

**Heteroatom doped carbon prepared by
pyrolysis of bio-derived amino acid as highly
active catalysts for oxygen electro-reduction
reaction**

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Table S1 Composition (wt %) of the catalysts and nitrogen doped concentration results from element analysis. Nitrogen doping concentrations were given in terms of atomic N/C ratio.

Name	C	N	H	S	Total	Atomic N/C ratio (X 100)
PAA-ALA	74.80	2.13	0.28	0	77.21	2.4
PAA-CYS	64.24	2.69	0.60	2.74	70.27	3.6
PAA-GLY	59.39	8.23	0.97	0	68.59	11.9
PAA-NIC	85.09	0.83	0.08	0	86.00	0.8
PAA-VAL	83.23	1.19	0.11	0	84.53	1.2

Table S2 Calculated compositions of the catalysts and heteroatom doping concentrations on the surface from XPS results. Heteroatom doping concentrations were given in terms of atomic N/C or S/C ratio.

Contents	Carbon (at. %)		Nitrogen (at. %)			Oxygen (at. %)	Sulfur (at. %)		Atomic ratio ($\times 100$)		
	Comp*	C-C	F. G.*	Pyridinic	Graphitic		N-O*	C-S-C	C-S(O) _x -C	N/C	S/C
PAA-ALA		74.9 (0.52)	(0.48)	(0.17)	1.9 (0.68)	(0.15)	23.2	0		2.5	0
PAA-CYS		62.8 (0.38)	(0.62)	(0.13)	1.3 (0.69)	(0.17)	35.5	0.4 (0.08)	(0.92)	2.1	0.6
PAA-GLY		49.5 (0.31)	(0.69)	(0.30)	2.3 (0.50)	(0.20)	48.2	0		4.6	0
PAA-NIC		82.9 (0.52)	(0.48)	(0.20)	1.3 (0.52)	(0.28)	15.8	0		1.6	0
PAA-VAL		85.7 (0.30)	(0.70)	(0.19)	1.5 (0.42)	(0.39)	12.8	0		1.8	0

* Comp.: Components

* F. G.: functional groups (C-N, C-O, C=O and C(O)O)

* N-O: pyridinic oxide

Fig. S1 The peaks of D- and G- bands from Raman spectroscopy for PAA catalysts. (a) PAA-ALA, (b) PAA-CYS, (c) PAA-GLY, (d) PAA-NIC and (e) PAA-VAL.

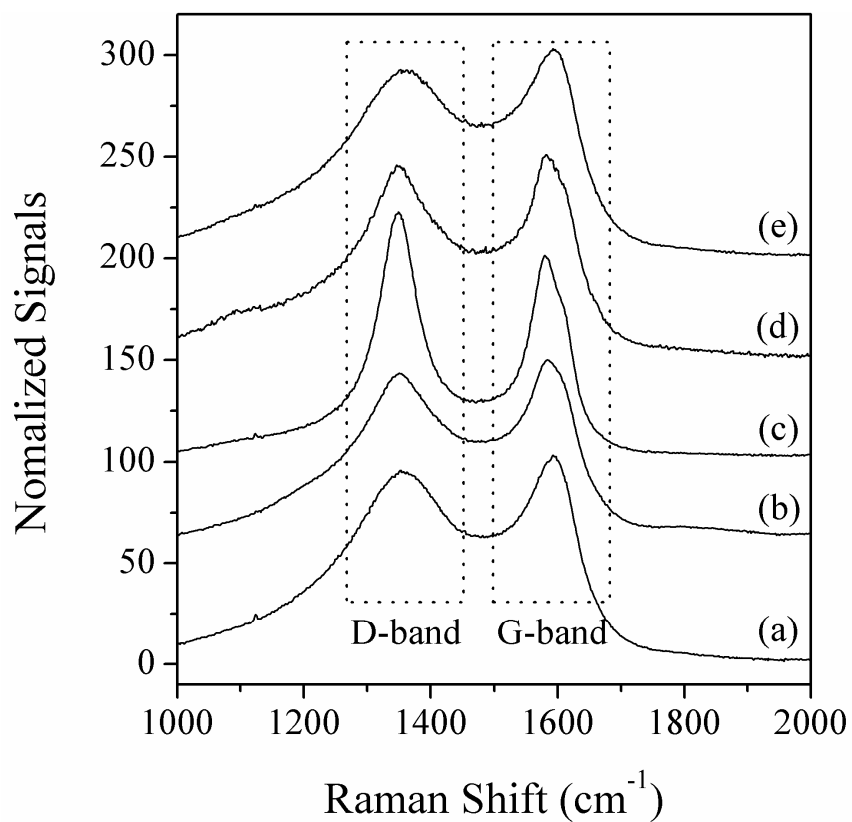


Fig. S2 XPS-C_{1s} analysis of the PAA catalysts; (a) PAA-ALA, (b) PAA-CYS, (c) PAA-GLY, (d) PAA-NIC and (e) PAA-VAL. Assigned black dotted lines mean C-C bonding of carbon and other dotted lines (color) mean various functional group such as C-N, C-O, C=O and C(O)O.

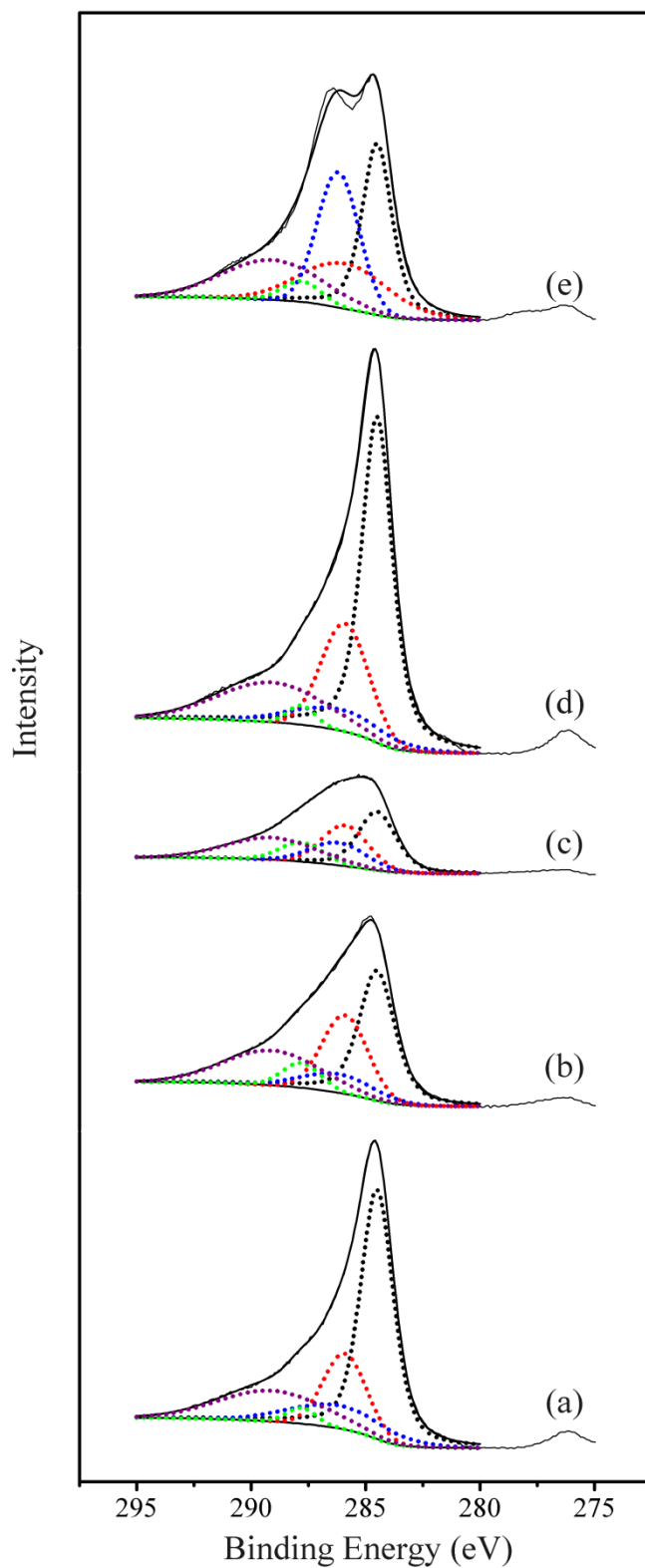


Fig. S3 XPS-N_{1s} analysis of the PAA catalysts; (a) PAA-ALA, (b) PAA-CYS, (c) PAA-GLY, (d) PAA-NIC and (e) PAA-VAL. Assigned black, red and blue dotted lines indicate the peaks of pyridinic-, graphitic- and pyridinic oxide nitrogen, respectively.

