

Supplementary Information

***In situ* solution plasma synthesis of nitrogen-doped carbon nanoparticles as metal-free electrocatalysts for the oxygen reduction reaction**

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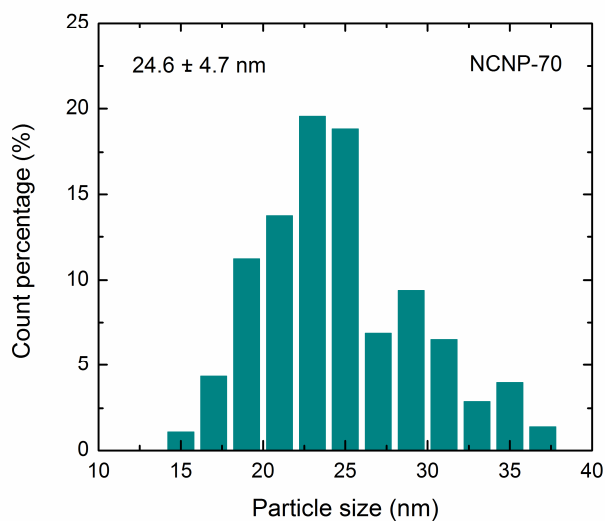


Fig. S1 Particle size distribution of NCNP-70 deduced from bright-field TEM image.

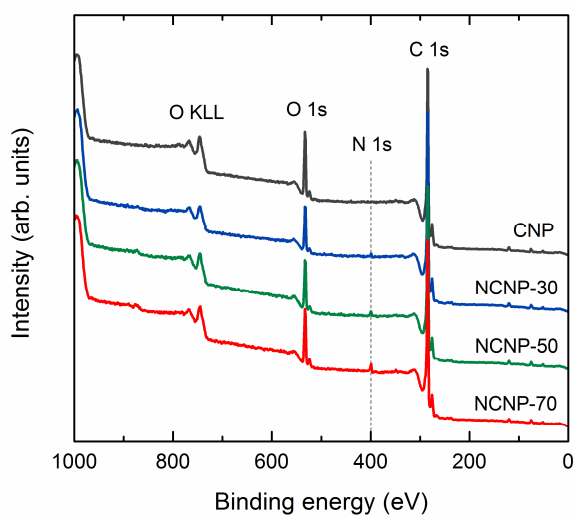


Fig. S2 XPS survey spectra of CNP, NCNP-30, NCNP-50, and NCNP-70. The vertical dashed line indicates the position of N 1s peak.

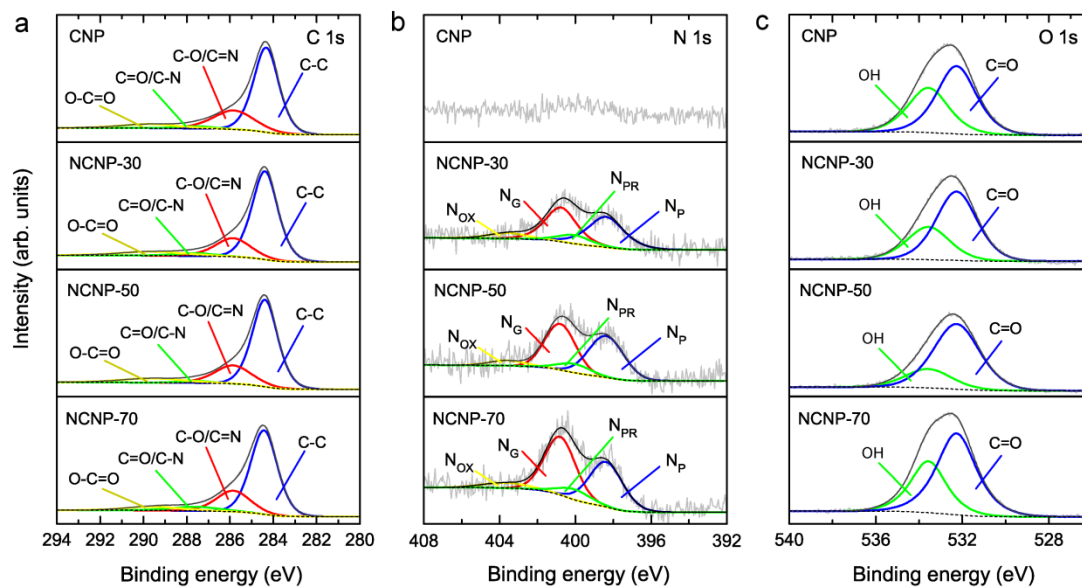


Fig. S3 High-resolution XPS spectra of all catalysts: (a) C 1s, (b) N 1s and (c) O 1s.

Table S1 Relative amount of different nitrogen bonding configurations obtained from the qualitative analysis of high-resolution XPS N 1s spectra of NCNP-30, NCNP-50, and NCNP-70 in Fig. S3b.

Sample	XPS N1s spectra			
	Pyridinic-N (N_P)	Pyrrolic-N (N_{PR})	Graphitic-N (N_G)	Pyridinic N-oxide (N_{OX})
NCNP-30	41.1%	10.4%	40.3%	8.2%
NCNP-50	43.7%	8.5%	42.3%	5.5%
NCNP-70	38.9%	8.7%	46.6%	5.8%

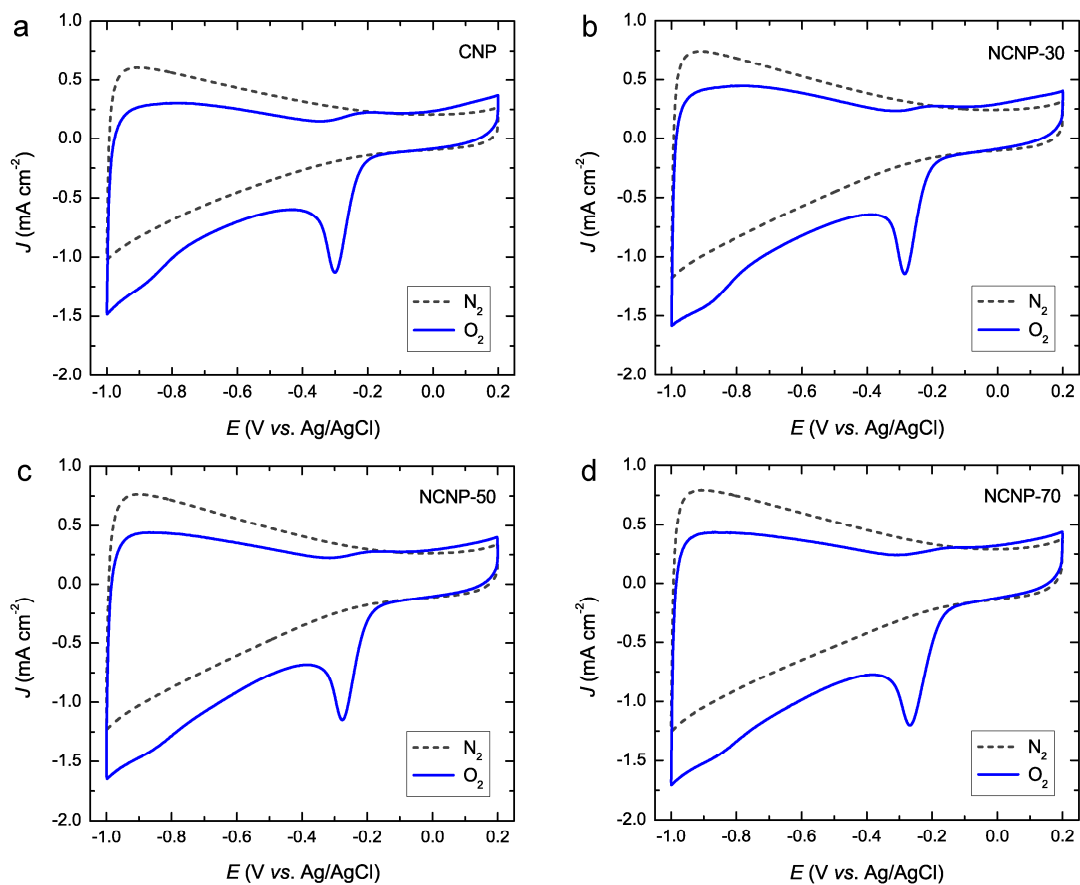


Fig. S4 CV curves of the ORR for (a) CNP, (b) NCNP-30, (c) NCNP-50, and (d) NCNP-70 modified on GC electrodes in a 0.1 M KOH solution saturated with N_2 (black dashed line) and O_2 (blue solid line).

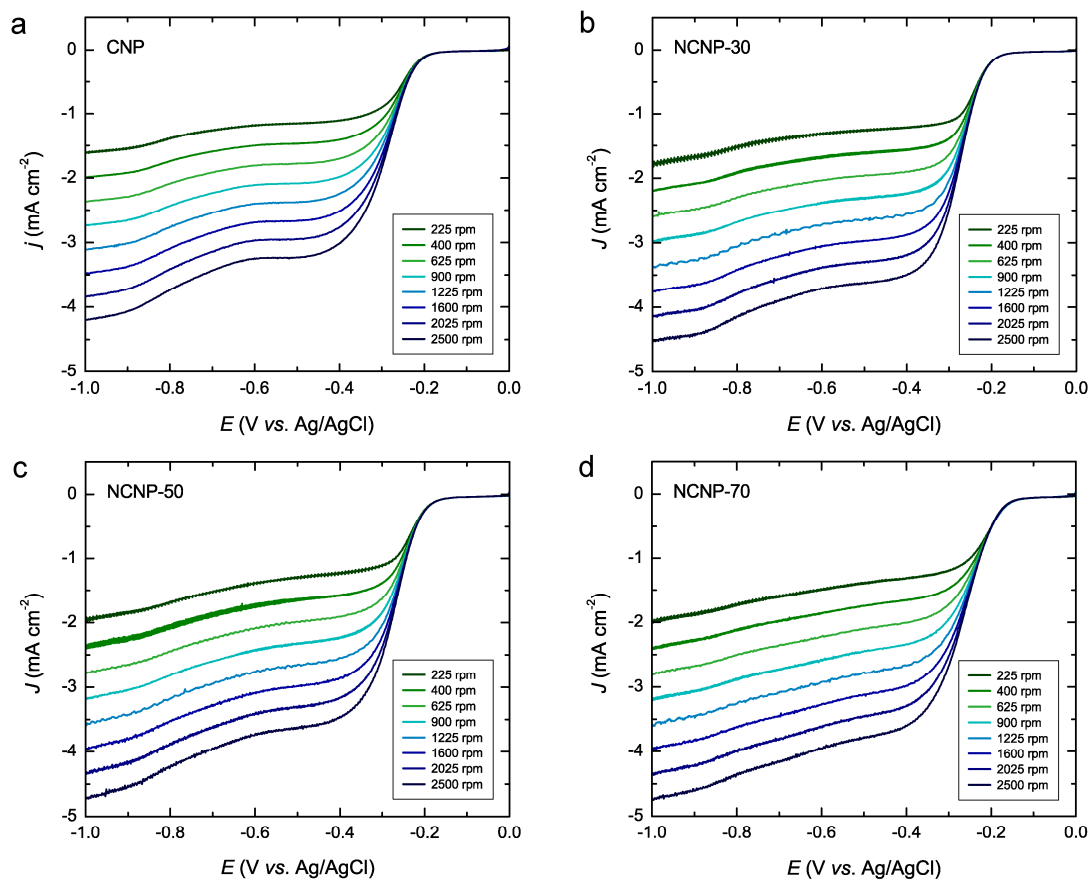


Fig. S5 LSV curves of the ORR for all catalysts in an O₂-saturated 0.1 M KOH solution at a scan rate of 10 mV s⁻¹ and different rotation speeds from 225 to 2500 rpm: (a) CNP, (b) NCNP-30, (c) NCNP-50, and (d) NCNP-70.

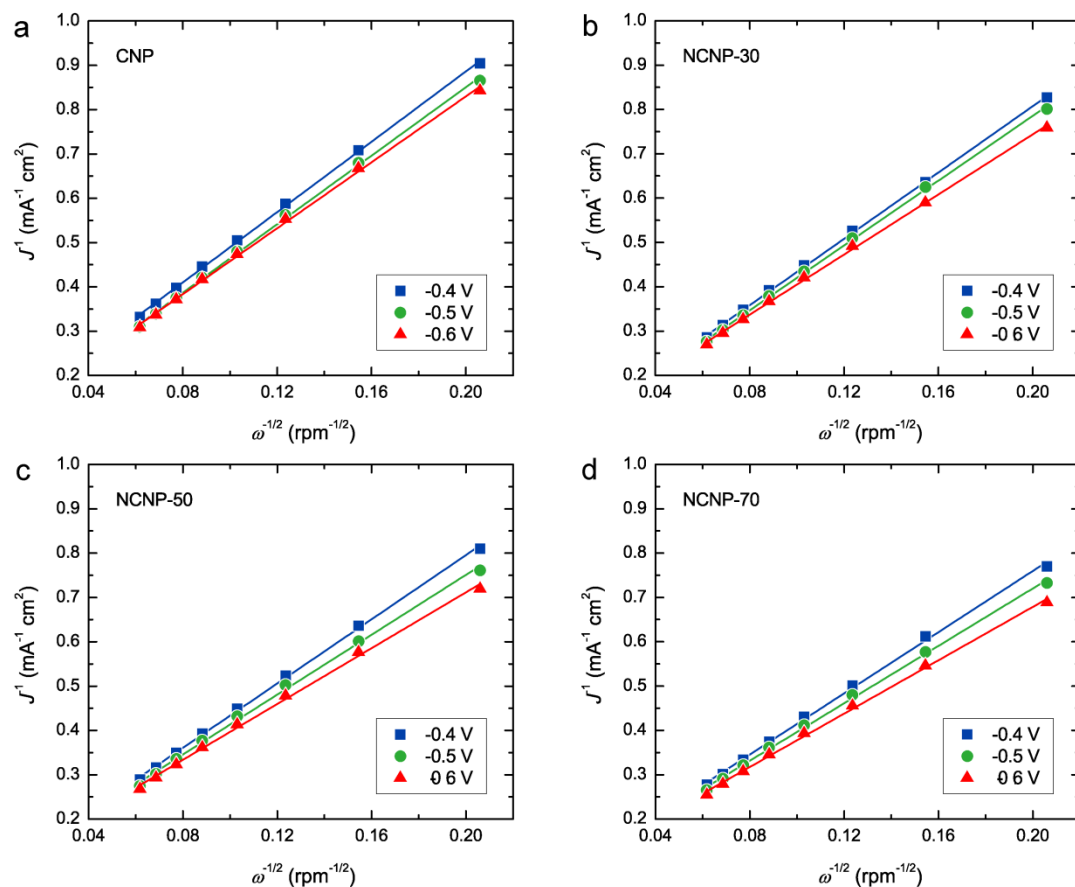


Fig. S6 K–L plots at potentials from -0.4 to -0.6 V on the basis of LSV data in Fig. S5 of (a) CNP, (b) NCNP-30, (c) NCNP-50, and (d) NCNP-70.

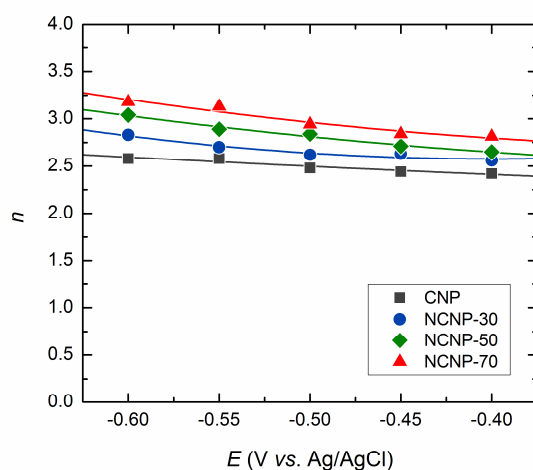


Fig. S7 Electron transfer number (n) obtained from the K–L plots (Fig. S6) as a function of potential from -0.4 to -0.6 V: (a) CNP, (b) NCNP-30, (c) NCNP-50, and (d) NCNP-70.

Table S2 Electrochemical results of bare GC electrode, 20%Pt/C, CNP, NCNP-30, NCNP-50, and NCNP-70 obtained at a potential of -0.4 V. The onset potential (E_{onset}) is determined from LSV-RRDE curve.

	E_{onset} (V vs. Ag/AgCl)	J_K (mA cm $^{-2}$)	n_{K-L}	n_{RRDE}	HO $_2^-$ yield (%)
GC	-0.31	7.87	2.38	2.34	83.0
20%Pt/C	-0.09	19.6	4.05	3.85	7.65
CNP	-0.22	10.8	2.42	2.40	81.4
NCNP-30	-0.21	13.9	2.56	2.62	68.6
NCNP-50	-0.20	14.1	2.65	2.71	64.9
NCNP-70	-0.17	14.5	2.80	2.86	59.5

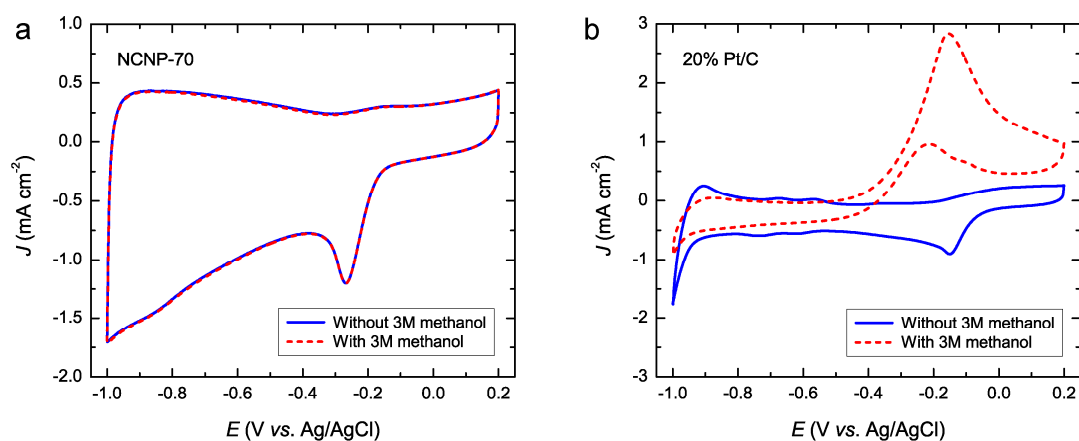


Fig. S8 Comparative CV curves with (solid line) and without the introduction of 3 M methanol (dashed line) of NCNP-70 (b) and 20 wt% Pt/C.