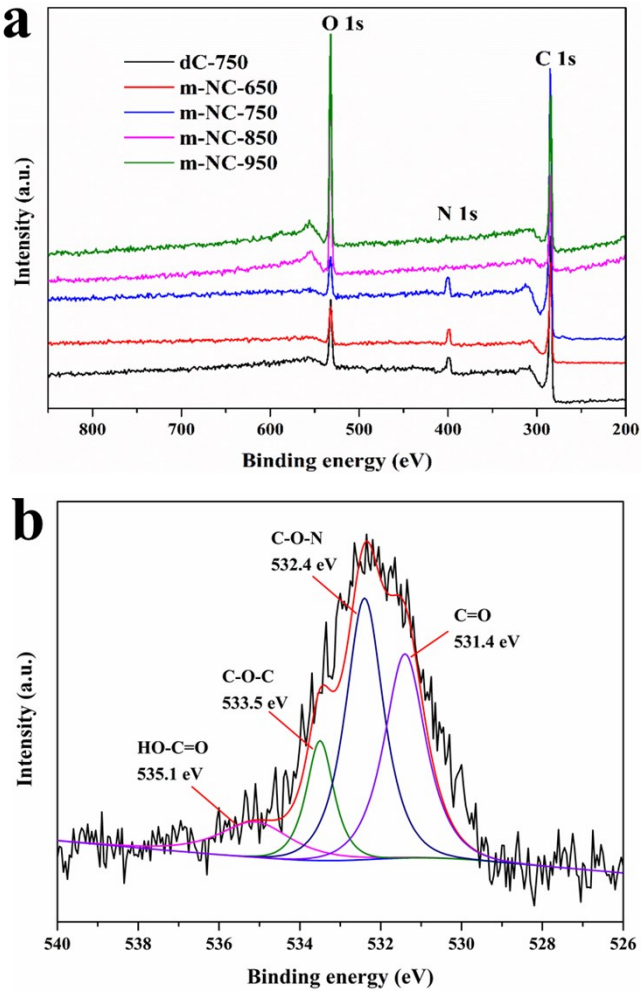

Fig. S4 (a) XPS survey spectra of as-prepared materials. (b) O 1s spectra of m-NC-750.

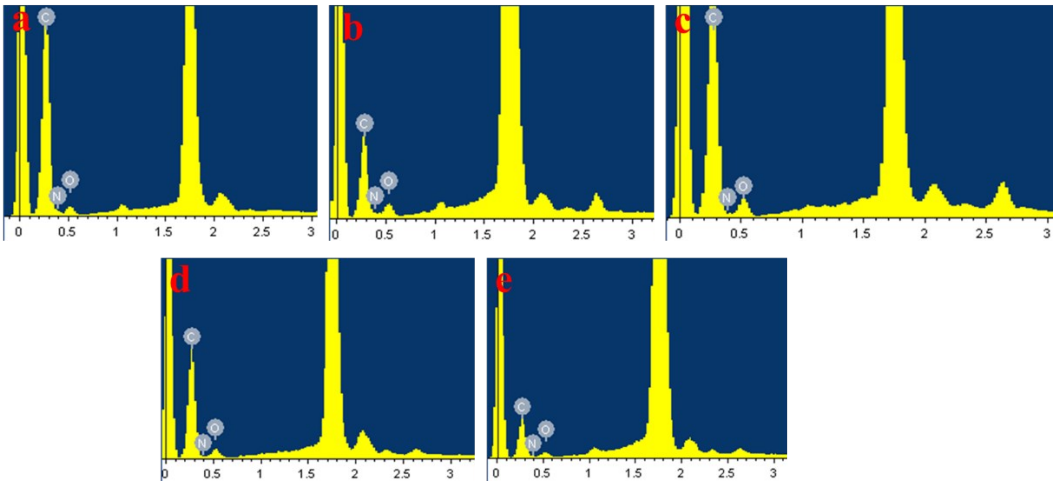

Fig. S5 EDX spectrum of (a) dC-750, (b) m-NC-650, (c) m-NC-750, (d) m-NC-850 and (e) m-NC-950.

Table S2 The relative atomic ratios of the different types of N.

Sample	Graphitic N (atomic%)	Pyrrolic N (atomic%)	Pyridinic N (atomic%)
dC-750	1.21	1.05	2.41
m-NC-650	1.27	2.85	3.55
m-NC-750	3.92	3.33	4.14
m-NC-850	-	-	-
m-NC-950	-	-	-

Table S3 On-set and half-wave potential for Pt/C, dC-750 and m-NC-T at 1600 rpm in 0.1 M KOH.

Sample	$E_{1/2}$ (V_{RHE})	E_0 (V_{RHE})
Pt/C	0.81	0.95
dC-750	0.53	0.66
m-NC-650	0.79	0.95
m-NC-750	0.82	0.96
m-NC-850	0.82	0.95
m-NC-950	0.78	0.91

Table S4 Comparison of the ORR performances for various N-doped carbon catalysts at 1600 rpm in 0.1 M KOH.

Catalyst	$E_{1/2}$ (V_{RHE})	E_0 (V_{RHE})	References
m-NC-750	0.82	0.96	**This work**
PHNG-800	0.81	0.94	[1]
$N_{0.54}$-Z_3/M_1-900	0.824	0.94	[2]
NPC	0.86	0.94	[3]
Polymer-modified	0.7	0.87	[4]
FC-NH4Cl-800-1	0.85	0.94	[5]
Cu@NC-700	0.86	0.926	[6]
Cu_3P@NPPC-650	0.78	0.85	[7]
PFeC-900	0.71	0.95	[8]
NCNT 4	0.78	0.96	[9]
N-doped porous Carbon nanosheets	0.77	0.90	[10]
Porous carbon Nanofiber	0.79	0.88	[11]
N-Doped graphene	0.84	0.92	[12]
NPCN-900	0.78	0.92	[13]

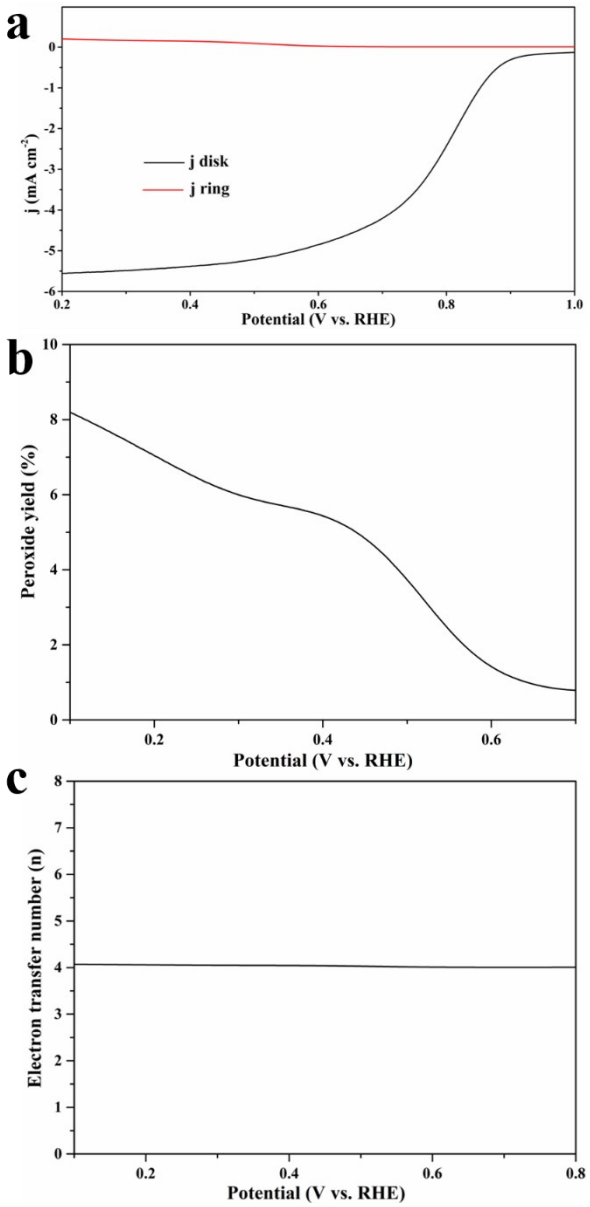

Fig. S6 (a) RRDE voltammogram curve of m-NC-750 at 1600 rpm. (b) Peroxide yield and (c) electron transfer numbers for m-NC-750.

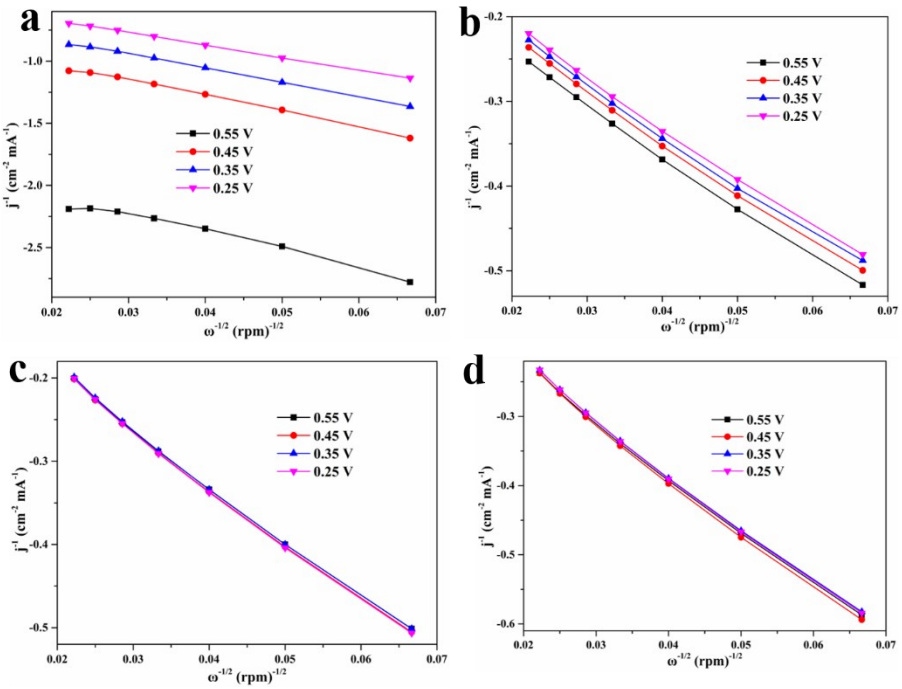

Fig. S7 The Koutecky-Levich (K-L) plots of (a) dC-750, (b) m-NC-650, (c) m-NC-850 and (e) m-NC-950.

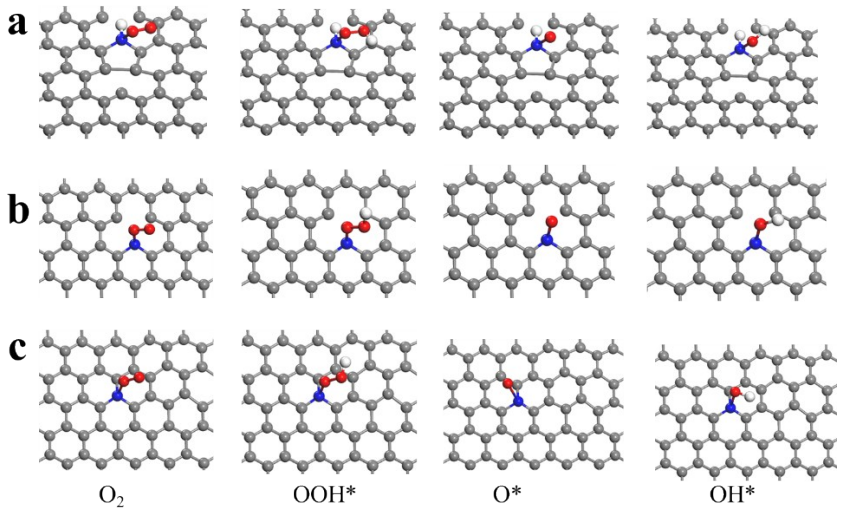

Fig. S8 Optimized atomic structures for O_2, OOH*, O* and OH* intermediates absorbed on (a) pyridinic N, (b) pyrrolic N and (c) graphite N dopant carbon hybrid models of electrocatalytic ORR. Colour code: Gray, blue and red balls represent C, N and O atoms, respectively.

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