Electronic Supplementary Material (ESI) for Catalysis Science & Technology.

Electronic Supplementary Information

Metal-Organic Framework-Derived Hybrid of Fe_3C Nanorods-Encapsulated, N-Doped CNT on Porous Carbon Sheet for Highly Efficient Oxygen Reduction and Water Oxidation

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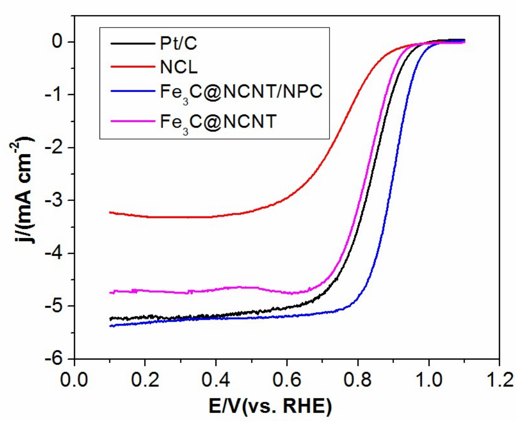

Figure S1. Steady-state polarization curves of ORR obtained with the samples prepared at different temperatures.

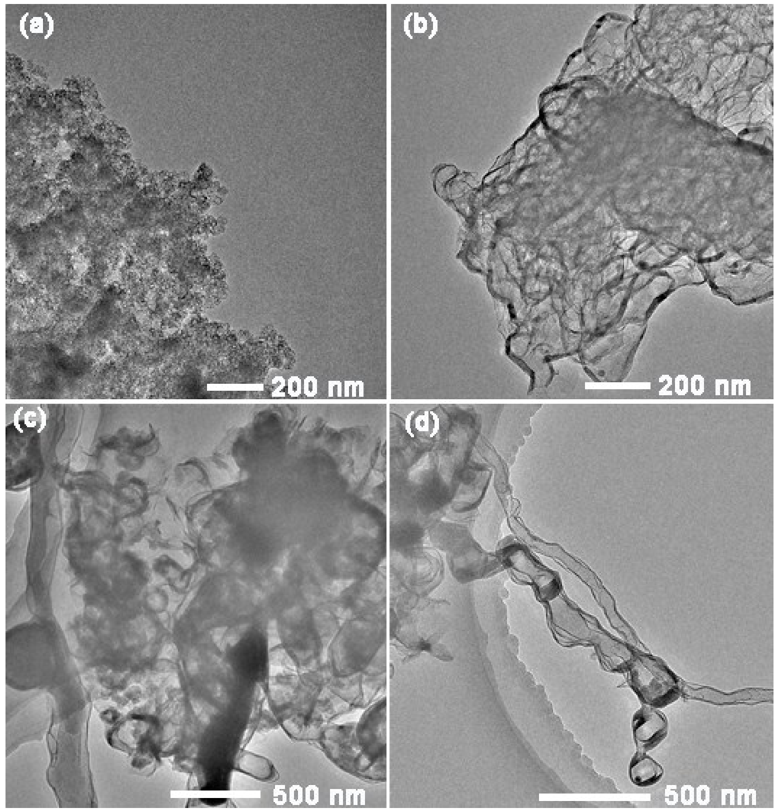

Figure S2. TEM images of the catalysts Fe_3C@NCNT/NPC obtained at different reaction stage (a, 0h), (b, 0.5h), (c-d, 1h).

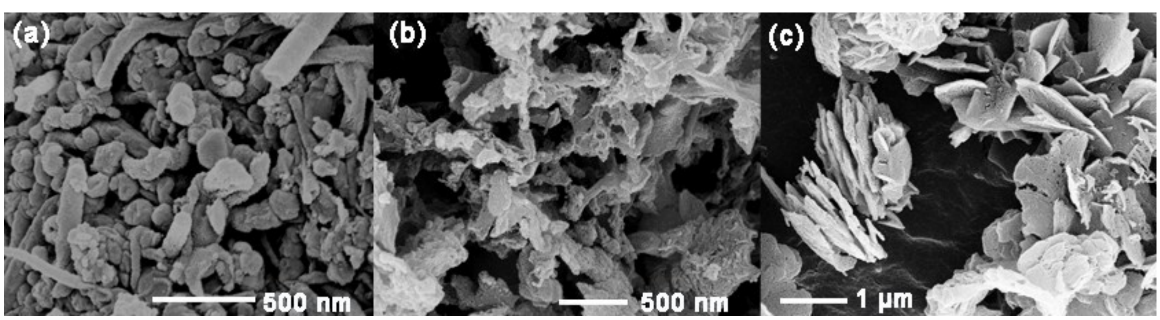

Figure S3. SEM images of the catalysts annealed at 800 ^{o}C: (a) with adding 50 wt% melamine; (b) with reducing 50 wt% melamine; (c) pure MOF.

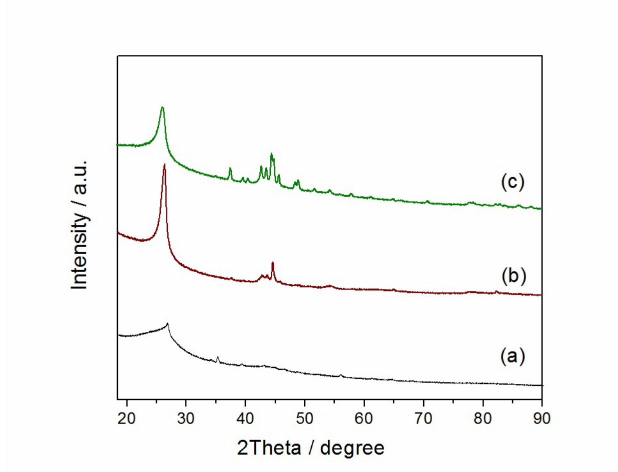

Figure S4. XRD of (a) NCL, (b) Fe_3C@NCNT/NPC, (c) Fe_3C@NCNT.

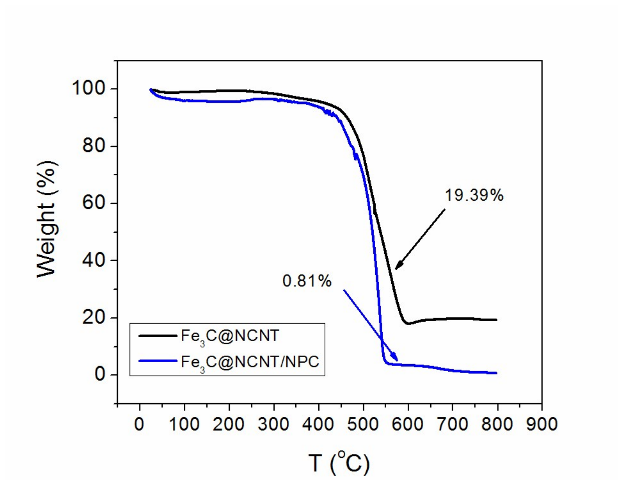

Figure S5. TGA of Fe_3C@NCNT/NPC and Fe_3C@NCNT.

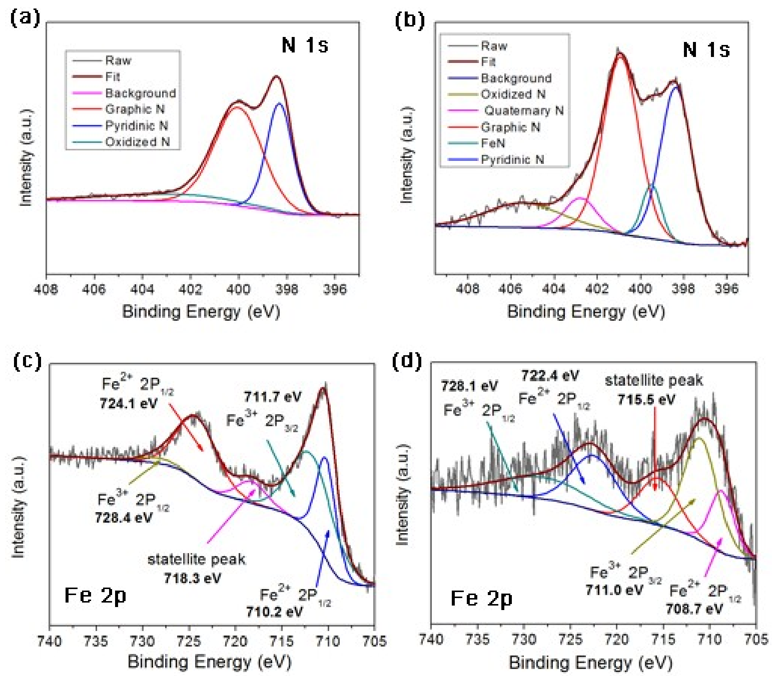

Figure S6. The high-resolution N 1s and Fe 2p spectrum of (a, c) NCL, (b, d) Fe_3C@NCNT.

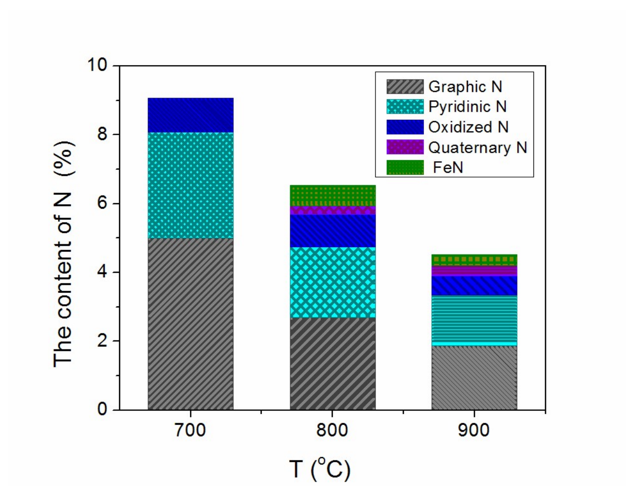

Figure S7. The content of N at different temperatures of 700, 800 and 900 ^{o}C for NCL, Fe_3C@NCNT/NPC and Fe_3C@NCNT respectively.

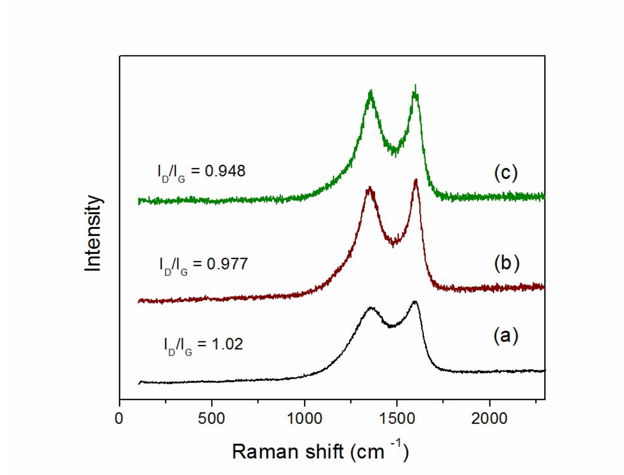

Figure S8. Raman spectrum of (a) NCL, (b) Fe_3C@NCNT/NPC, (c) Fe_3C@NCNT.

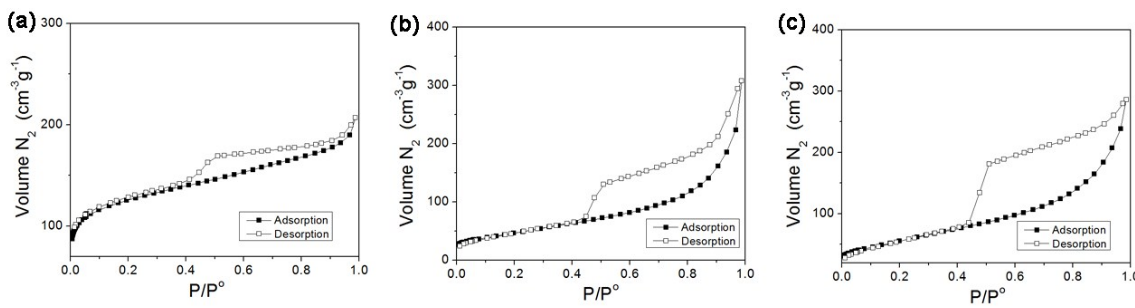

Figure S9. N_2 adsorption-desorption isotherms of (a) NCL, (b) Fe_3C@NCNT/NPC, (c) Fe_3C@NCNT.

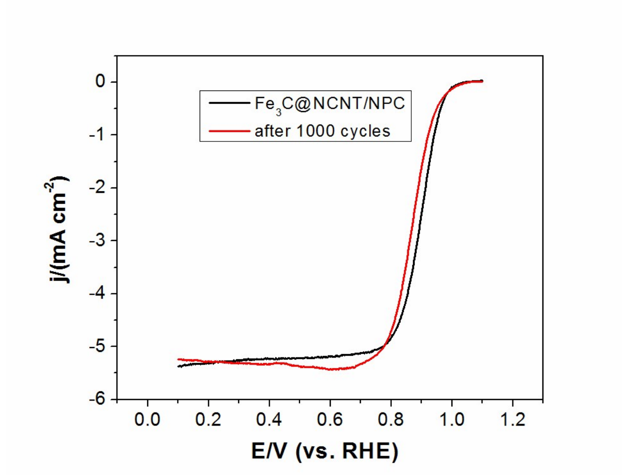

Figure S10. Steady-state polarization curves of ORR obtained with the samples of Fe_3C@NCNT/NPC after 1000 cycles in 0.1M KOH solution.

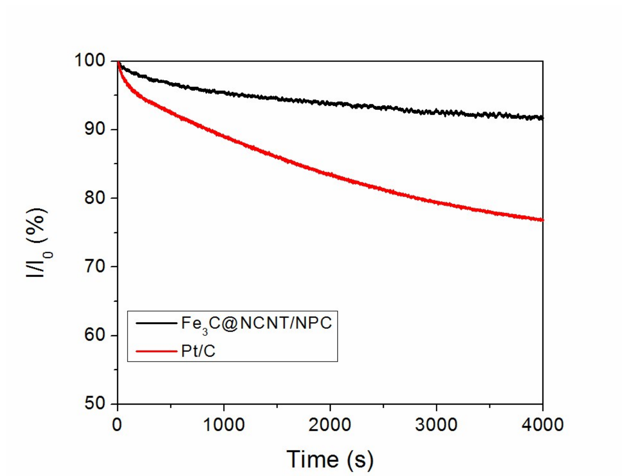

Figure S11. i-t result of Fe_3C@NCNT/NPC and Pt/C in 0.1 M KOH solution.

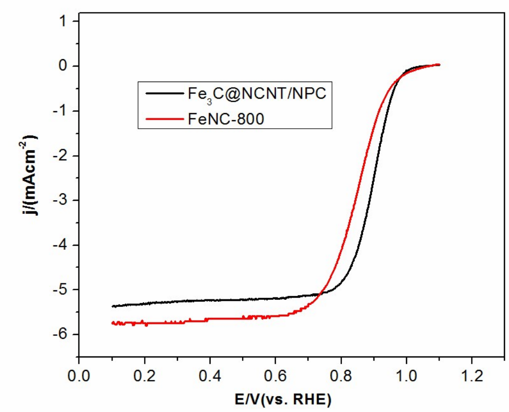

Figure S12. Steady-state polarization curves of ORR obtained with the samples of FeNC-800 and Fe_3C@NCNT/NPC in 0.1M KOH solution.

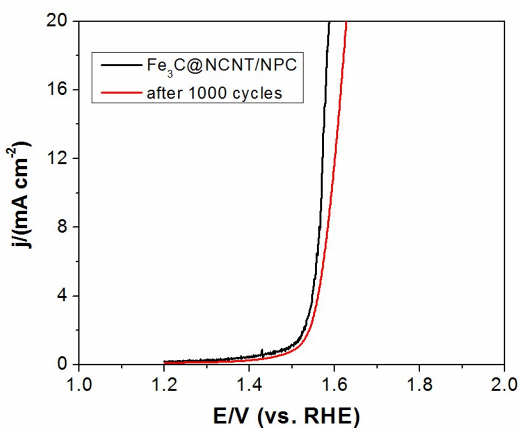

Figure S13. Steady-state polarization curves of ORR obtained with the samples of Fe_3C@NCNT/NPC after 1000 cycles in 0.1M KOH solution.

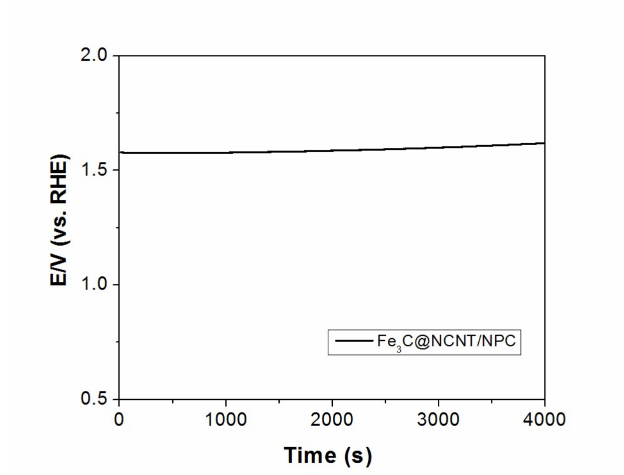

Figure S14. v-t result of Fe_3C@NCNT/NPC toward OER in 0.1 M KOH solution.

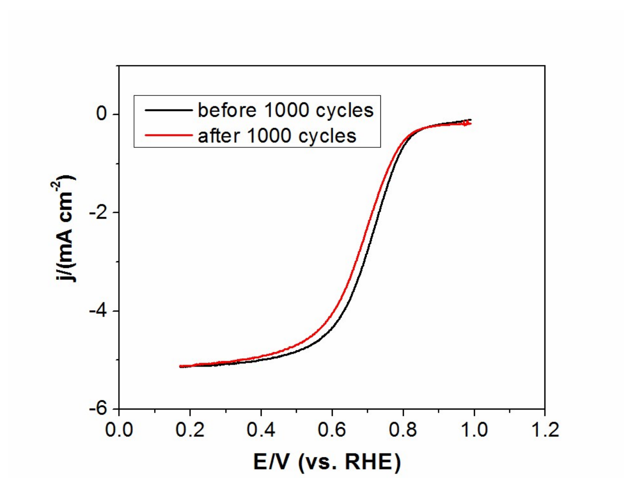

Figure S15. Steady-state polarization curves of ORR obtained with the samples of Fe_3C@NCNT/NPC after 1000 cycles in 0.5 M H_2SO_4 solution.

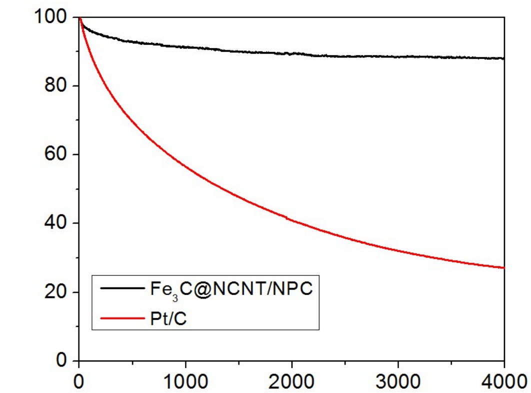

Figure S16. i-t result of Fe_3C@NCNT/NPC and Pt/C in 0.5 M H_2SO_4 solution.

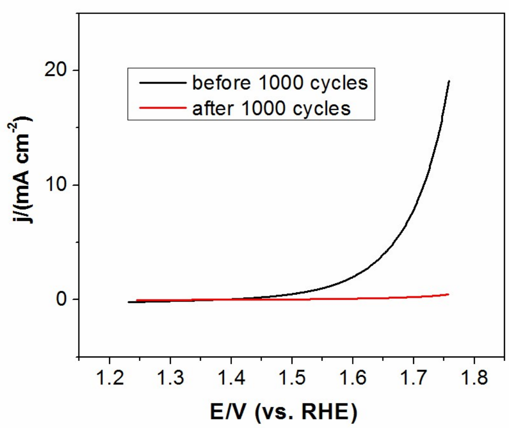

Figure S17. Steady-state polarization curves of OER obtained with the samples of Fe_3C@NCNT/NPC after 1000 cycles in 0.5 M H_2SO_4 solution.

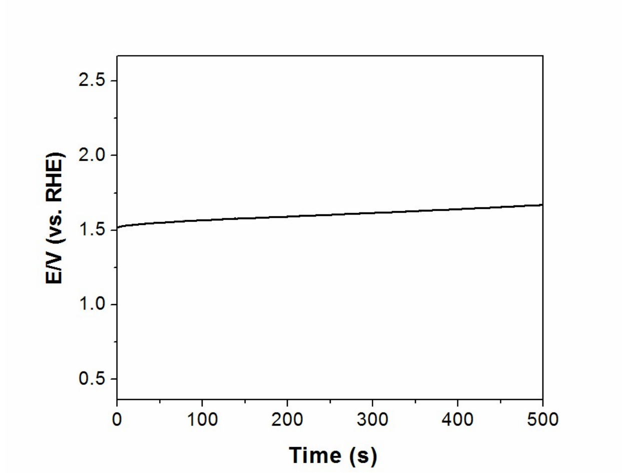

Figure S18. v-t result of Fe_3C@NCNT/NPC toward OER in 0.5 M H_2SO_4 solution.

Table S1. N_2 adsorption-desorption characterization of the samples obtained at different temperatures.

Sample	Surface Area (m^2 g^{-1})	Pore volume (cm^3 g^{-1})	Pore size (nm)
NCL	413.1	0.279	1.289
Fe_3C@NCNT/NPC	175.1	0.417	3.79
Fe_3C@NCNT	211.4	0.403	3.969

Table S2. Comparison of ORR catalytic performances in alkaline solution between Fe_3C@NCNT/NPC and other non-precious metal-based catalysts reported previously.

Catalyst	Onset potential (V vs. RHE)	Half-wave potential (V vs. RHE)	Ref.
Fe_3C@NCNT/NPC	1.0	0.90	This work
P-CNCo-20	0.93	0.85	1
Co@Co_3O_4@C-CM	0.93	0.81	2
NC-900	0.83	0.68	3
GNPCSs-800	0.957	0.82	4
CNPs	1.03	0.85	5
Fe_3C/C-800	1.05	0.83	6
Fe-N-CNFs	-0.02 (vs. Ag/AgCl)	-0.140 (vs. Ag/AgCl)	7
N-graphene/CNT	0.117	-	8
PMF-800	-	0.861	9
FePhen@MOF-$ArNH_3$	1.03	0.86	10
Fe−N−GC-900	1.01	0.86	11
Fe-NCB-900	−	0.8	12
Fe_3C/NG-800	1.03	0.86	13
NCNT/CoO-NiO-NiCo	1.0	0.83	14
Fe−N/C−800	0.92	0.81	15
Fe−N_4/C	-	0.87	16
Co_3O_4–N–rmGO	-	0.83	17
N–Fe–CNT/CNP	-	0.87	18

Table S3. Comparison of OER catalytic performances in alkaline solution between the Fe_3C@NCNT/NPC and other non-precious metal-based catalysts reported previously.

Catalyst	Overpotential (V)	KOH (M)	Tafel slope (mV dec^{-1})	Ref.
Fe_3C@NCNT/NPC	0.34	1	62	This work
Fe/C/N	0.36	0.1	-	19
Fe@N–C-700	0.48	0.1	-	20
Co_3O_4/rm-GO	0.31	1	67	17
α-MnO2-SF	0.49	0.1	77.5	21
$Ca_2Mn_2O_5$/C	0.47	0.1	149	22
CoO/NG	0.34	1	71	23
Fe-Ni oxides	0.38	1	51	24
NiFe-B	0.35	1	67	25
$LiNi_{1-x}Fe_xPO_4$@C	0.31	1	78	26
$Co(OH)_2$	0.35	1	-	27
$Co_{0.5}Fe_{0.5}S$@N-MC	0.34	1	159	28
Co-P film	0.34	1	47	29
CoCo LDH	0.39	1	59	25
N-CG-Co	0.34	1	71	23
$Ni_xCo_{3-x}O_4$ nanowire	0.37	1	64	30
ZnCo LDH	0.51	0.1	83	31
graphitic C_3N_4 nanosheets/carbon nanotubes	0.37	0.1	83	32
P-doped graphitic C_3N_4	0.4	0.1	62	33

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