

Supplementary Information

N-, P- and Fe- tridoped nanoporous carbon derived from plant biomass: an excellent oxygen reduction electrocatalyst for zinc-air battery †

Wei Wan^a, Qiang Wang^a, Li Zhang^a, Hai-Wei Liang^b, Ping Chen^{a,*}, and Shu-Hong Yu^{b,*}

^a School of Chemistry and Chemical Engineering, Anhui University, Hefei, Anhui, 230601, P. R. China

^b Division of Nanomaterials and Chemistry, Hefei National Laboratory for Physical Sciences at Microscale, Collaborative Innovation Center of Suzhou Nano Science and Technology, Department of Chemistry, University of Science and Technology of China, Hefei, Anhui 230026, P. R. China

* **Correspondence to:** Prof. S. H. Yu (E-mail: shyu@ustc.edu.cn), Fax: +86 551 63603040; Dr. P. Chen (E-mail: chenping@ahu.edu.cn)

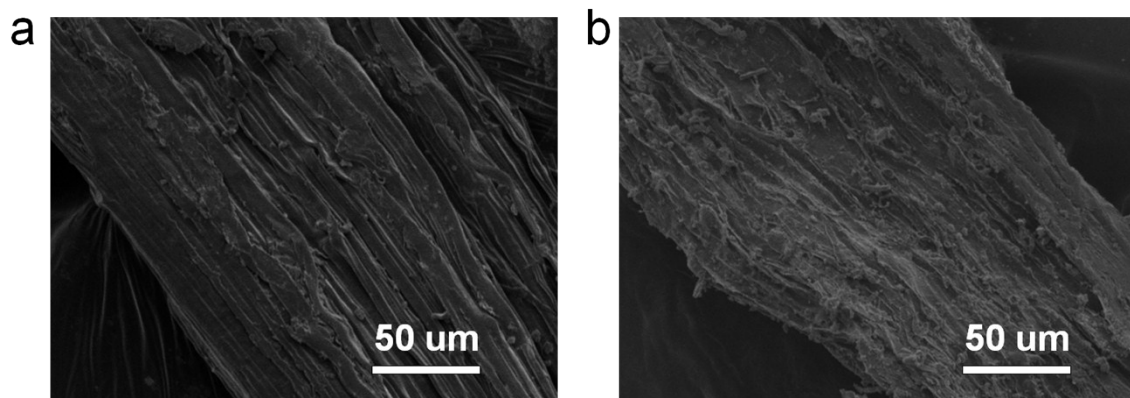


Figure S1. (a-b) SEM images of the corn silk and the carbonaceous product after the hydrothermal process.

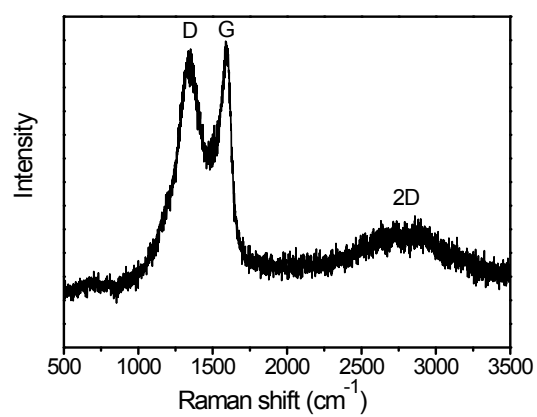


Figure S2. Raman spectra of the typical N-P-Fe-C catalyst

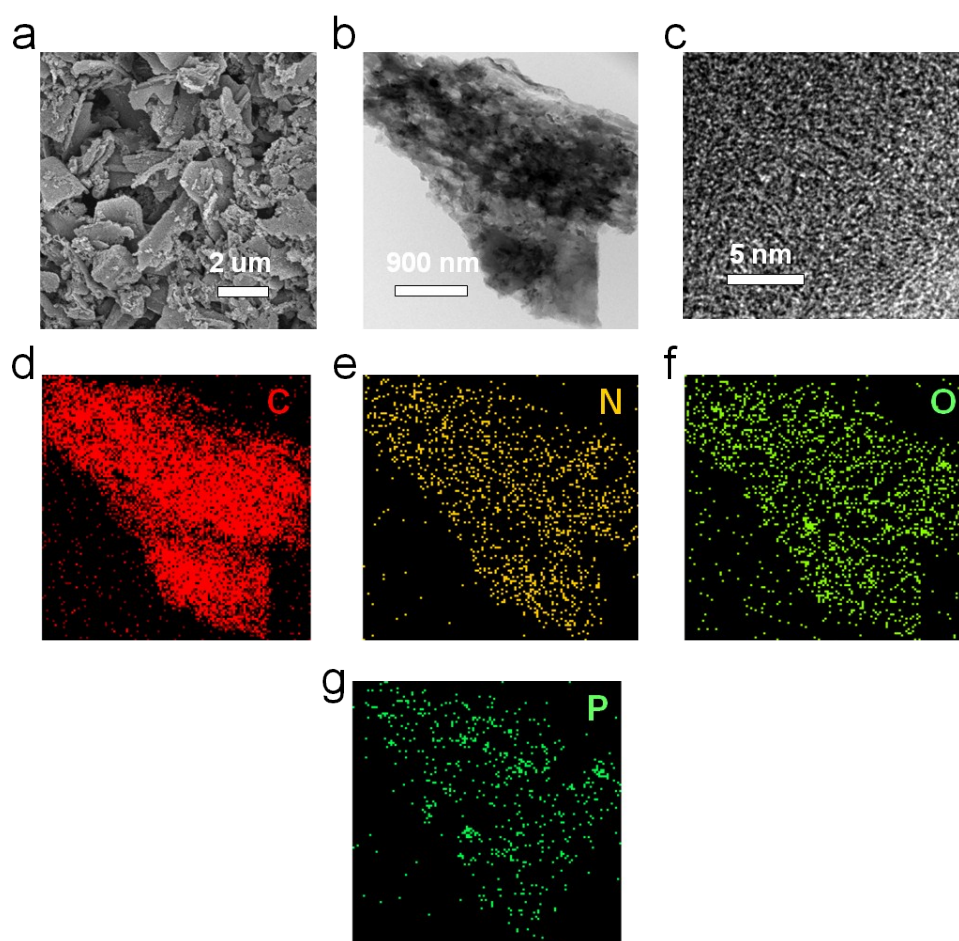


Figure S3. (a-c) SEM, STEM and HRTEM images of the N-P-C catalyst; (d-g) C, N, O and P elemental mappings.

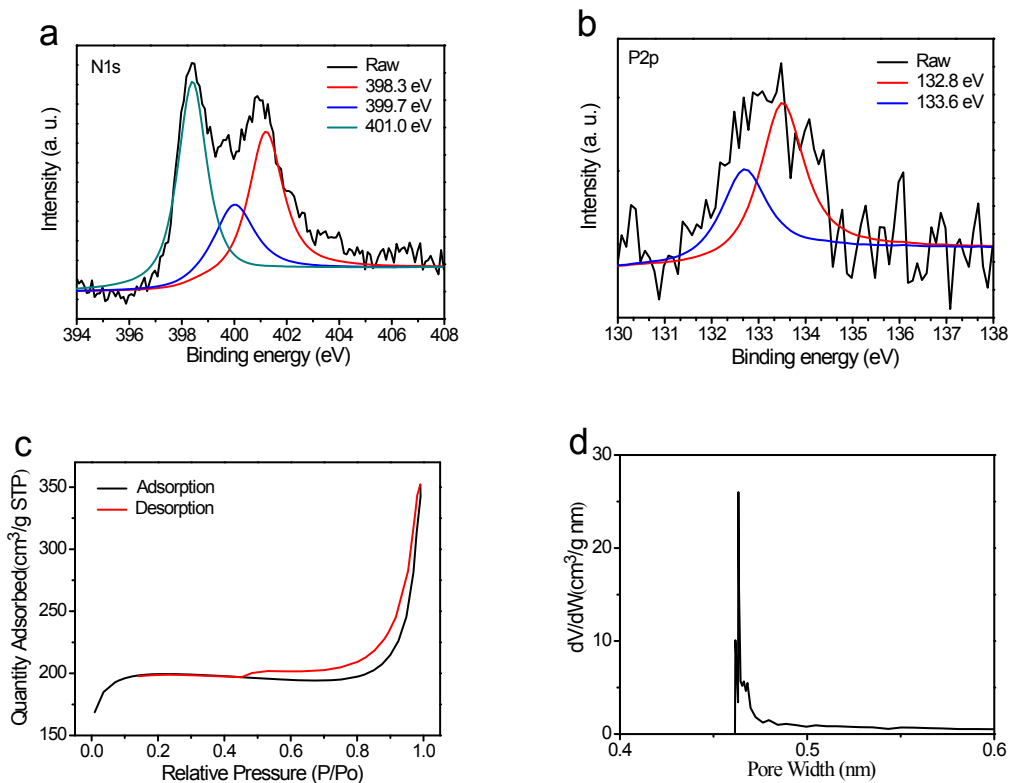
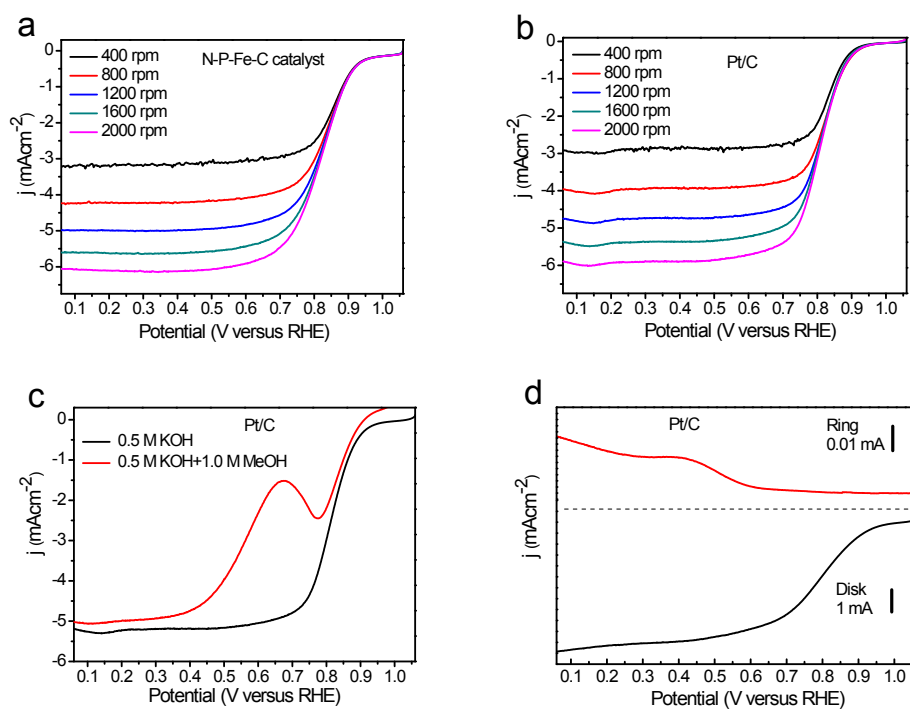


Figure S4. (a-b) high-resolution N1s and P2p XPS spectra of the N-P-C catalyst; (c-d) nitrogen adsorption-desorption isotherm and pore-size distribution of the N-P-C catalyst.



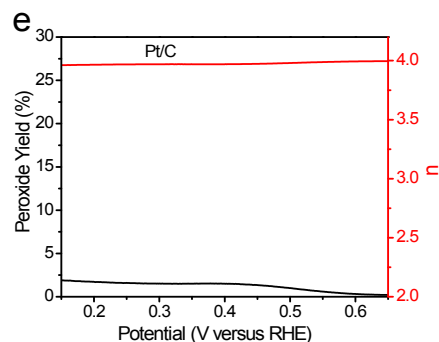


Figure S5. (a) RDE voltammograms for the ORR at the typical N-P-Fe-C catalyst electrode at the various rotation speeds (sweep rate 20 mV s^{-1}); (b) RDE voltammograms for the ORR at the Pt/C electrode at the various rotation speeds (sweep rate 20 mVs^{-1}); (c) RDE voltammograms in O_2 -saturated 0.1 M KOH solution at room temperature (rotation speed 1600 rpm , sweep rate 20 mVs^{-1}) for the Pt/C with or without 1.0 M methanol; (d-e) RRDE voltammograms, the electron transfer number (n) and peroxide yield for the Pt/C catalyst in O_2 -saturated 0.1 M KOH . The electrode rotation speed was 1600 rpm , sweep rate was 20 mVs^{-1} .

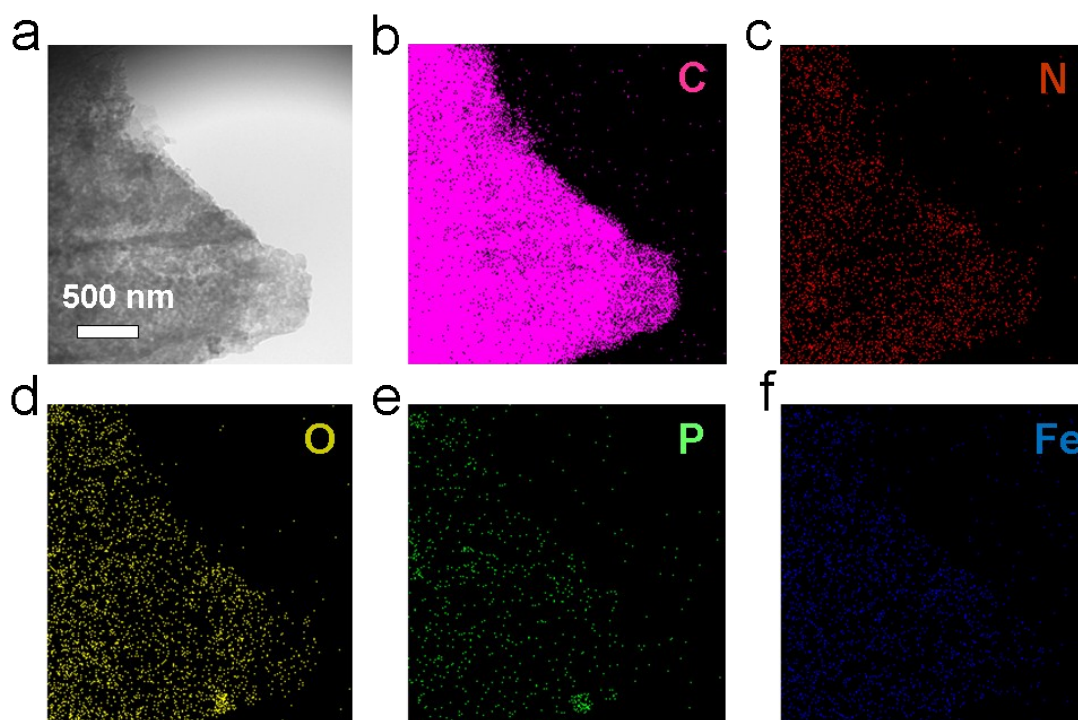


Figure S6. (a) STEM image and (b-f) carbon, nitrogen, oxygen, phosphorus and iron element mappings of the typical N-P-Fe-C catalyst after 25000 seconds, at 0.800 V (versus RHE)

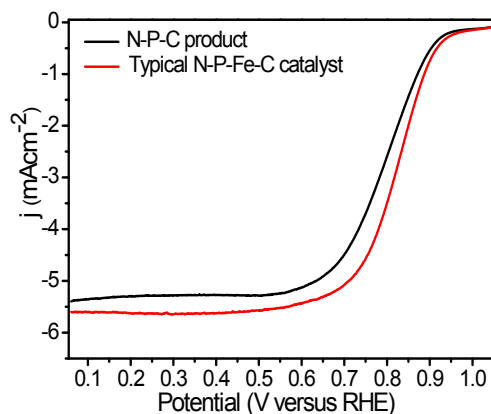


Figure S7. RDE voltammograms for the ORR at the N-P-C product and typical N-P-Fe-C catalyst electrode in O_2 -saturated 0.1 M KOH at room temperature (rotation speed 1600 rpm, sweep rate 20 mV s^{-1})

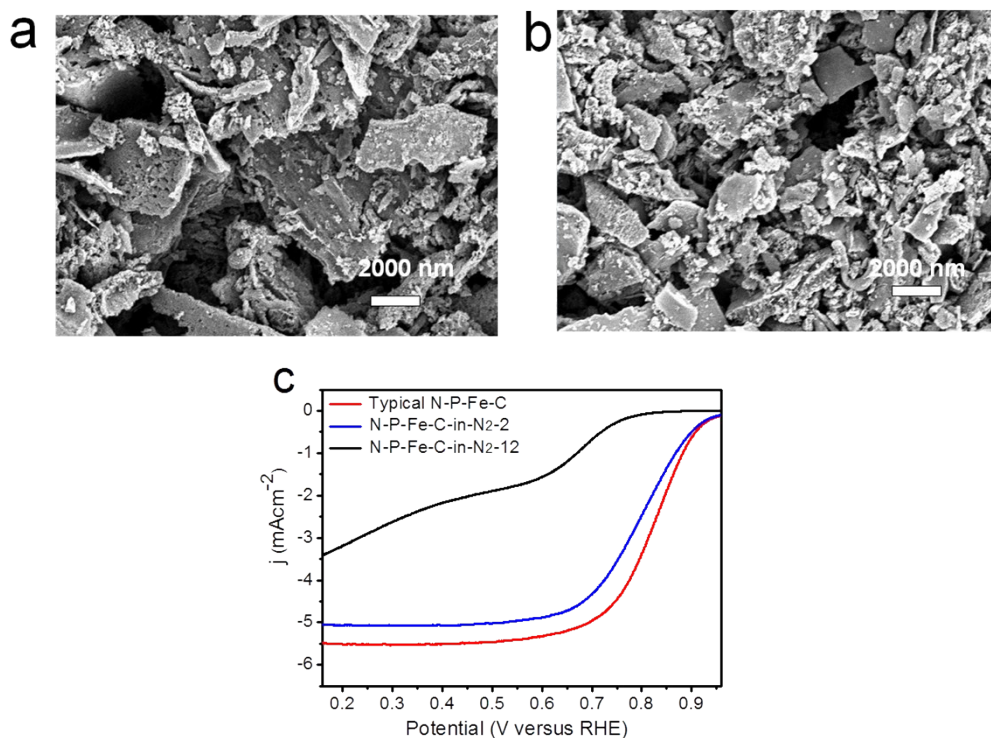


Figure S8. (a-b) SEM images of the N-P-Fe-C-in- N_2 -12 and N-P-Fe-C-in- N_2 -2 products; (c) RDE voltammograms in O_2 -saturated 0.1 M KOH at room temperature (rotation speed 1600 rpm, sweep rate 20 mVs^{-1}) for the typical N-P-Fe-C, N-P-Fe-C-in- N_2 -12 and N-P-Fe-C-in- N_2 -2 catalysts.

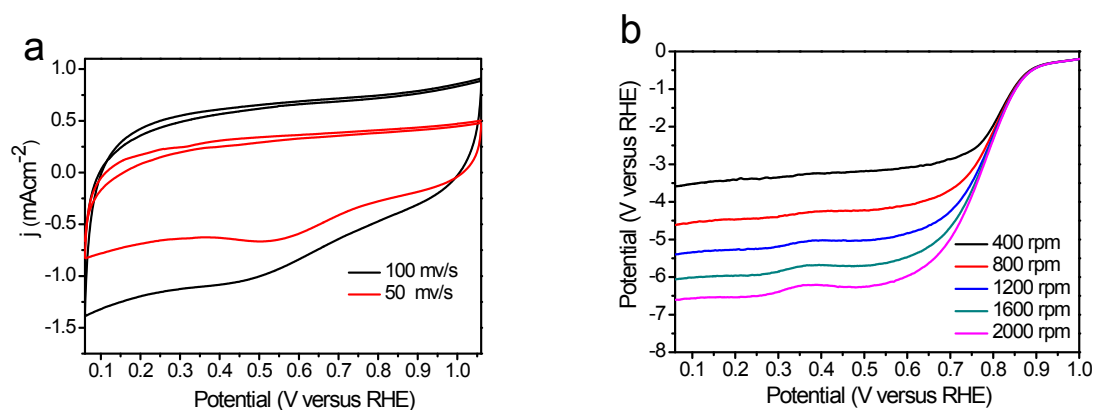


Figure S9. (a) Cyclic voltammetry at the similar N-P-Fe-C product electrode in N_2 -saturated 0.1 M KOH at the sweep rate 50 and 100 mVs^{-1} ; (b) RDE voltammograms for the ORR at the similar N-P-Fe-C product electrode at the various rotation speeds (sweep rate 20 $mV s^{-1}$).

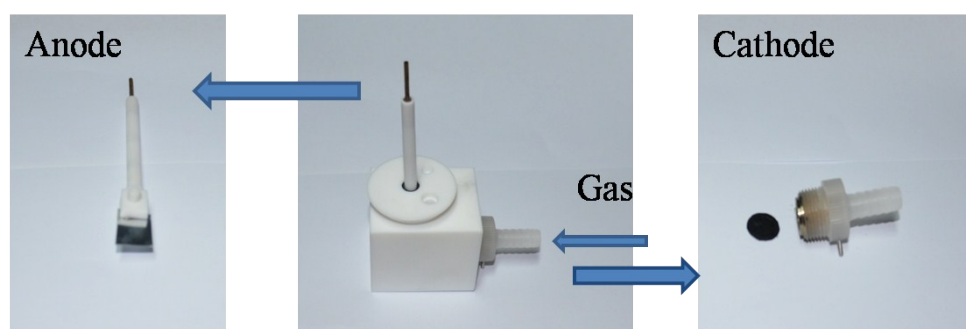


Figure S10. The photographs of the electrochemical cell

Table S1. Content of C, N, O, P and Fe of the products from the XPS data

Samples	Atomic Content, %				
	C	N	O	P	Fe
Typical N-P-Fe-C	86.50	6.55	6.17	0.40	0.38
N-P-C	86.87	6.35	6.42	0.36	without
N-P-Fe-C-in- N_2 -2	86.27	6.85	6.11	0.42	0.35
N-P-Fe-C-in- N_2 -12	91.10	2.81	4.81	0.37	0.36