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Supporting Information

Graphene/Nitrogen-Doped Porous Carbon Sandwiches for Metal-Free Oxygen Reduction Reaction: Conductivity versus Active Sites

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Supplementary figures

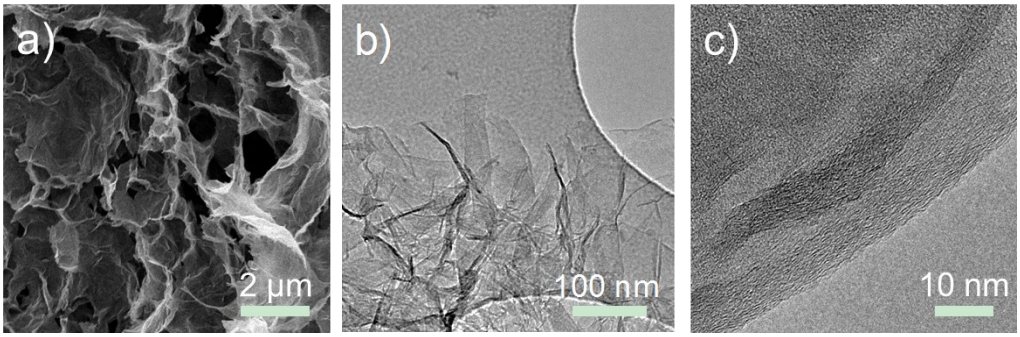

Fig. S1 (a) SEM image and (b, c) TEM images of rGO obtained after HTC and high-temperature annealing.

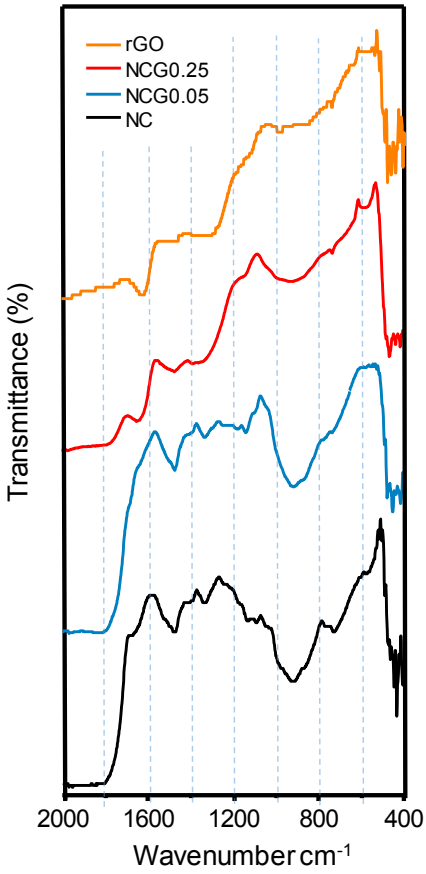

Fig. S2 FTIR spectra of NC, NCG0.05, NCG0.25 and rGO

Journal Name

ARTICLE

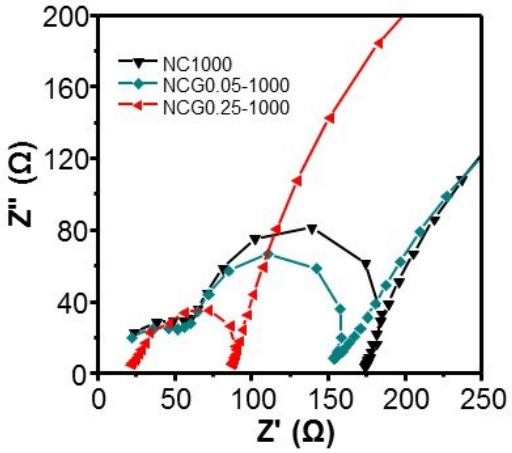

Fig. S3 Electrical conductivity of different samples measured by the impedance

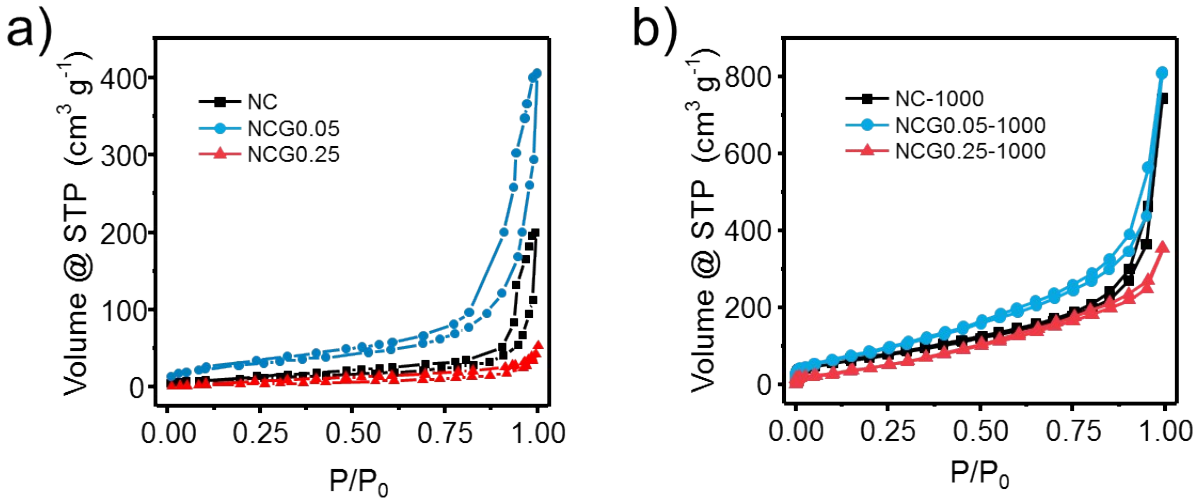

Fig. S4 The N_2 sorption isotherms of samples obtained after (a) HTC and (b) high-temperature annealing.

Journal Name

ARTICLE

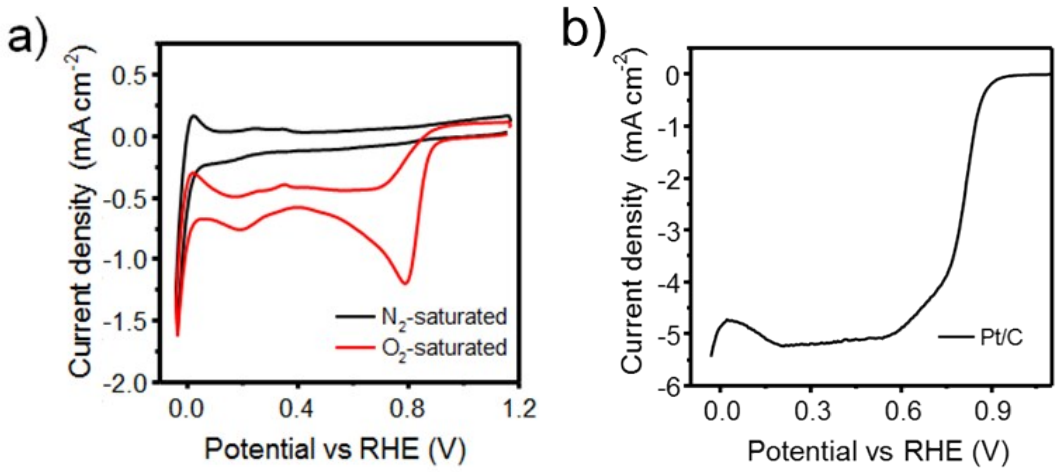

Fig. S5 (a) CV and (b) LSV curves of Pt/C catalyst.

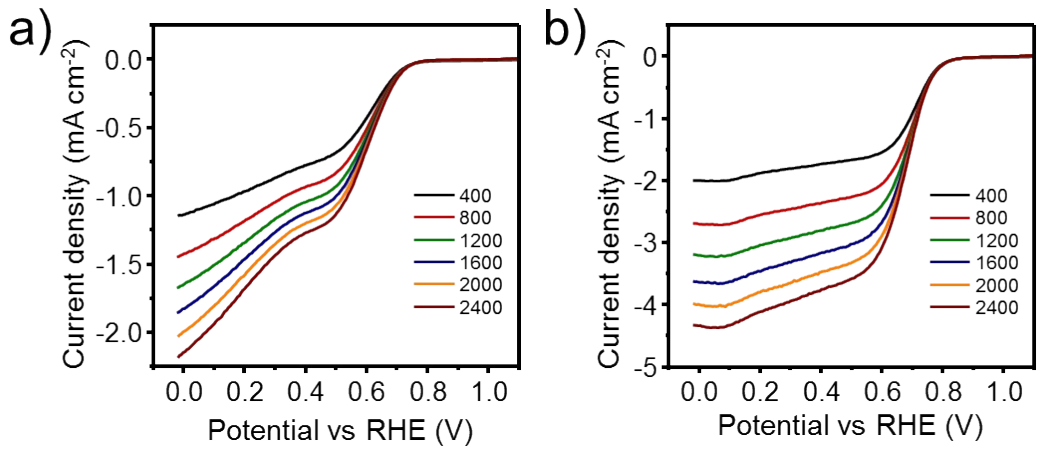

Fig. S6 LSV curves of (a) NCG0.25 and (b) NC-1000 at different rotating speeds of 400, 800, 1200, 1600, 2000, and 2400 rpm, respectively.

Journal Name

ARTICLE

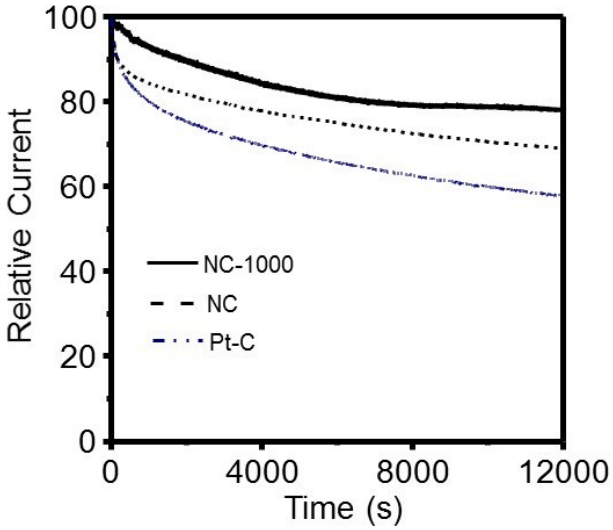

Fig. S7 Current−time chronoamperometric responses of NC-1000, NC and Pt-C measured at peak potential in CV curves as shown in Fig. 4a.

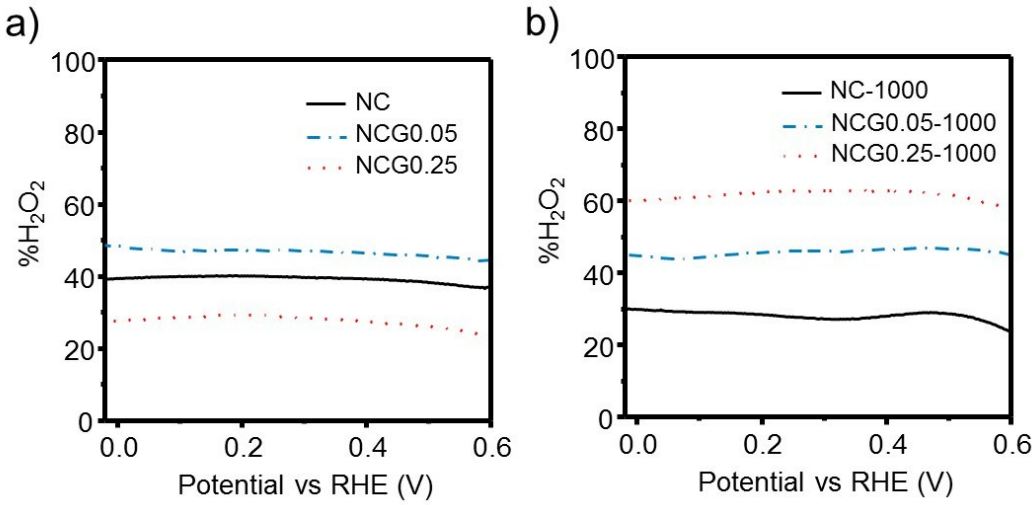

Fig. S8 Peroxide yields of (a) NC, NCG0.05, NCG0.25 and (b) NC-1000, NCG0.05-1000, NCG0.25-1000 in 0.1M KOH at rotating speed of 1600 rpm.

Journal Name

ARTICLE

Supplementary tables

Table S1 Mass record of different samples during fabrication.

	GO (mg)	**Chitosan (mg)**	**Monocomponent-calculated yield (mg)[a]**			**Experimental yield (mg)**
			rGO	HTC-chitosan	Product	
GO	60	0	25.9	0	25.9	25.9
NC	0	1200	0	372.0	372.0	372.0
NCG0.25	60	180	25.9	55.8	81.7	122.6
NCG0.05	60	1200	25.9	372.0	397.9	672.4

a) The monocomponent-calculated yield was calculated based on the yield of chitosan and GO in monocomponent HTC systems. Experimental yield refers to the mass of product obtained in the actual experiment.

Journal Name

ARTICLE

Table S2 XPS results of different samples.

Sample	Atom Species (at. %)						
	C	O	N	Pyridinic-N	Pyrrolic-N	Quaternary-N	Oxidized-N
NC	75.16	21.39	3.45	1.27	1.38	0.79	-
NCG0.05	76.13	18.22	5.65	1.49	2.97	1.19	-
NCG0.25	80.97	15.01	4.02	1.08	2.15	0.79	-
NC-1000	90.87	7.45	1.68	0.47	-	0.97	0.24
NCG0.05-1000	96.48	2.04	1.48	0.26	-	0.98	0.23
NCG0.25-1000	94.39	4.39	1.22	0.17	-	0.84	0.21

Journal Name

ARTICLE

Table S3 Specific surface area and total pore volume of different samples.

Sample	NC	NCG0.05	NCG0.25	NC-1000	NCG0.05-1000	NCG0.25-1000
SSA (m^2 g^{-1})	36	99	25	278.9	339	223
Pore volume (cm^3 g^{-1})	0.1	0.34	0.06	0.81	0.91	0.43

Table S4 The ORR peak potential and peak current density in CV curves as shown in Fig. 4a.

Sample	Peak potential vs RHE (mV)	Peak current density (mA cm^{-2})
NC	504	0.539
NCG0.05	498	0.425
NCG0.25	552	0.590
NC-1000	689	1.152
NCG0.05-1000	606	1.059
NCG0.25-1000	558	0.924

Table S5 ORR activity observed from the LSV curves in Fig. 4b.

	NC	NCG0.05	NCG0.25	NC-1000	NCG0.05-1000	NCG0.25-1000
Onset potential* (mV)	832	839	922	993	987	844

Journal Name

ARTICLE

Saturated current density (mA cm^{-2})	1.57	1.75	1.85	3.61	3.39	3.15
Half wave potential (mV)	340	357	524	666	600	363

* The onset potential is determined as the potential required for a current density of -2 μA cm^{-2} (vs. RHE)