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Electronic Supplementary Information

Tuneable Graphitic-N and Amino-N in Nitrogen-doped Carbon *via* Solution Plasma Process and Their Synergistic Effect for Advanced Oxygen Reduction Reaction

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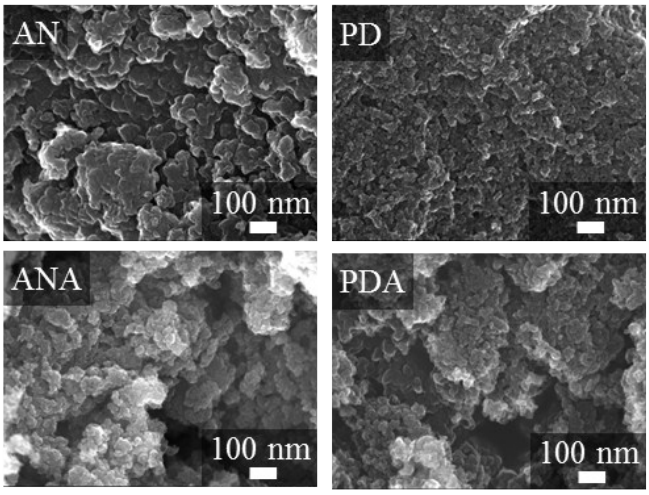

Fig. S1 FE-SEM images of carbon samples formed by the precursor of (a) pure acrylonitrile (AN), (b) pyridine (PD), (c) mixture of acrylonitrile and anthracene (ANA) and (d) mixture of pyridine and anthracene (PDA)

Table S1: Atomic percentage of AN, PD, ANA, and PDA from the EDS mapping

Sample	C (at. %)	N (at. %)	O (at. %)	W (at. %)
AN	86.41	3.36	10.15	0.13
PD	85.91	3.45	10.55	0.09.
ANA	86.42	3.15	10.18	0.15
PDA	85.45	3.05	11.36	0.14

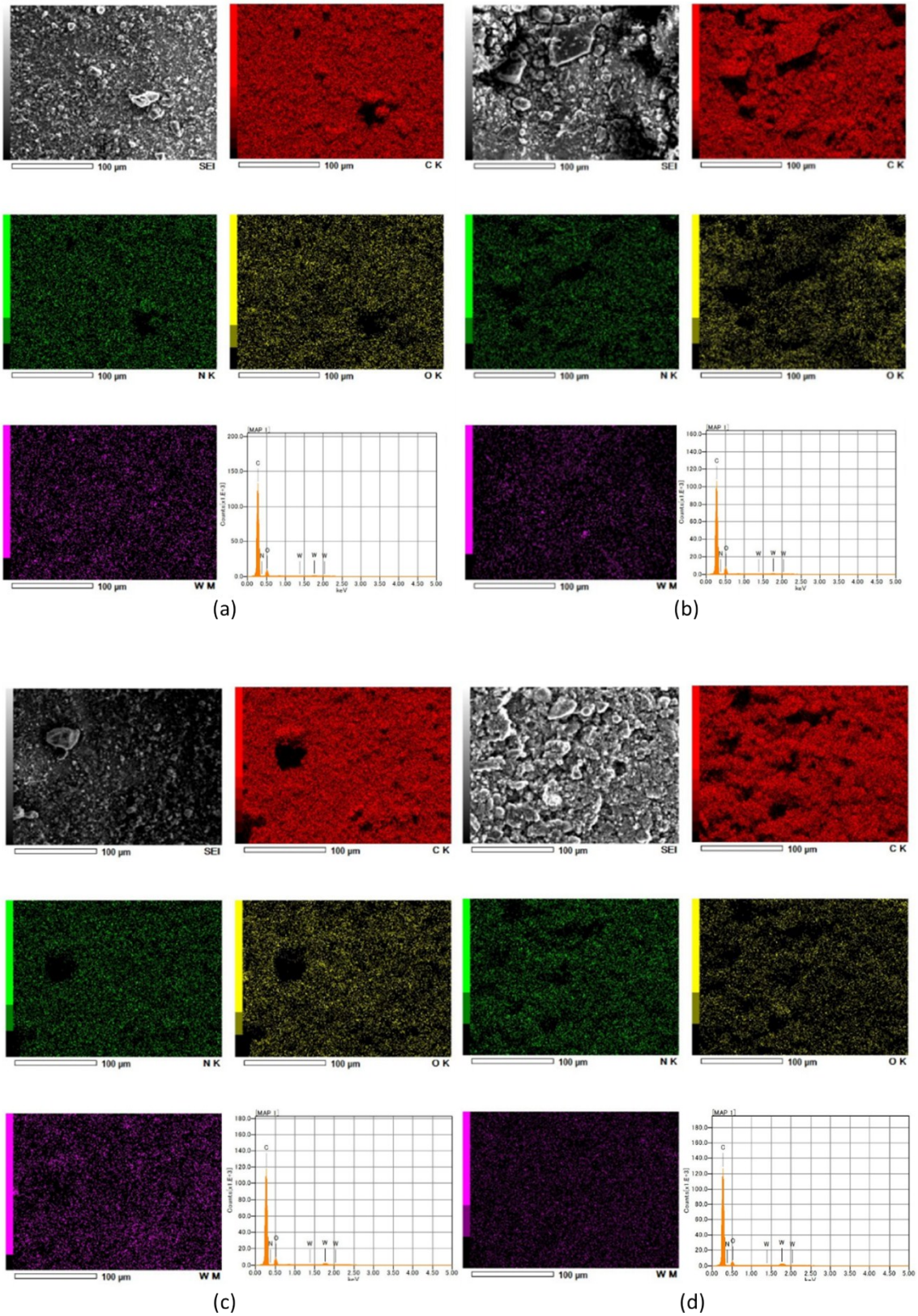

Fig S2 EDS mapping obtained from (a) AN, (b) PD, (c) ANA and (d) PDA with a magnification of 500.

Table S2 Specific surface area of AN, ANA, PD and PDA measured by Brunauer-Emmett-Teller (BET) absorption

Sample	AN	PD	ANA	PDA
Surface area (m^2/g)	134.34	126.51	164.34	181.77

Table S3 Surface composition of AN. PD, ANA, and PDA from the XPS spectra

Sample	C (at. %)	N (at. %)	O (at. %)	W (at. %)
AN	81.34	4.30	13.86	0.50
ANA	82.19	3.90	13.36	0.55
PD	84.78	2.73	12.10	0.40
PDA	86.45	2.63	10.98	0.54

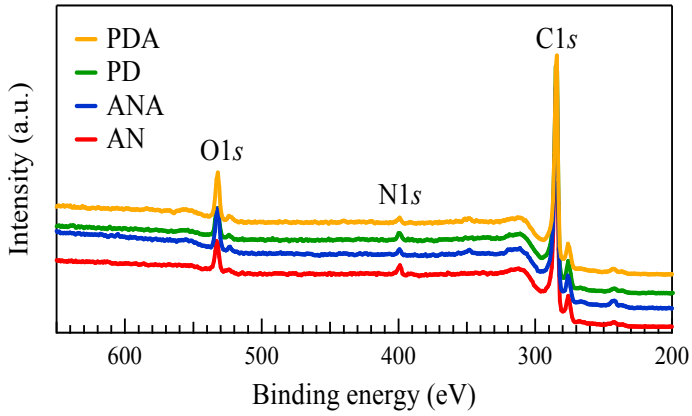

Fig. S3 Survey XPS spectra of PD, PDA, AN and ANA

Table S4 Bonding states of carbon in AN, ANA, PD, and PDA from detailed deconvolution of XPS O1*s* spectra

Bonding	Peak Position(eV)	Relative atomic percentage (%)			
		AN	ANA	PD	PDA
Quinone	530.2	2.6	3.0	4.6	4.5
O=C-OH	531.2 - 531.6	36.5	31.5	40.3	30.5
C=O	532.2 - 532.4	29.3	43.9	30.3	31.0
C-OH	533.0 – 533.3	21.8	11.7	17.2	27.9
C-O	533.8 - -534.2	9.6	9.76	7.5	6.0

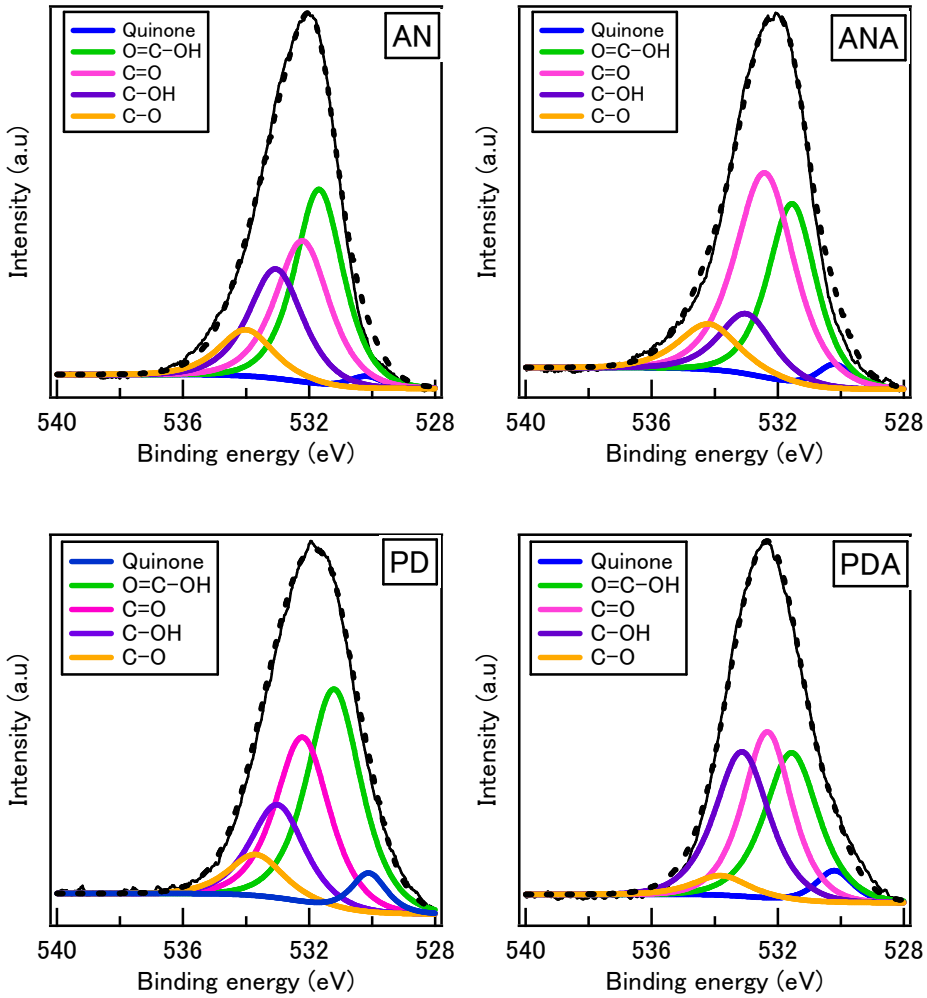

Fig. S4 High resolution O 1*s* spectra with peak deconvolution of AN, ANA, PD and PDA

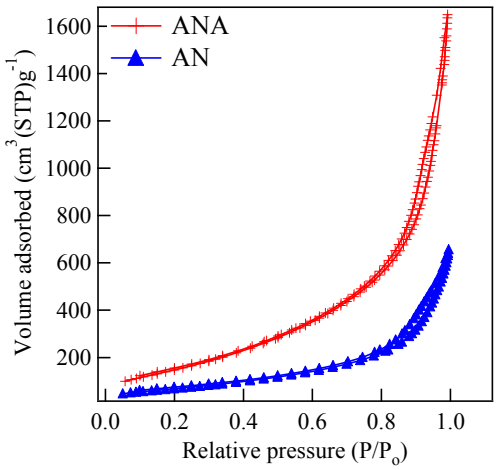

Fig. S5 Nitrogen adsorption–desorption isotherms of AN and ANA.

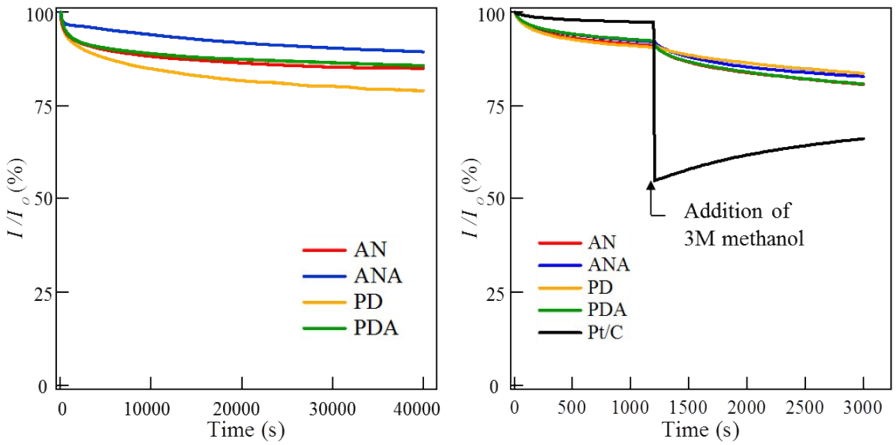

Fig. S6 (a) Current-time (*i-t*) chronoamperometric response of carbon catalysts at 0.46 V in an O_2 saturated 0.1 M KOH solutions at 1600 rpm for 40 000 s (b) Methanol tolerance test of AN, ANA, PD, PDA and 20 wt. % Pt/C at 0.46 V (V versus RHE) and 1600 rpm in an O_2-saturated 0.1 M KOH solution, where 3M of methanol was added at 1200 s

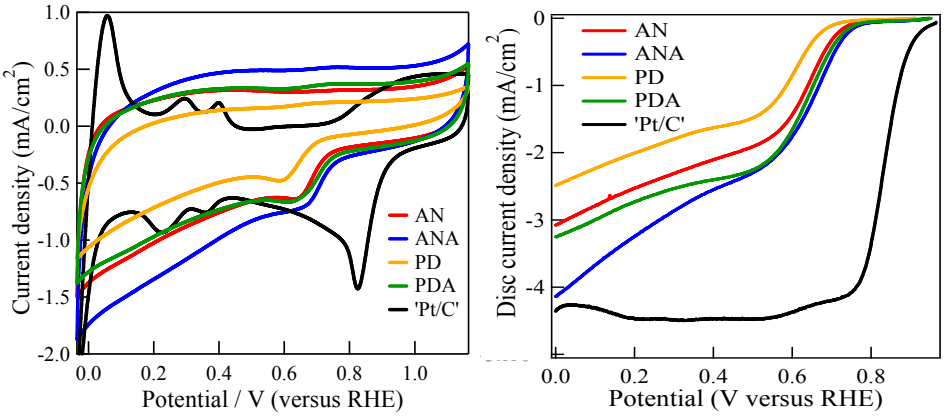

Fig. S7 (a) CV curves of various catalysts in O_2 saturated 0.1 M KOH solutions at a scan rate of 50 mV/s (b) LSV curves of various catalysts on an RRDE in an O_2 saturated 0.1 M KOH solution at a scan rate of 10 mV/s and a rotation speed of 1600 rpm after background subtraction

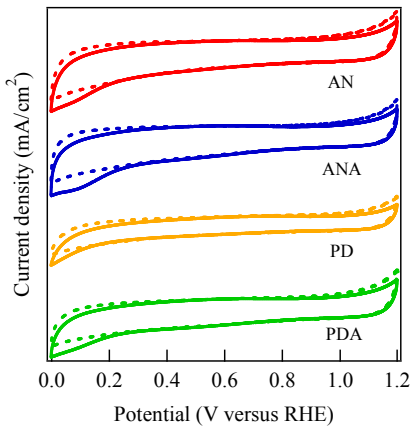

Fig. S8 CV curves of four catalysts in N_2 and O_2 saturated 0.5 M H_2SO_4 solution at a scan rate of 50 mV s^{-1} (N_2: dashed line, O_2: solid line).