Supporting Information

Fe–N-doped carbon foam nanosheets with embedded Fe_2O_3 nanoparticles for highly efficient oxygen reduction in both alkaline and acidic media

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Electrochemical measurements

The kinetic parameters can be analyzed with the Koutecky–Levich equation:

$$J^{-1}=J_K^{-1}+J_L^{-1}=(nFkC)^{-1}+(0.62nFCD^{2/3}\upsilon^{-1/6}\omega^{1/2})^{-1}$$

wherein J, J_K *and* J_L represent the measured current density, the kinetic current density, and diffusion limiting current density, respectively, ω is rotation rate of the electrode, n is the electron transfer number, F is the Faraday constant, C is the bulk concentration of O_2 dissolved in the electrolyte (1.2×10^{-3}mol L^{-1}), D is the diffusion coefficient of O_2 in the electrolyte (1.9×10^{-5} cm^{-2} s^{-1}), υ is the kinematic viscosity of the electrolyte (1.0×10^{-2} cm^{-2} s^{-1}), and k is the electron transfer rate constant.[1] The values of C, D and υ are the same in both 0.1 M KOH and 0.5 M H_2SO_4 solution.[2]

References:

1. R. E. Davis, G. L. Horvath, C. W. Tobias, *Electrochim. Acta*, 1967, **12**, 287-297.
2. J. H. Xue, L. Zhao, Z. Y. Dou, Y. Yang, Y. Yue, Z. Zhu, *Rsc Adv,* 2016, **6,**110820-110830

Table S1. BET surface areas and total pore volumes of Fe_2O_3@Fe-N-C-800-BM and Fe_2O_3@Fe-N-C obtained at different carbonization temperatures

Sample	T(°C)[a]	S_{BET} (m^2 g^{-1})[b]	V_{total} (cm^3 g^{-1})[c]
Fe_2O_3@Fe-N-C-700	700	497	0.58
Fe_2O_3@Fe-N-C-800	800	646	0.85
Fe_2O_3@Fe-N-C-900	900	527	0.73

[a] Carbonization temperature.

[b] BET specific surface areas obtained from N_2 adsorption isotherm in the range of P/P_0 = 0.05-0.3.

[c] Total pore volume was obtained at P/P_0 of 0.98.

Table S2. XPS data for the surface species of Fe_2O_3@Fe-N-C-800-BM and Fe_2O_3@Fe-N-C-T materials obtained at different temperatures and their content nitrogen species

Sample	N (at%)	Fe (at%)	pyridinic-N (%)	graphitic-N (%)	oxidized-N (%)
Fe_2O_3@Fe-N-C-700	17.8	1.9	53	41	6
Fe_2O_3@Fe-N-C-800	9.9	2.3	46	47	7
Fe_2O_3@Fe-N-C-900	4.8	0.7	41	49	10
Fe_2O_3@Fe-N-C-800-BM	10.6	0.2	43	50	7

Table S3. The data of catalytic activity for Fe_2O_3@Fe-N-C-T in 0.1 M KOH solution

Samples	Onset-potential V (vs. Ag/AgCl)	Half-wave potential	J [a] (mA cm^{-2})	J_K [b] (mA cm^{-2})
Fe_2O_3@Fe-N-C-700	0.001	-0.278	0.880	9.09
Fe_2O_3@Fe-N-C-800	0.054	-0.104	3.617	11.73
Fe_2O_3@Fe-N-C-900	0.052	-0.115	3.406	10.85
Fe_2O_3@Fe-N-C-800-BM	0.021	-0.270	1.765	5.11
Pt/C	0.056	-0.136	2.565	9.57

[a] The experimental current density (J) at -0.15 V determined at the polarization curve at 1600rpm in 0.1M KOH solution

[b] The kinetic current densities (J_K) at -0.10 V determined at the polarization curve at 1600rpm in 0.1M KOH solution

Table S4. The data of catalytic activity for Fe_2O_3@Fe-N-C-Tin 0.5 M H_2SO_4 solution

Samples	Onset-potential V (vs. Ag/AgCl)	Half-wave potential	J^a (mA cm^{-2})	$J_K{}^b$ (mA cm^{-2})
Fe_2O_3@Fe-N-C-700	0.637	0.380	2.805	7.04
Fe_2O_3@Fe-N-C-800	0.698	0.535	4.656	10.47
Fe_2O_3@Fe-N-C-900	0.640	0.499	4.405	9.16
Fe_2O_3@Fe-N-C-800-BM	0.680	0.494	3.523	6.19
Pt/C	0.702	0.569	4.439	12.25

[a] The experimental current density (*J*) at 0.35V determined at the polarization curve at 1600rpm in 0.5M H_2SO_4 solution

[b] The kinetic current densities (J_K) at 0.60V determined at the polarization curve at 1600rpm in 0.5M H_2SO_4 solution

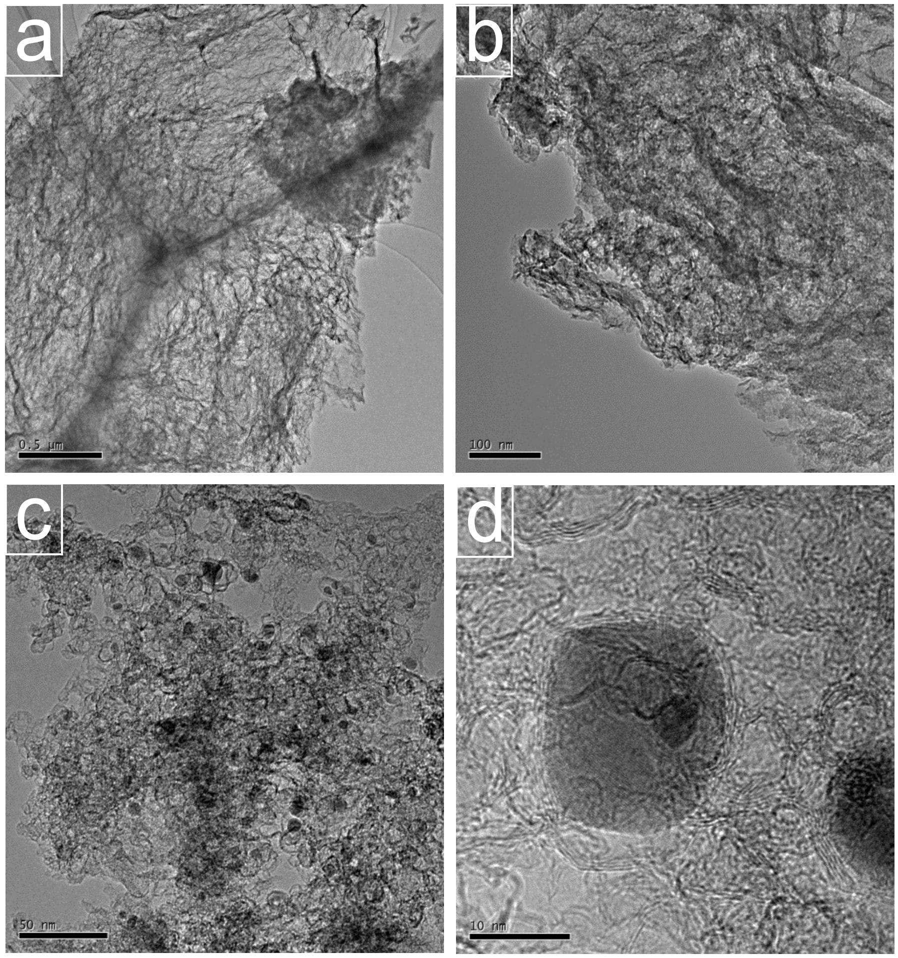


Fig. S1 (a, b) TEM images of Fe_2O_3@Fe-N-C-700; (c, d) TEM images of Fe_2O_3@Fe-N-C-900.

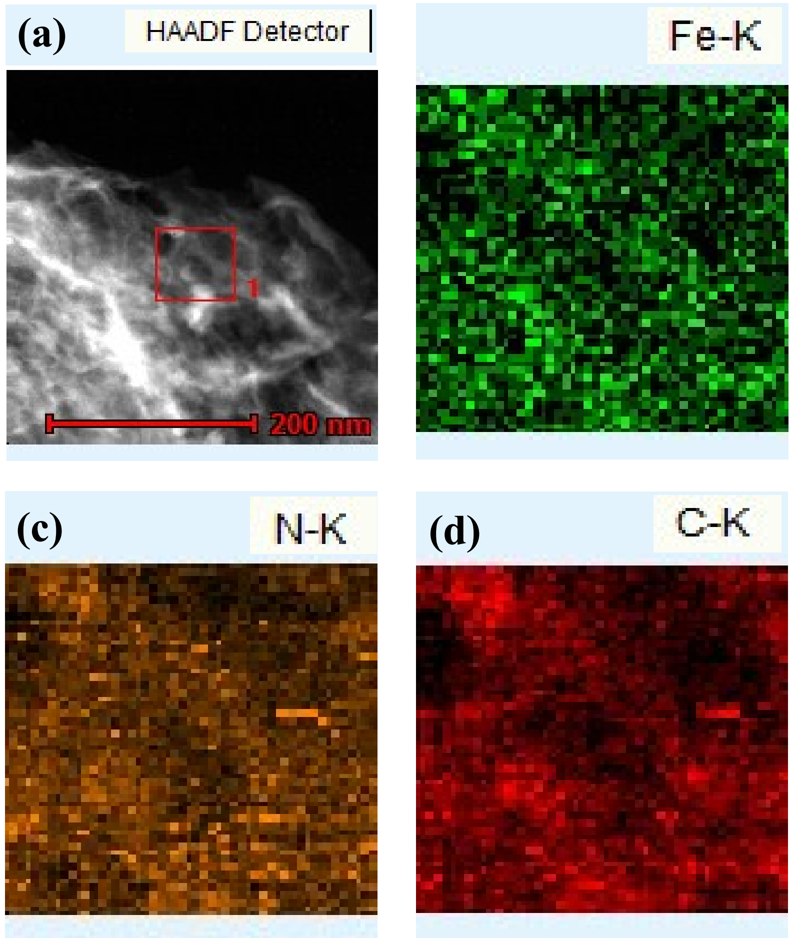


Fig. S2 (a) STEM image of Fe_2O_3@Fe-N-C-800, and elemental mapping images (recorded in region 1) of (b) Fe, (c) N, and (d) C.

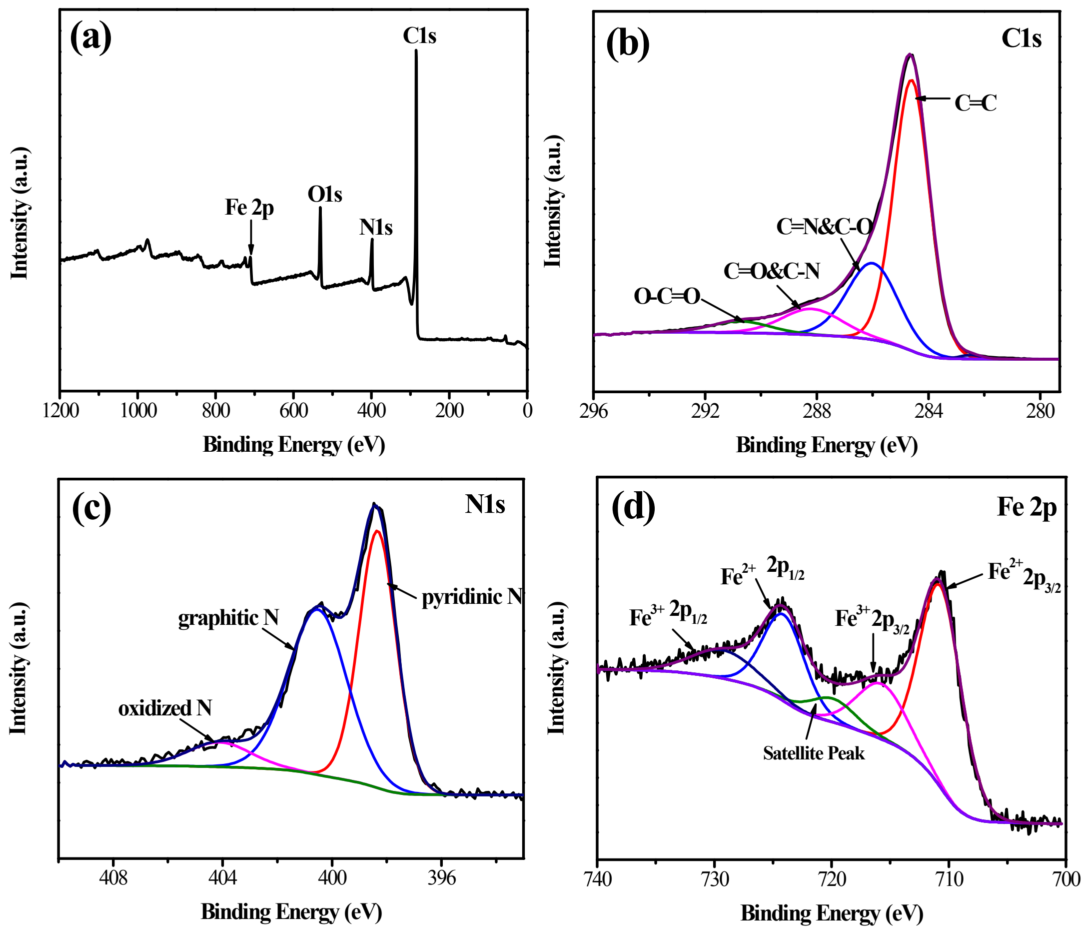


Fig. S3 (a) Wide XPS survey of theFe_2O_3@Fe-N-C-800. High-resolution (b) C1s, (c) N1s, and (d) Fe 2p spectra of the Fe_2O_3@Fe-N-C-800.

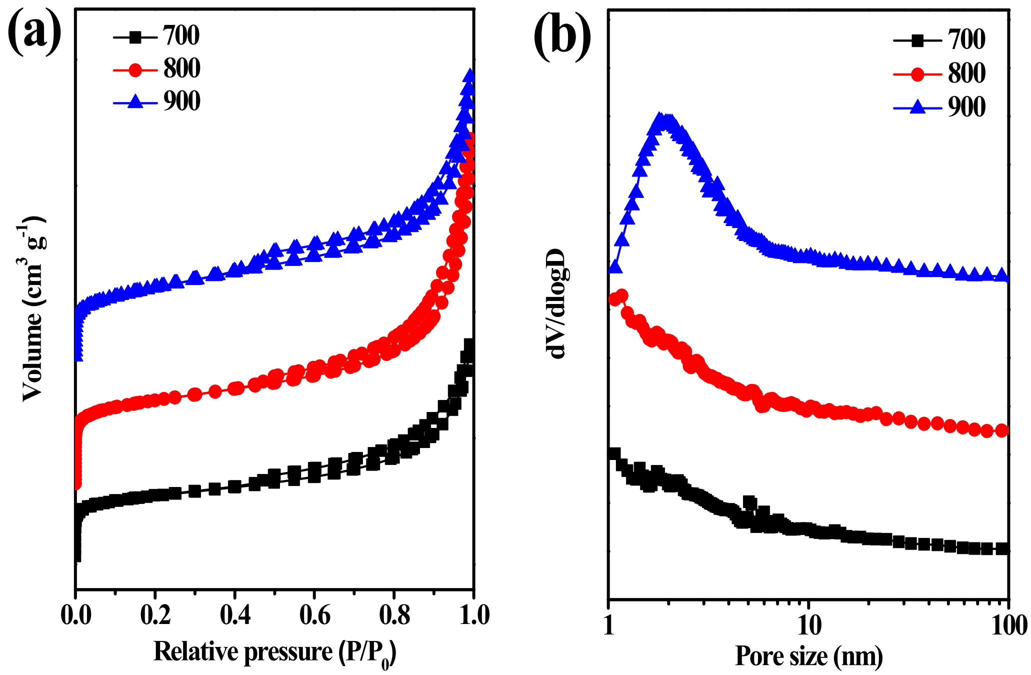


Fig. S4 (a)Nitrogen adsorption-desorption isotherms of Fe_2O_3@Fe-N-C-T samples prepared at different carbonization temperature of 700,800 and 900°C,respectively; (b) the corresponding pore size distribution curves.

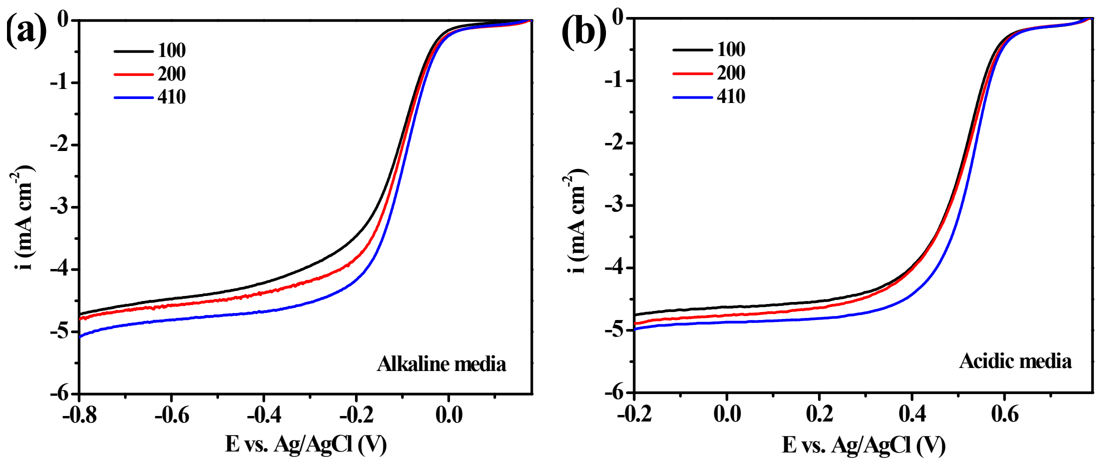


Fig. S5 LSVs of Fe_2O_3@Fe-N-C-800 with different catalyst loadings(100, 200 and 410 μg cm^{-2}) at a scan rate of 5 mV s^{-1} and a rotation rate of 1600 rpm in O_2-saturated (a) 0.1 M KOH and (b) 0.5 M H_2SO_4, respectively.

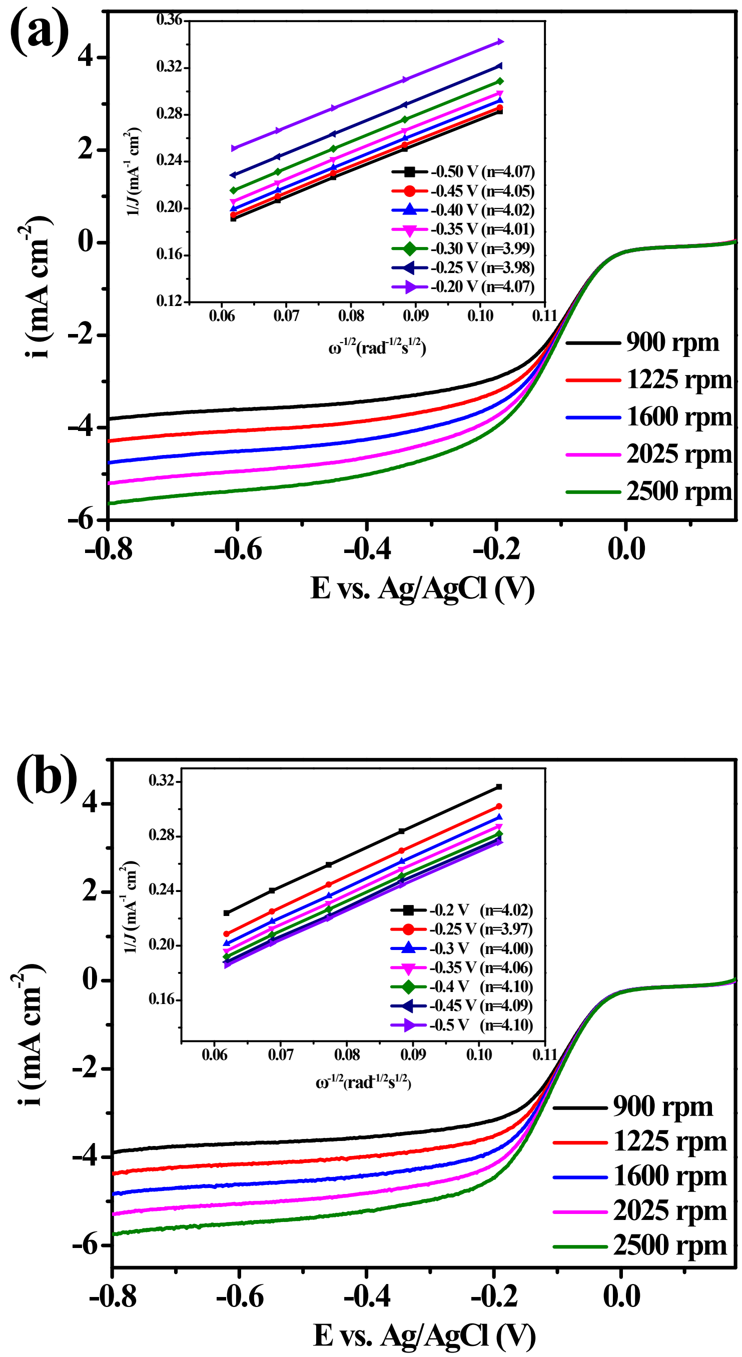
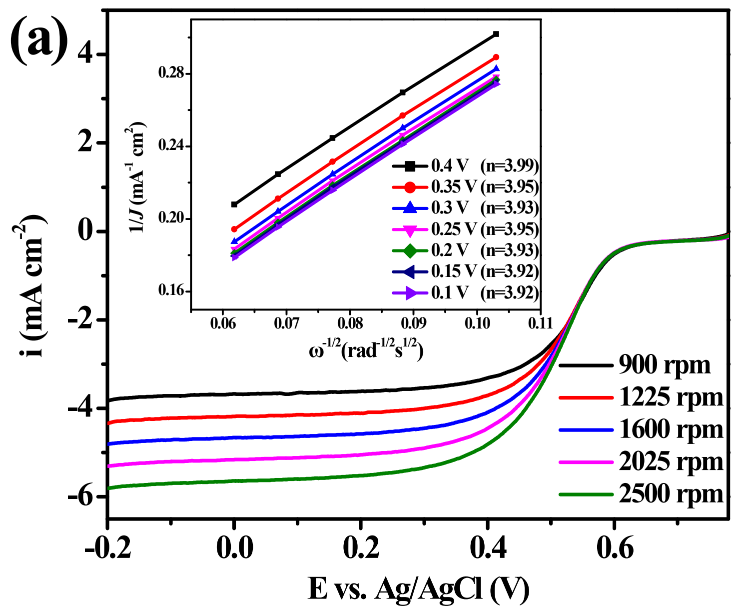


Fig. S6 LSV curves at rotation rate from 900 to 2500 rpm and the corresponding K-L plots (inset) of Fe_2O_3@Fe-N-C-800 with the catalyst loading of (a) 100 μg cm^{-2} and (b) 200 μg cm^{-2}in 0.1M KOH solution.



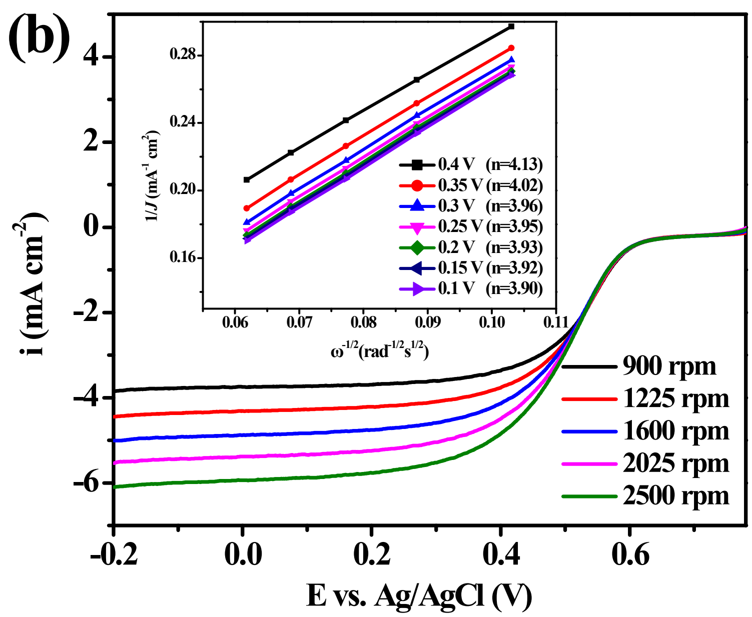


Fig. S7 LSV curves at rotation rate from 900 to 2500 rpm and the corresponding K-L plots (inset) of Fe_2O_3@Fe-N-C-800 with the catalyst loading of (a) 100 μg cm^{-2} and (b) 200 μg cm^{-2}in 0.5M H_2SO_4 solution.

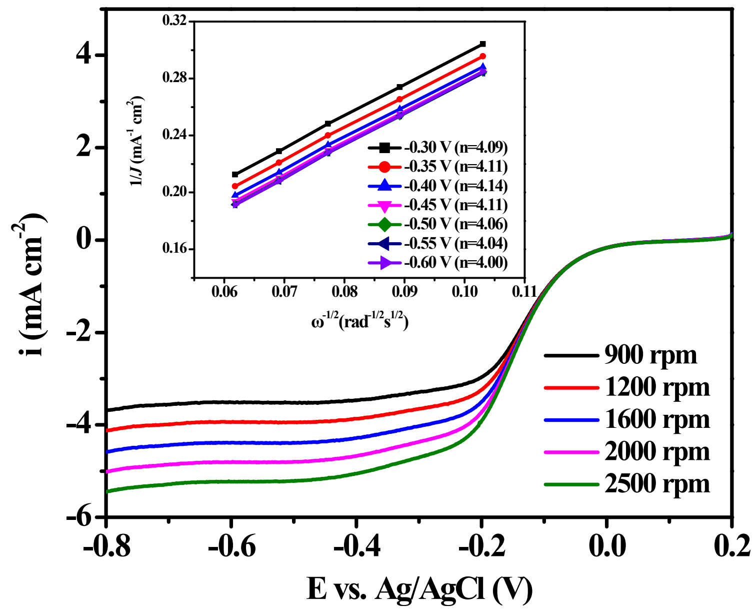


Fig. S8 LSV curves at rotation rate from 900 to 2500 rpm and the corresponding K-L plots (inset) of Pt/C with the catalyst loading of 41μg Pt cm^{-2}in 0.1M KOH solution.

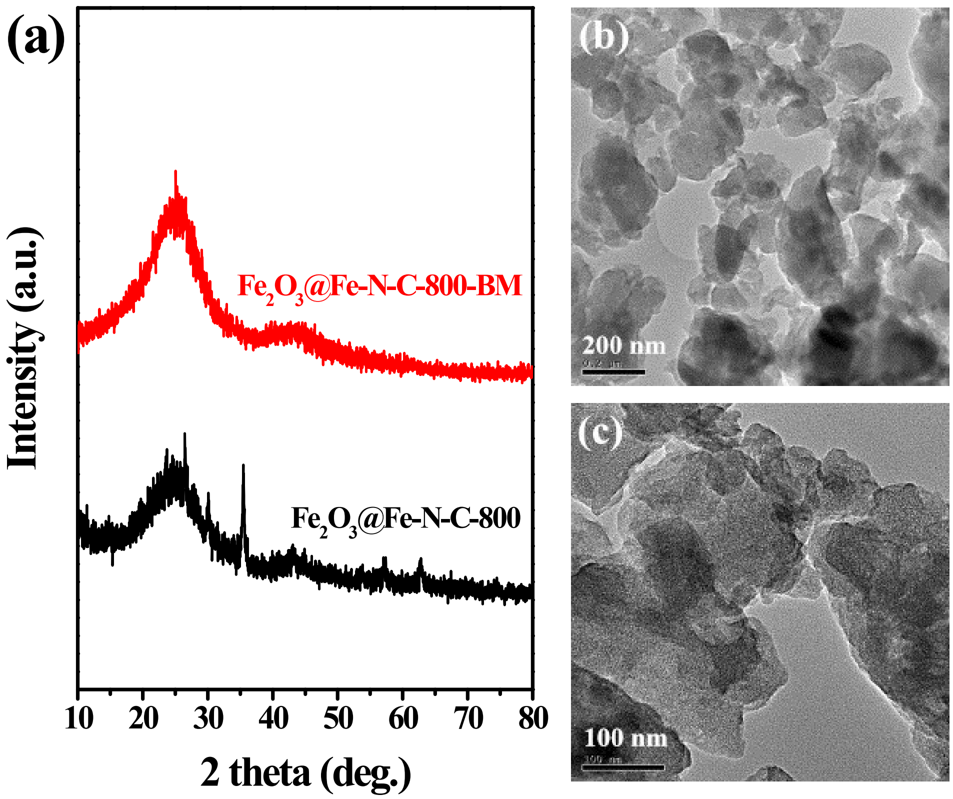


Fig. S9 (a) XRD patterns of Fe_2O_3@Fe-N-C-800 and Fe_2O_3@Fe-N-C-800-BM; (b, c) TEM images of Fe_2O_3@Fe-N-C-800-BM.

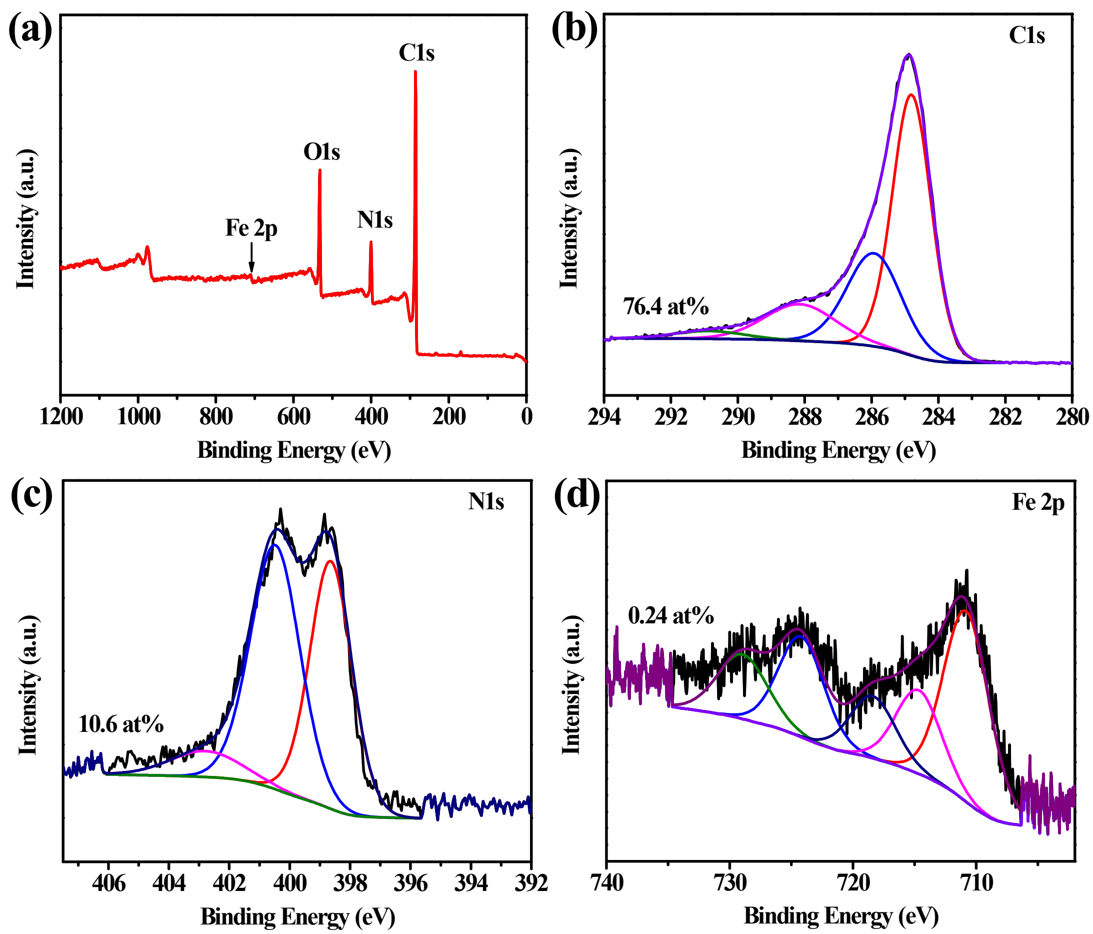
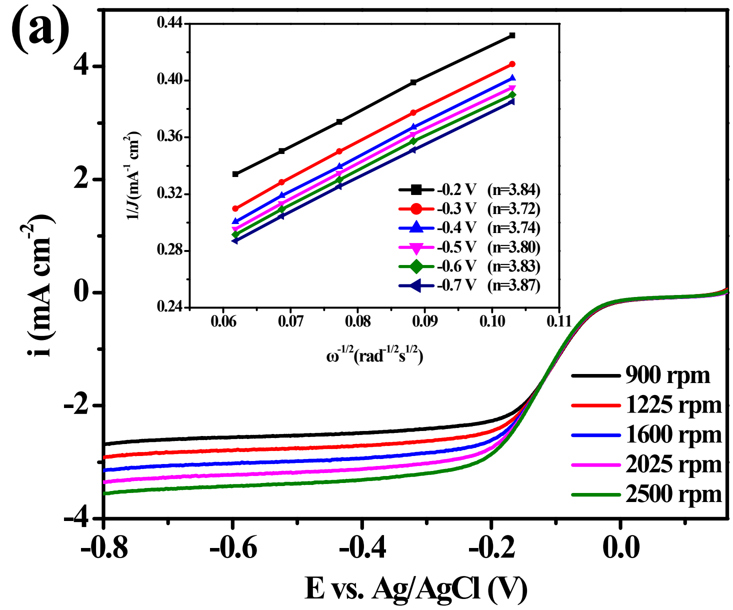


Fig. S10 (a)Wide XPS survey of the Fe_2O_3@Fe-N-C-800-BM. High-resolution (b) C1s, (c)N1s, and (d) Fe 2p spectra of the Fe_2O_3@Fe-N-C-800-BM.



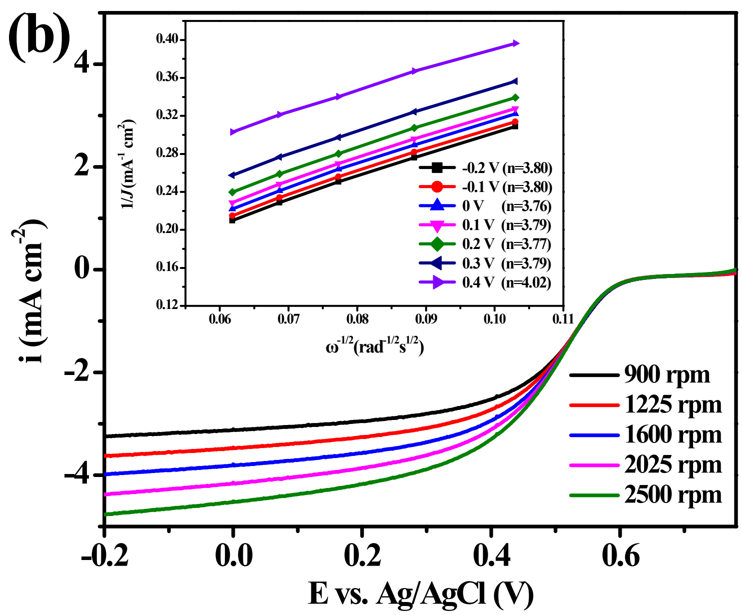


Fig. S11 LSV curves at rotation rate from 900 to 2500 rpm and the corresponding K-L plots (inset) of the Fe_2O_3@Fe-N-C-800-BMin (a) 0.1M KOH and (b) 0.5M H_2SO_4 solution.