Supporting Information

One-Pot Synthesis of Fe/N/S-Doped Porous Carbon Nanotubes for Efficient Oxygen Reduction Reaction

Zhong Tan,[a,b] Huanxin Li,[a,b] Qiaoxia Feng,[a,b] Lanlan Jiang,[a,b] Hongyu Pan,[a,b] Zhongyuan Huang,[a,b] Qiang Zhou,[a,b] Haihui Zhou,[a,b*] Shuai Ma,[a,b] Yafei Kuang[a,b*]*

[a] State Key Laboratory for Chemo/Biosensing and Chemometrics, Hunan University, Changsha, 410082, China

[b] College of Chemistry and Chemical Engineering, Hunan University, Changsha, 410082, China

[*]Corresponding Authors: zhongyuan.222@163.com; haihuizh@163.com and yafeik@163.com.

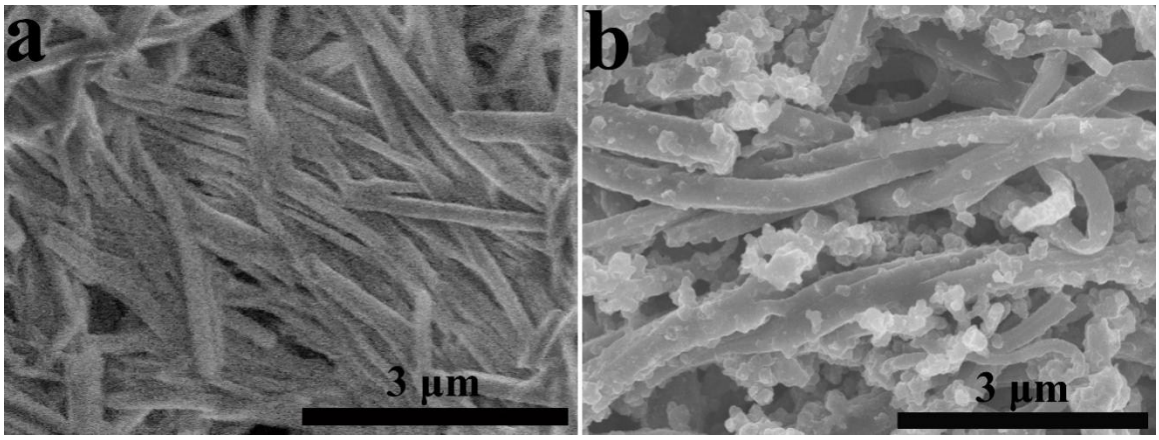

Figure S1 SEM images of (a) MO-$FeCl_3$ template and (b) Fe-MO-PPy NT.

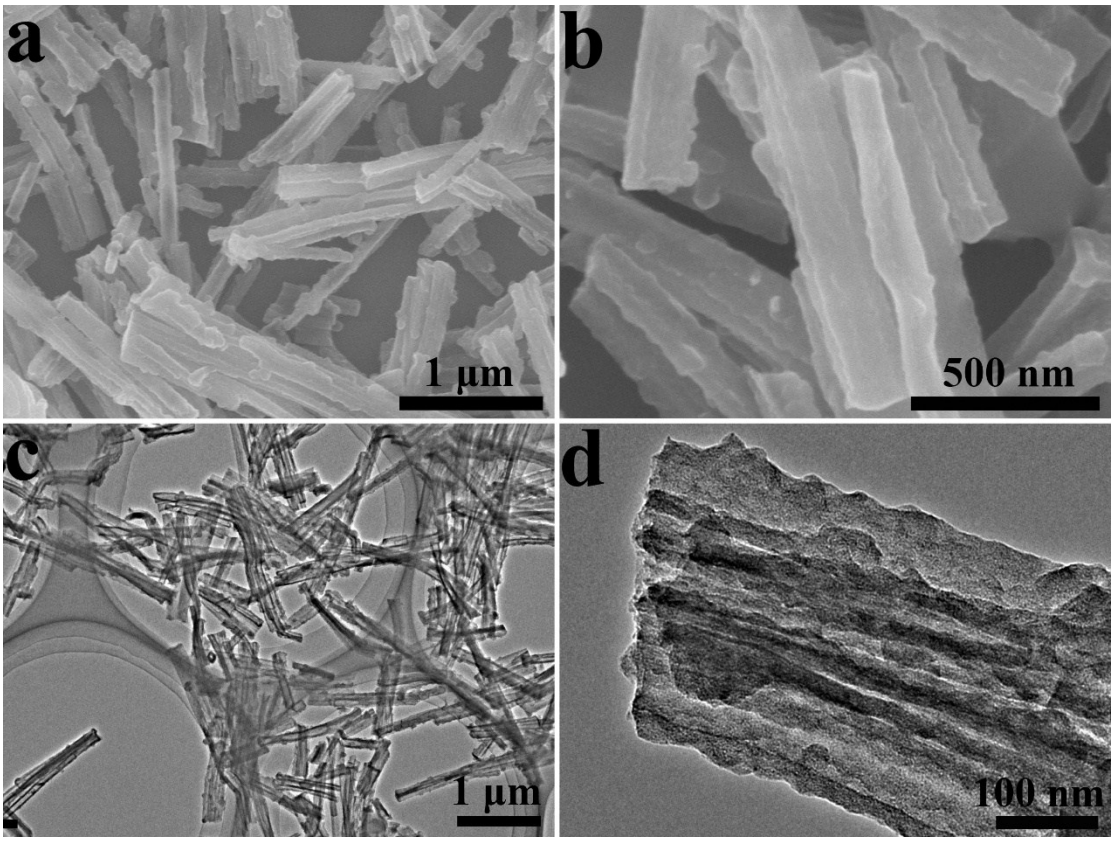

Figure S2 (a, b) SEM images and (c, d) TEM images with different magnifications of Fe/N/S-CNT.

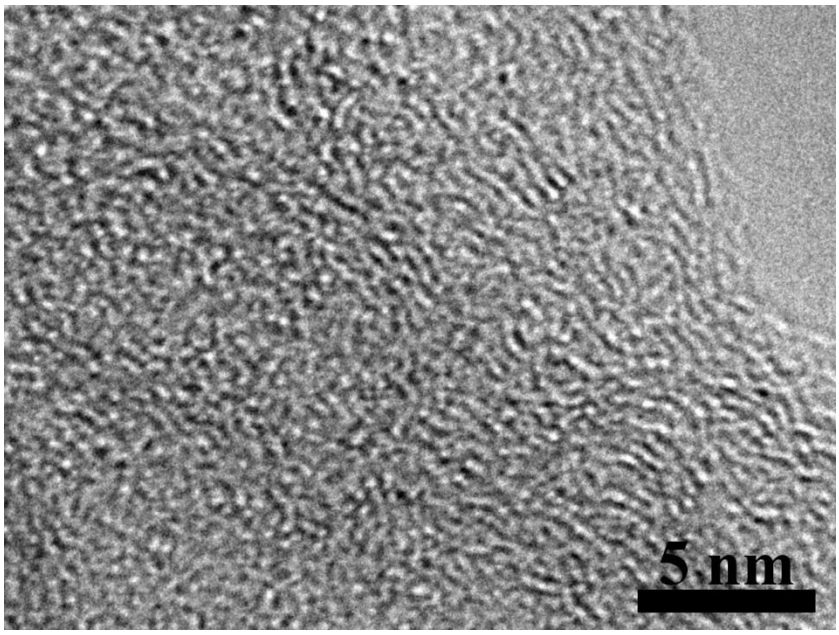

Figure S3 High-magnification TEM image of Fe/N/S-PCNT.

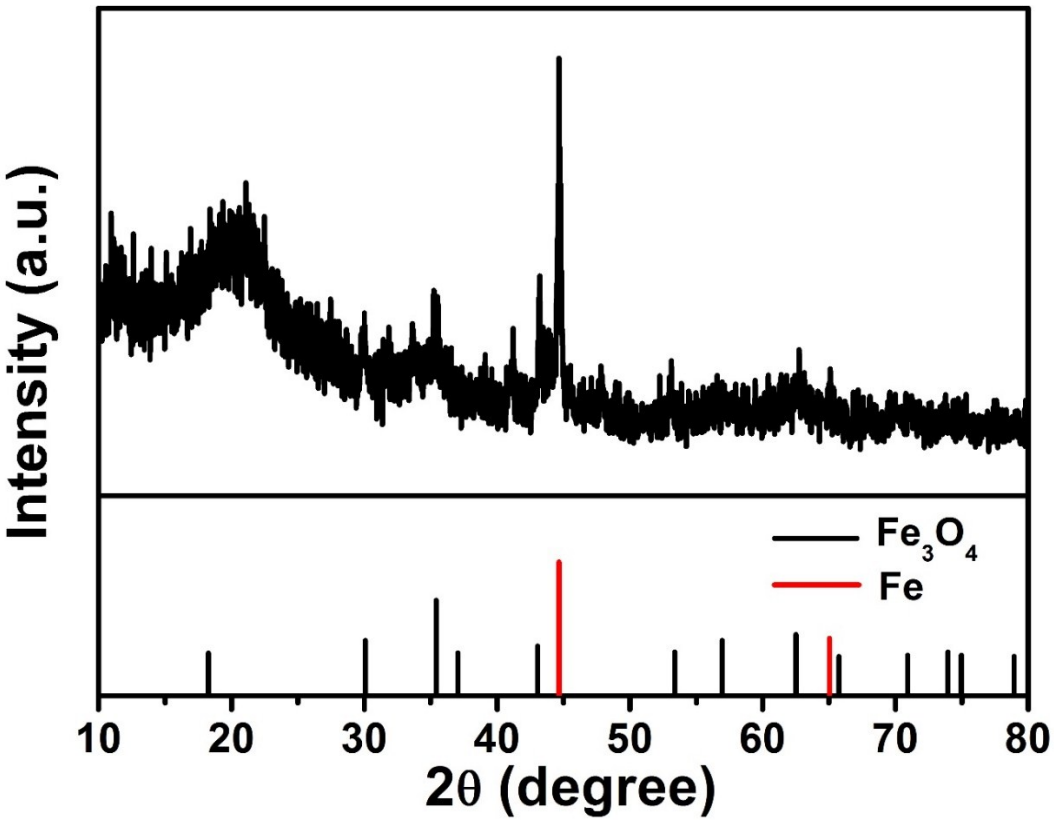

Figure S4 XRD pattern of Fe/N/S-PCNT before acid etching.

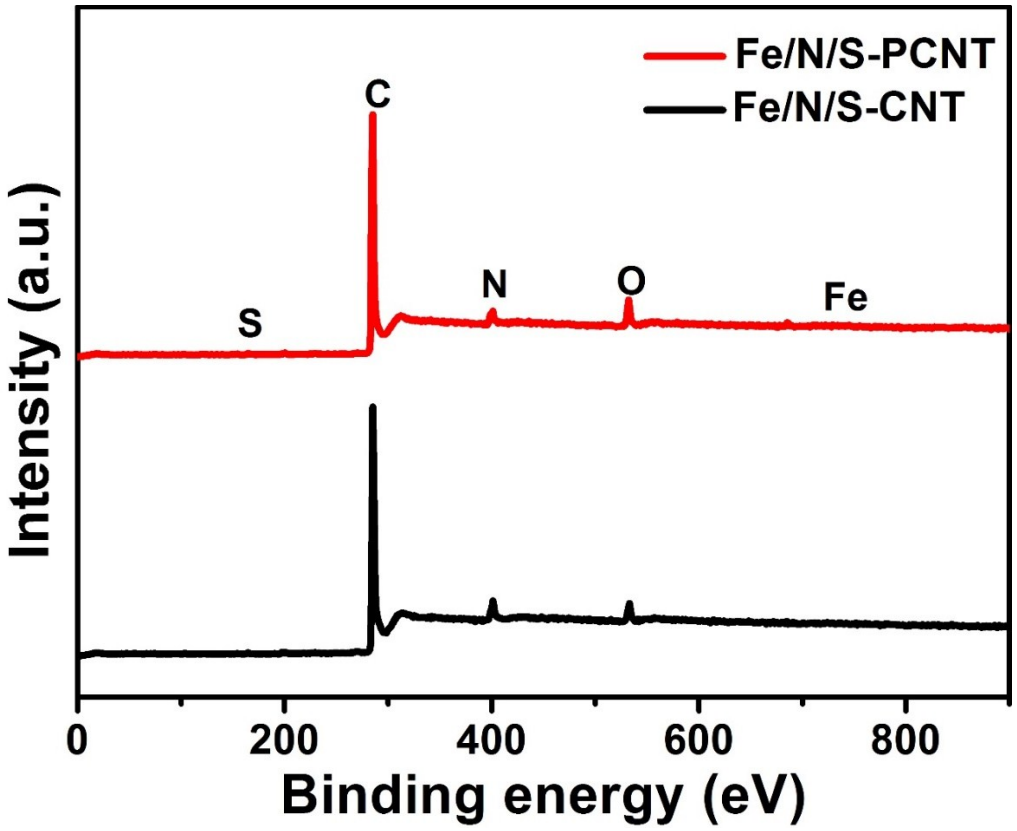

Figure S5 XPS surveys of Fe/N/S-PCNT and Fe/N/S-CNT.

Table S1 The contents of different elements measured by XPS.

Sample	C (at %)	N (at %)	S (at%)	O (at %)	Fe (at %)
Fe/N/S-PCNT	**87.59**	**5.77**	**0.56**	**5.72**	**0.36**
Fe/N/S-CNT	**87.8**	**7.46**	**0.45**	**3.97**	**0.32**

Table S2 Surface area and pore volume parameters of Fe/N/S-PCNT and Fe/N/S-CNT samples.

Sample	S_{BET} ($m^2\ g^{-1}$)	$S_{micropore}$ ($m^2\ g^{-1}$)	$S_{mesopore}$ ($m^2\ g^{-1}$)	V_{total} ($cm^3\ g^{-1}$)	$V_{micropore}$ ($cm^3\ g^{-1}$)	$V_{mesopore}$ ($cm^3\ g^{-1}$)
Fe/N/S-PCNT	1152	906.6	245.4	0.646	0.440	0.206
Fe/N/S-CNT	304.6	253.3	50.7	0.234	0.119	0.115

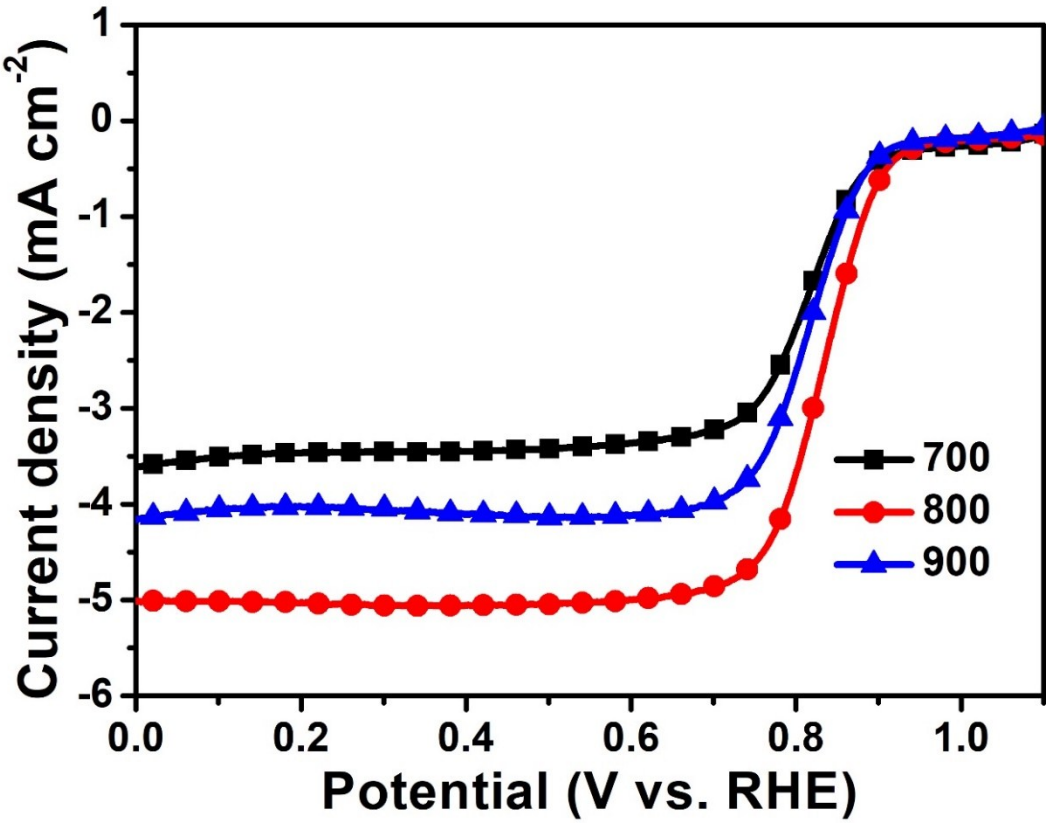

Figure S6 LSV curves of various Fe/N/S-PCNT obtained by pyrolysis at 700 °C, 800 °C and 900 °C in O_2-saturated 0.1 M KOH at a rotation speed of 1600 rpm.

In order to optimize the pyrolysis temperature, Fe/N/S-PCNT catalysts calcined at different temperatures were prepared and their ORR performance were evaluated by LSV test. As shown in Figure S6. The Fe/N/S-PCNT obtained at 800 °C exhibited the best ORR catalytic performance with an optimized onset potential and half-wave potential. Therefore, 800 °C is considered to be the optimum pyrolysis temperature.

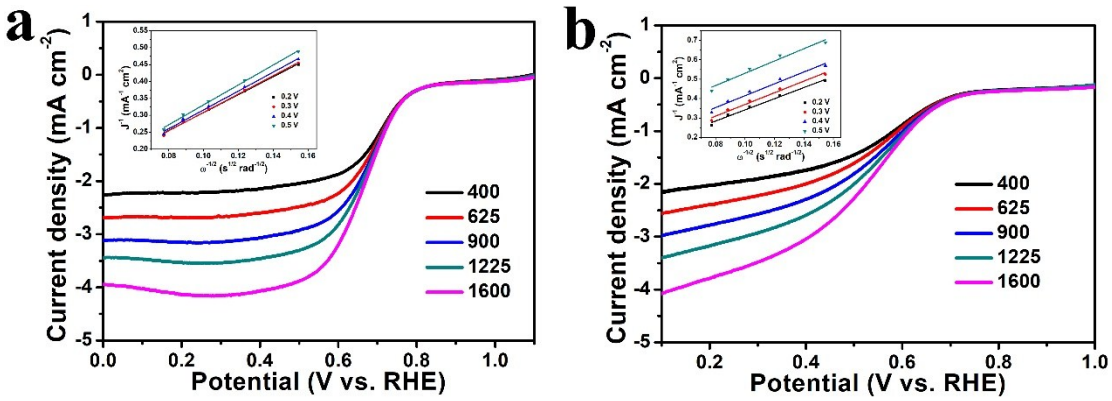

Figure S7 LSV curves of Fe/N/S-CNT at various rotation rates and (inset) the corresponding K-L plots at different potentials in (a) O_2-saturated 0.1 M KOH and (b) O_2-saturated 0.5 M H_2SO_4.

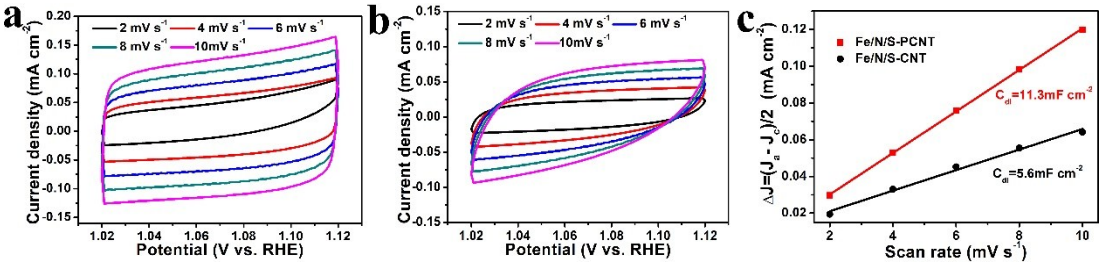

Figure S8 CV curves at various scan rates of (a) Fe/N/S-PCNT and (b) Fe/N/S-CN in the range of 1.02-1.12 V vs. Ag/AgCl. (c)Average variance between the anodic and cathodic currents $((\Delta J = J_a - J_c)/2)$ at 0.107 V against the scan rate for Fe/N/S-PCNT and Fe/N/S-CNT. The linear slope is equivalent to the double-layer capacitance, C_{dl}, was used to represent the electrochemical active surface area.

Table S3 Comparison of reported ORR performances for non-noble metal catalysts

Catalyst	Electrolyte	E_{onset} (V vs RHE)	$E_{1/2}$ (V vs RHE)	Reference
Fe/N/S-PCNT	0.1 M KOH	0.96	0.84	This work
	0.5 M H_2SO_4	0.80	0.62	
Fe-N-DSC	0.1 M KOH	1.03	0.84	ACS Nano 2018, 12, 208−216
	0.5 M H_2SO_4	0.81	0.65	
S, N-Fe/N/C-CNT	0.1 M KOH	-	0.85	Angew. Chem. Int. Ed. 2017, 56, 610 –614
Fe-N-CNT	0.1 M KOH	0.85	0.73	ACS Appl. Mater. Interfaces 2015, 7, 24256−24264
	0.1 M $HClO_4$	0.77	0.46	
Fe-M-LA/C-700	0.1 M KOH	0.93	-	J. Mater. Chem. A, 2017, 5, 19790–19799
Fe-N-C	0.1 M KOH	0.92	0.81	J. Am. Chem. Soc. 2014, *136* (31), 11027-11033
	0.1 M $HClO_4$	0.80	0.60	
Co, N-CNF	0.1 M KOH	0.88	0.81	Adv.Mater.2016,28,1668 - 1674
Co-N-mC	0.1 MKOH	0.94	0.85	Small,2017, 2017, 13, 1602507
Co-N-B-CSs	0.1 M KOH	0.89	0.81	ACS Nano 2018, 12, 1894-1901
S-Fe/N/C	0.1 M KOH	0.91	0.84	ACS Appl. Mater. Interfaces 2016, 8, 19379-19385
	0.1 M $HClO_4$	0.83	0.66	
Fe_3C@N-CNT	0.1 M KOH	0.97	0.85	Energy Environ. Sci., 2016, 9, 3092--3096
Fe-N-CC	0.1 M KOH	0.94	0.83	ACS Nano 2016, 10, 5922−5932
	0.5 M H_2SO_4	0.80	0.52	