

Supplementary Information

Efficient Oxygen Reduction on Sandwich-like Metal@N-C composites with Ultrafine Fe Nanoparticles Embedded in N-doped Carbon Nanotubes Grafted on Graphene Sheets

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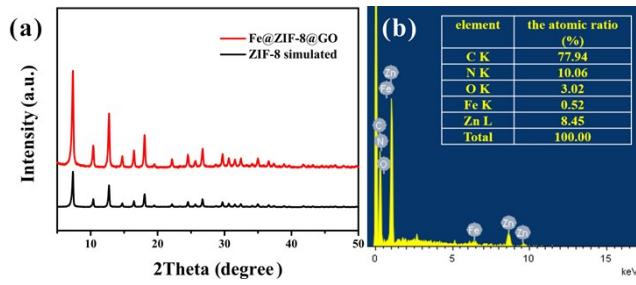


Fig. S1 (a) XRD pattern and (b) EDX spectrum of Fe@ZIF-8@GO precursor.

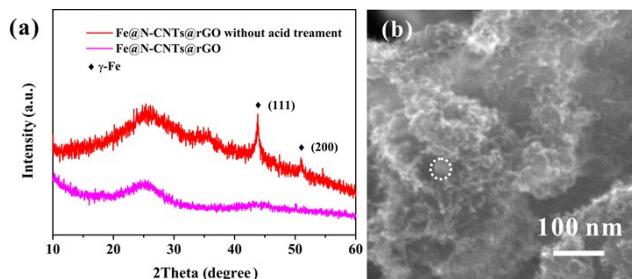


Fig. S2 (a) XRD patterns of Fe@N-CNTs@rGO before and after acid treatment, (b) SEM image of Fe@N-CNTs@rGO before acid treatment.

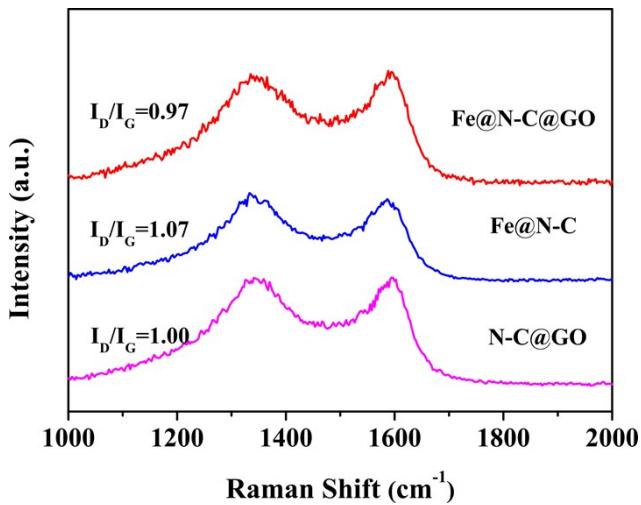


Fig. S3 Raman spectra of Fe@N-CNTs@rGO composites.

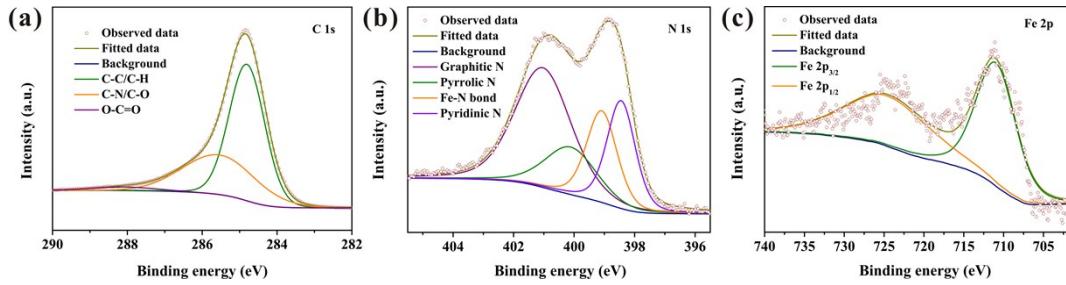


Fig. S4 High-resolution XPS spectra of (a) C 1s, (b) N 1s and (c) Fe 2p for Fe@N-CNTs@rGO composites.

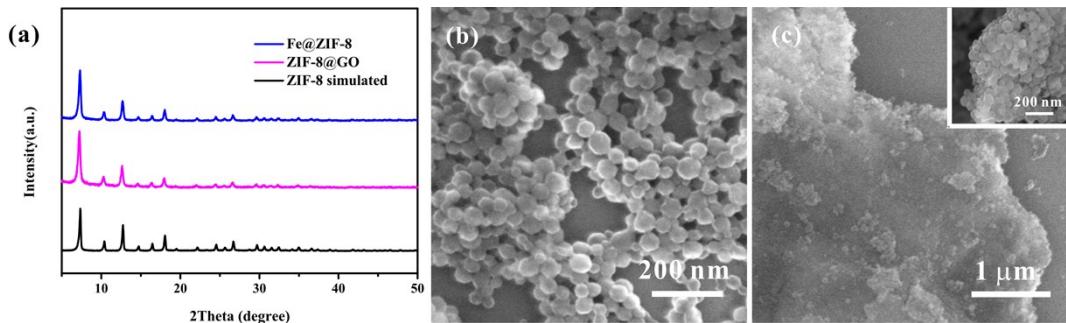


Fig. S5 (a) XRD patterns of Fe@ZIF-8, and ZIF-8@GO precursors, SEM images of the (b) Fe@ZIF-8 and (c) ZIF-8@GO precursors.

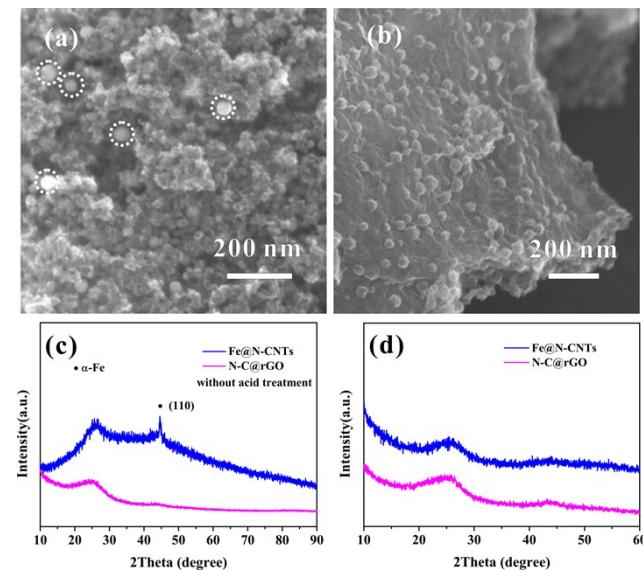


Fig. S6 SEM images of the (a) Fe@N-CNTs and (b) N-C@rGO without acid treatment, XRD patterns of Fe@N-CNTs and N-C@rGO (c) before and (d) after acid treatment.

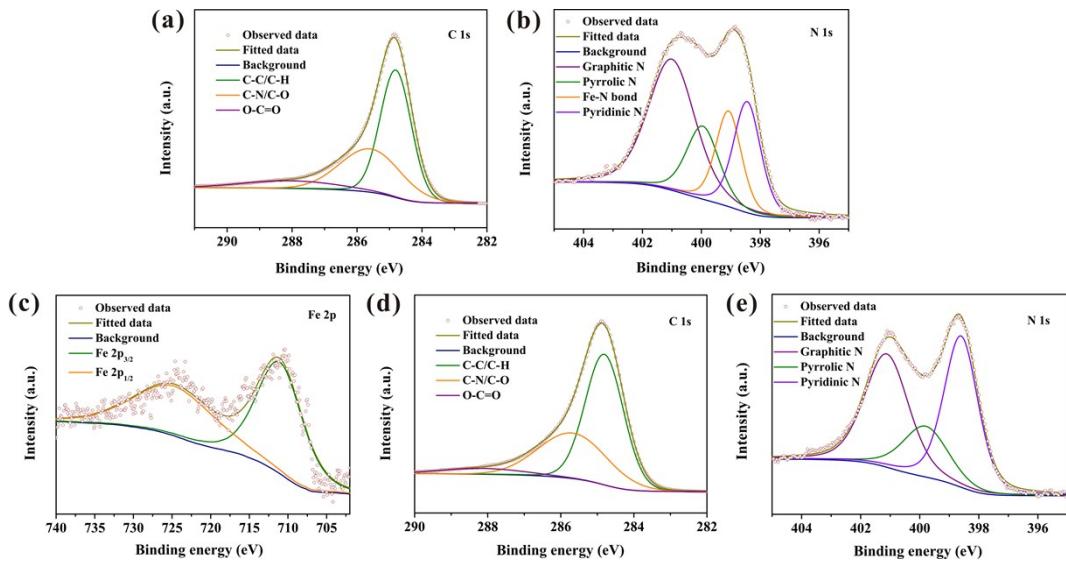


Fig. S7 High-resolution XPS spectra of (a) C 1s, (b) N 1s and (c) Fe 2p for Fe@N-CNTs composites, High-resolution XPS spectra of (d) C 1s and (e) N 1s for N-C@rGO composites.

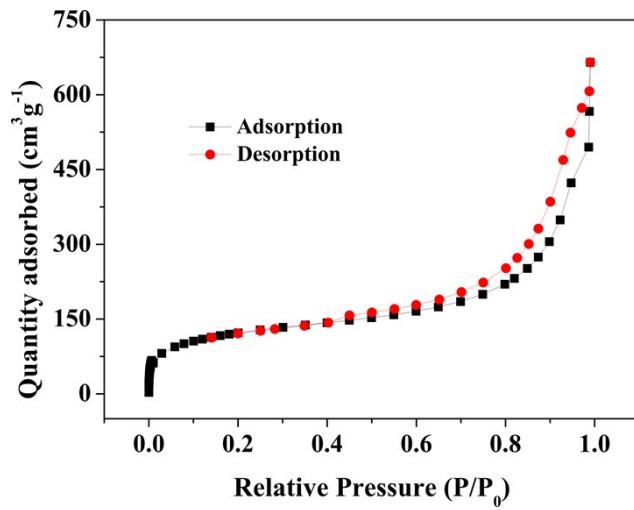


Fig. S8 Ar adsorption and desorption isotherms of Fe@N-CNTs@rGO composite.

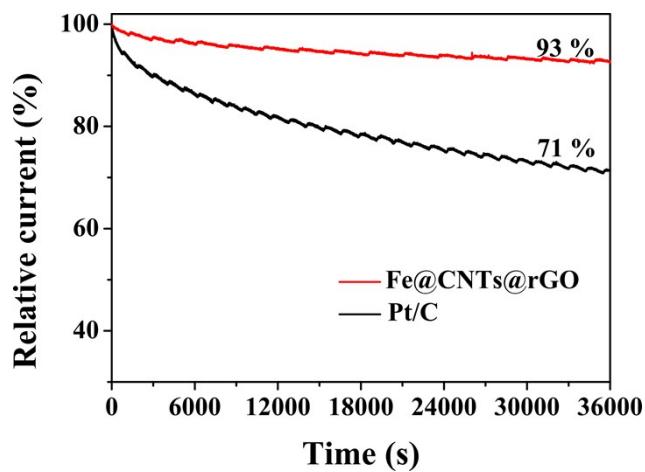


Fig. S9 i-t chronoamperometric response at 0.7 V (RHE) in O₂-saturated 0.1M KOH solution at a rotation rate of 1600 rpm.

Table S1 The relative atomic percentage contents of all the catalysts determined by using XPS.

catalysts	C (atomic %)	N (atomic %)	O (atomic %)	Fe (atomic %)	Zn (atomic %)
Fe@N-CNTs@rGO	87.13	5.63	6.65	0.51	0.08
Fe@N-CNTs	83.92	6.06	9.36	0.59	0.07
N-C@rGO	86.58	7.68	5.03	--	0.71

Table S2 Fitting results for N1s of all the catalysts

catalysts	graphitic-N (%)	Fe-N bond (%)	pyrrolic-N (%)	pyridinic-N (%)
Fe@N-NTs@rGO	44.6	18.8	16.3	20.4
Fe@N-CNTs	43.8	17.5	17.0	21.6
N-C@rGO	40.0	--	18.5	41.5