

Electronic Supplementary Information

Tunable ternary (P, S, N)-doped graphene as an efficient electrocatalyst for oxygen reduction reaction in an alkaline medium

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Supplementary data

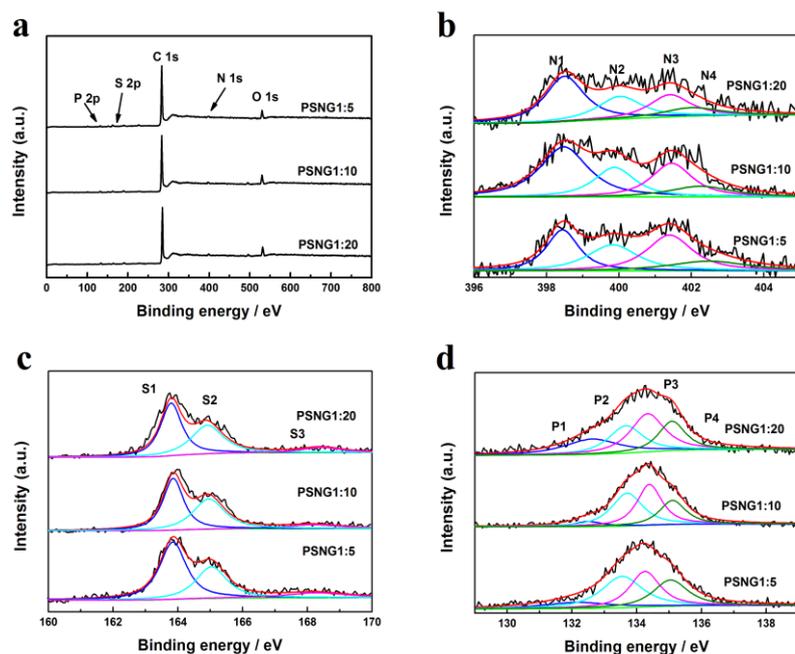


Fig. S1 (a) The survey XPS spectra of PSNG samples; (b) High-resolution N1s XPS spectra of PSNG samples; (c) High-resolution S2p XPS spectra of samples; (b) High-resolution P2p XPS spectra of PSNG samples.

Table S1 Relative surface concentrations of nitrogen species obtained by fitting high-resolution N1s XPS spectra of PSNG samples.

Sample	N1	N2	N3	N4
PSNG1:20	43.21	23.84	21.60	11.35
PSNG1:10	40.90	22.18	25.57	11.55
PSNG1:5	26.53	26.14	32.34	14.92

Table S2 Relative surface concentrations of sulfur species obtained by fitting high-resolution S2p XPS spectra of PSNG samples.

Sample	S1	S 2	S 3
PSNG1:20	48.82	41.58	9.60
PSNG1:10	48.48	41.89	9.63
PSNG1:5	54.25	35.96	9.79

Table S3 Relative surface concentrations of phosphorus species obtained by fitting high-resolution P2p XPS spectra of PSNG samples.

Sample	P1	P 2	P 3	P 4
PSNG1:20	21.79	24.37	33.40	20.44
PSNG1:10	5.225	36.35	36.12	22.29
PSNG1:5	11.55	34.79	29.21	24.45

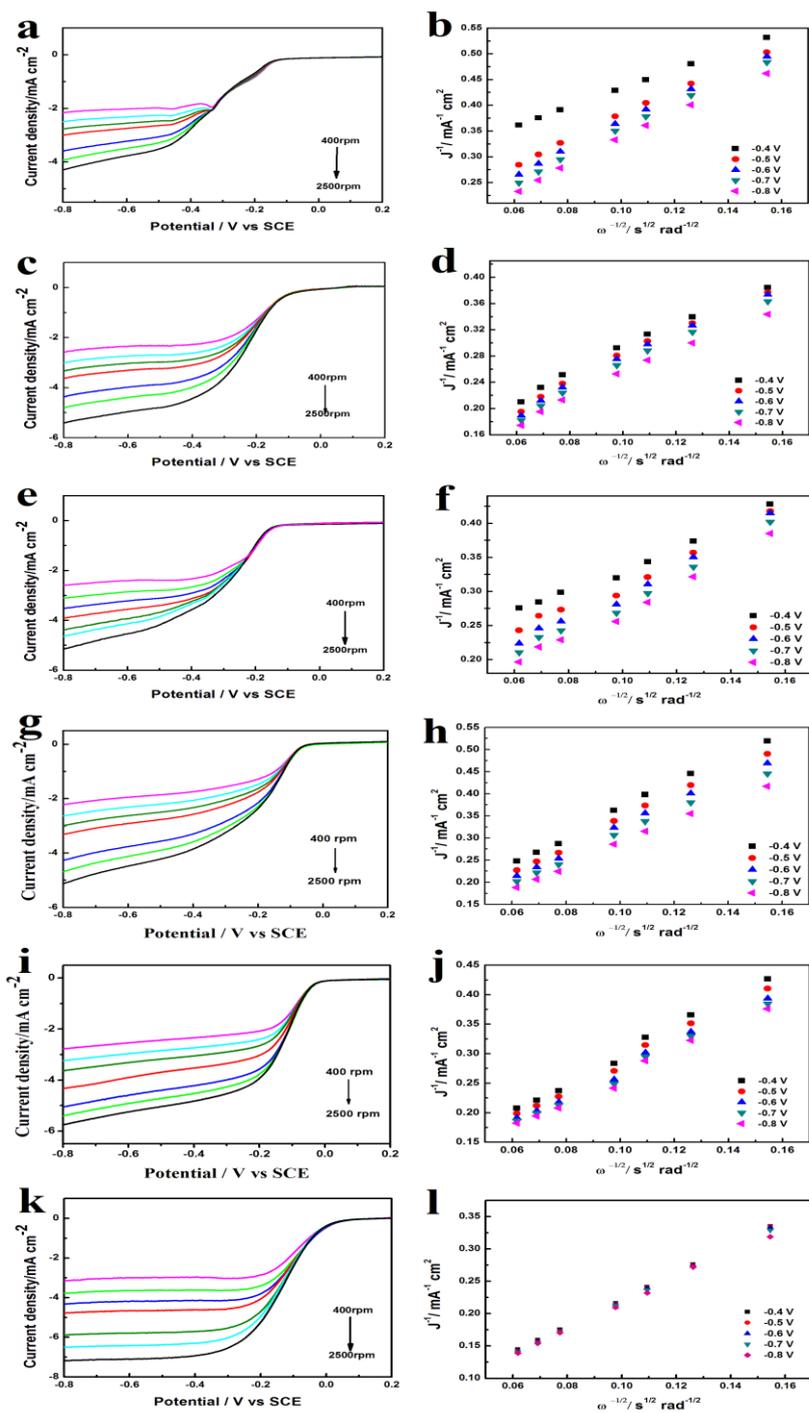


Fig. S2 LSVs for ORR on (a) RGO, (c) NG, (e) PNG, (g) PSNG1:20, (i) PSNG1:5 and (k) Pt/C at different rotation speeds from -0.8 to +0.2 V vs. SCE in O₂-saturated 0.1 M KOH at a scan rate of 10 mV s⁻¹. The corresponding K-L plots for (b) RGO, (d) NG, (f) PNG, (h) PSNG1:20, (j) PSNG1:5 and (l) Pt/C at different potentials.

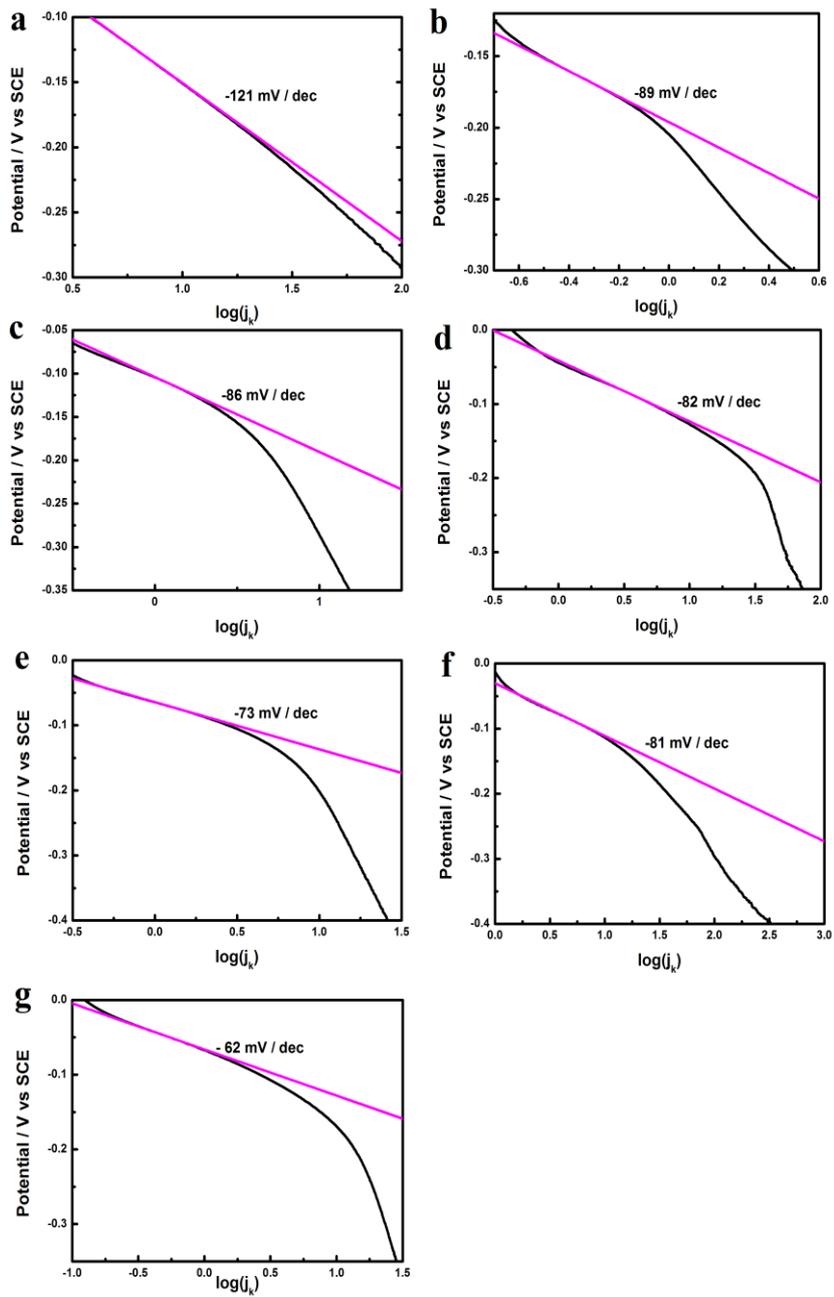


Fig. S3 Tafel plots of (a) RGO, (b) NG, (c) PNG, (d) PSNG1:5, (e) PSNG1:10, (f) PSNG1:20 and (g) Pt/C derived by the mass-transport correction of corresponding RDE data.

Table S4 A bench mark of our PSNG1:10 with values obtained from some other independent literatures. All in alkaline condition with 0.1 M KOH.

Electrocatalyst	$\Delta E_{\text{onset}}^{\text{a,c}}$ (V)	$\Delta E_{1/2}^{\text{a,c}}$ (V)	$j_L^{\text{b,c}}$ (mA cm ⁻²)	Loading (μg cm ⁻²)	Reference electrode	Ref.
PSNG1:10	-0.052	0.015	5.05	280	SCE	In this work
CNPS-900	-0.192	-0.056	3.01	159	SCE	1
PNS-P-C-2	-0.136	-0.068	5.75	503	RHE	2
GNSP-31	0.030	0.025	6.39	Not given	Ag/AgCl	3

a represents the difference of onset potentials or half-wave potentials between various catalysts and Pt/C.

b represents the diffusion-limited current densities of various catalysts at rotation speed of 1600 rpm.

c The onset (E_{onset}) and half-wave ($E_{1/2}$) potential are reported from the corresponding literatures and the corresponding figures in the present studies.

References

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- [2] J. Wu, X. J. Zheng, C. Jin, J. H. Tian, R. Z. Yang, *Carbon*, 2015, **9**, 2327-2338.
- [3] F. Razmjooei, K. P. Singh, M. Y. Song, J. S. Yu, *Carbon*, 2014, **78**, 257-267.