Electronic Supplementary Information

Unusual Formation of Tetragonal Microstructure from Nitrogen-Doped Carbon Nanocapsules with Cobalt Nanocores as a Bi-Functional Oxygen Electrocatalyst

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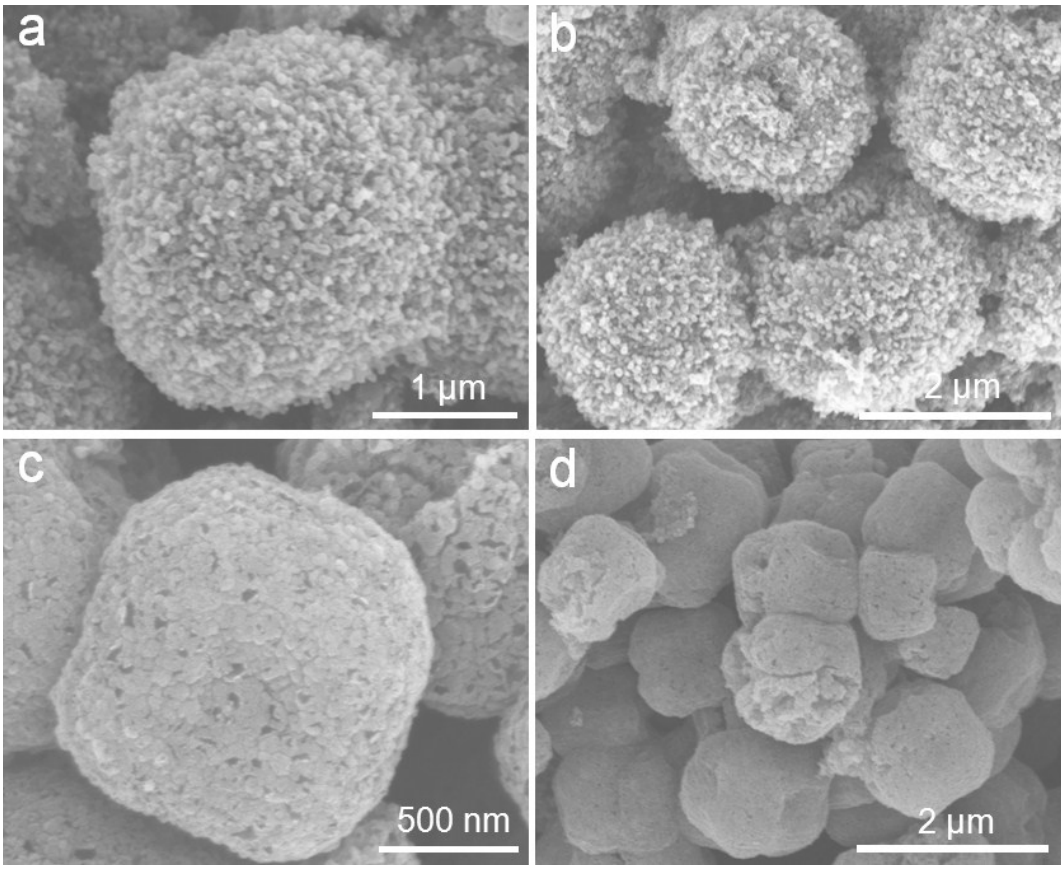
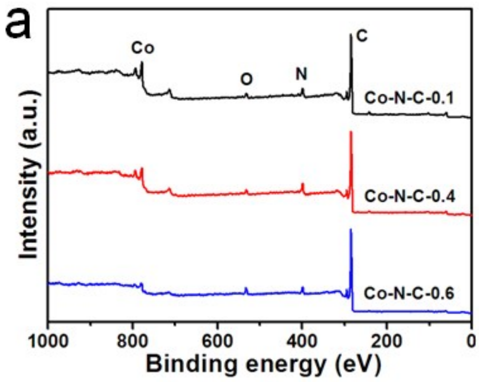


Fig. S1 SEM images of the as-prepared samples: (a) and (b) Co-N-C-0.1. (c) and (d) Co-N-C-0.6.



b

	C	N	O	Co
Co-N-C-0.1	86.11	7.87	2.82	3.2
Co-N-C-0.4	86.08	8.51	2.89	2.52
Co-N-C-0.6	88.61	7.04	3.09	1.26

Fig. S2 XPS analysis results of the as-prepared samples: (**a**) XPS spectra. (**b**) Elemental composition (atomic percentage) obtained from XPS analysis.

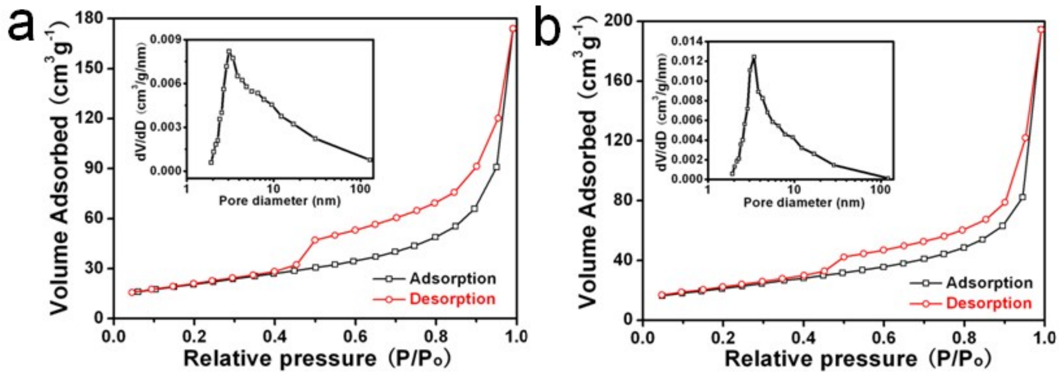


Fig. S3 N_2 adsorption-desorption isotherms of the as-prepared samples: (a) Co-N-C-0.1, (b) Co-N-C-0.6.

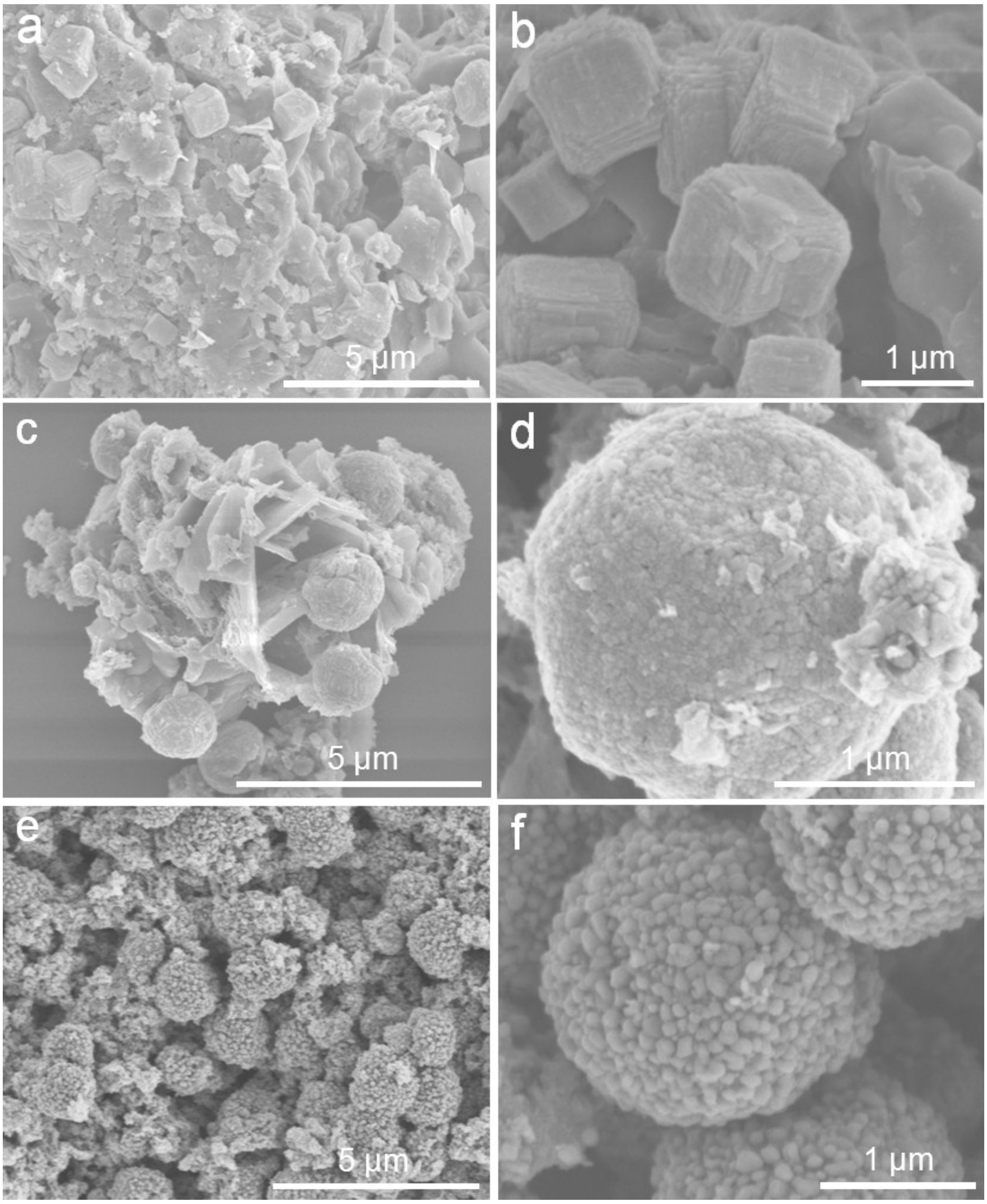


Fig. S4 SEM images of the as-prepared sample Co-N-C-0.4 after annealing at different temperatures: (a) and (b) at 300 ^{0}C. (c) and (d) at 400 ^{0}C. (e) and (f) at 500 ^{0}C.

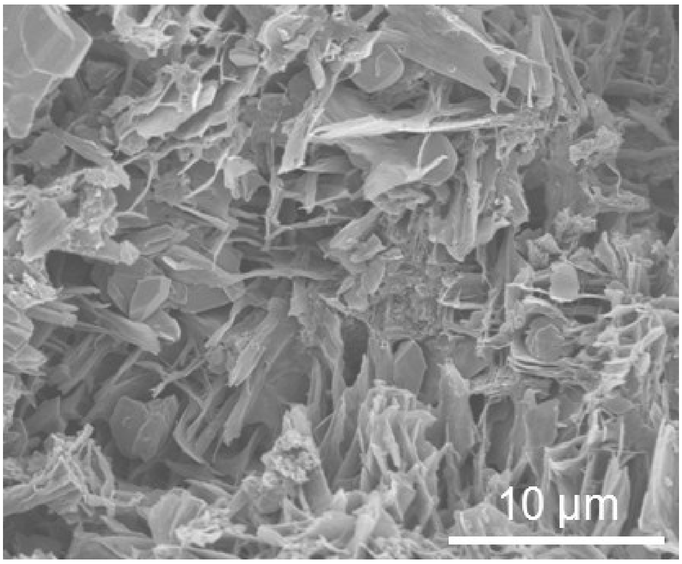


Fig. S5 SEM image of the as-prepared g-C_3N_4.

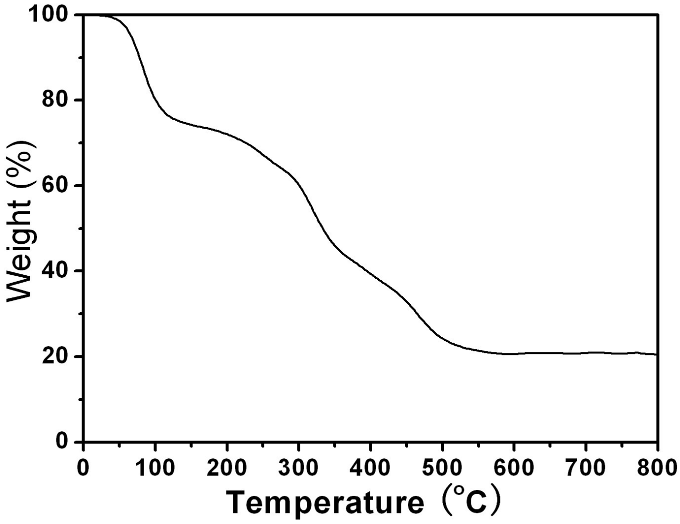


Fig. S6 TGA curve of the mixture of 0.1 g g-C_3N_4 and0.4 g $Co(CH_3COO)_2$•$4H_2O$.

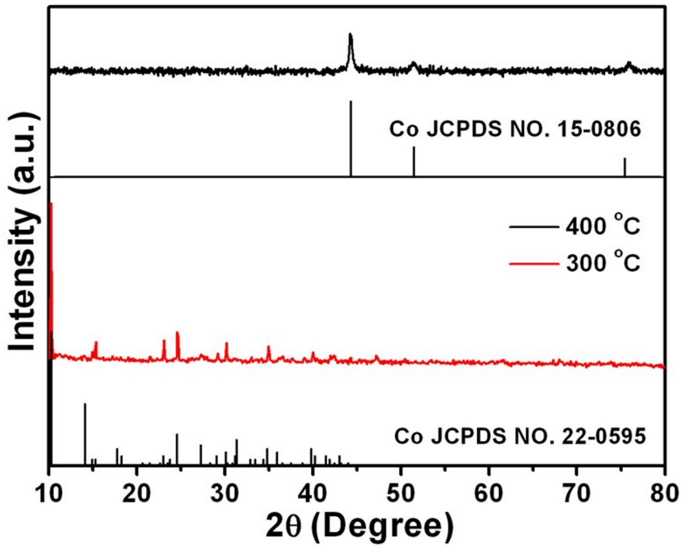


Fig. S7 XRD patterns of the Co-N-C-0.4 obtained at different temperature.

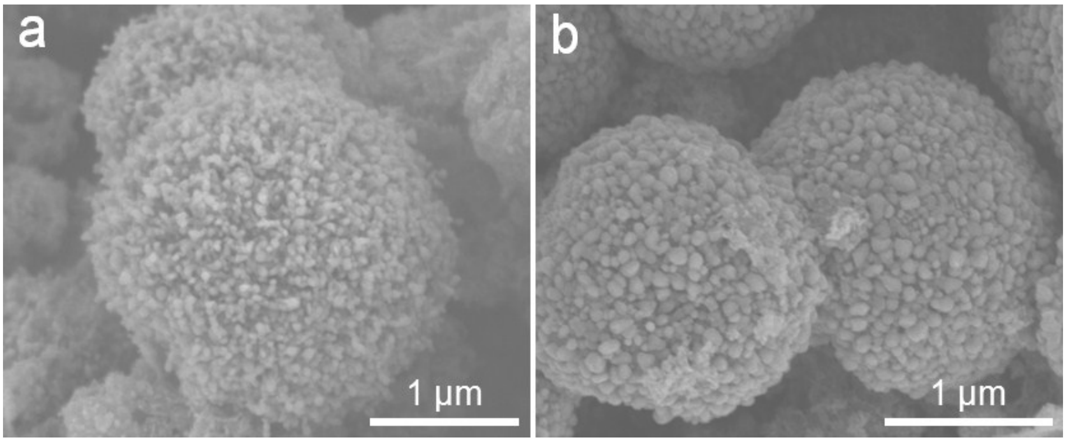


Fig. S8 SEM images of the as-prepared samples: (a) Co-N-C-0.1. (b) Co-N-C-0.4 without acid leaching treatment.

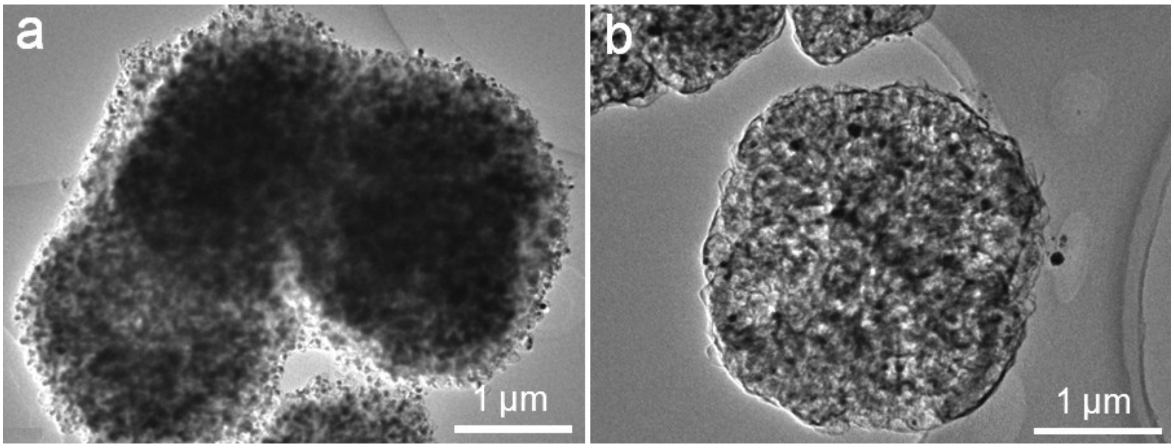


Fig. S9 TEM images of the as-prepared samples: (a) Co-N-C-0.1. (b) Co-N-C-0.6.

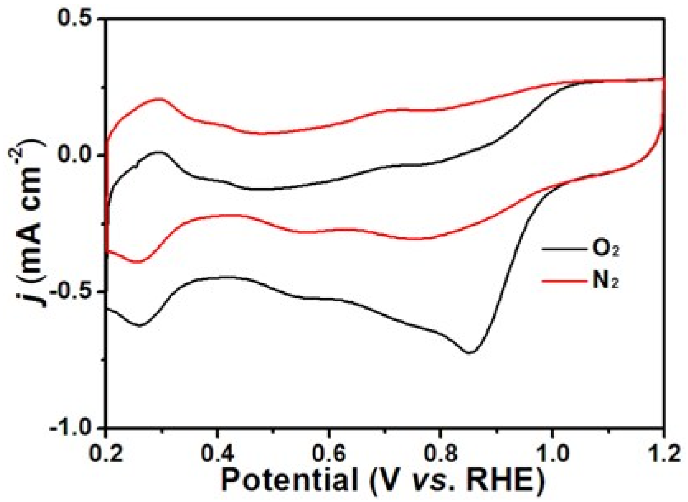


Fig. S10 CV profiles of the Pt/C in O_2(balck curve) and N_2 (red curve) saturated 0.1 M KOH solution at 1600 rpm with a scan rate of 20 mV s^{-1}.

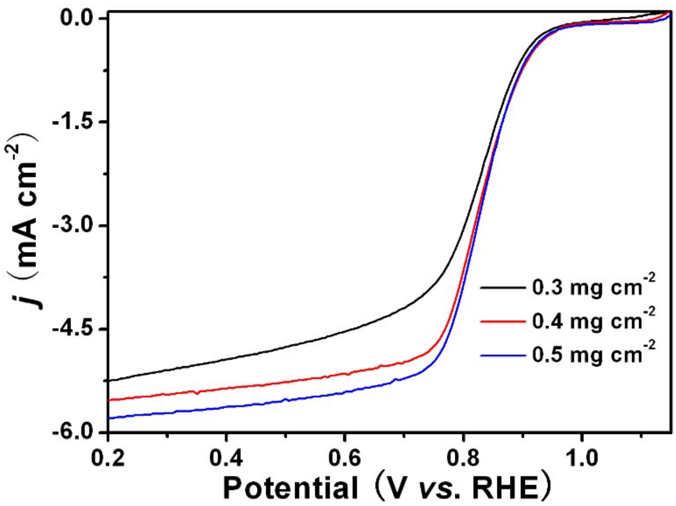


Fig. S11 LSV results of the as-prepared Co-N-C-0.4 catalyst with different loading amount. (in O_2 saturated 0.1 M KOH solution at a rotation rate of 1600 rpm)

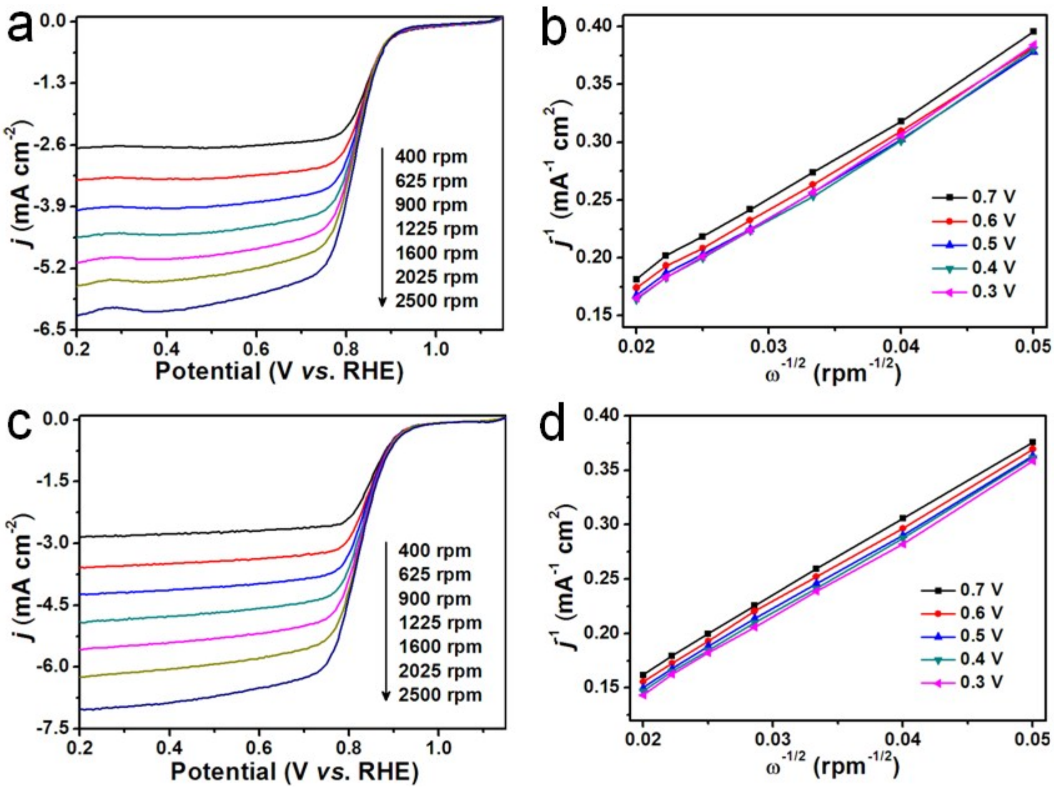


Fig. S12 (a) and (c) LSV results of Co-N-C-0.1 (a) and Co-N-C-0.6 (c) at different rotation rates. (b) and (d) the corresponding K-L plots.

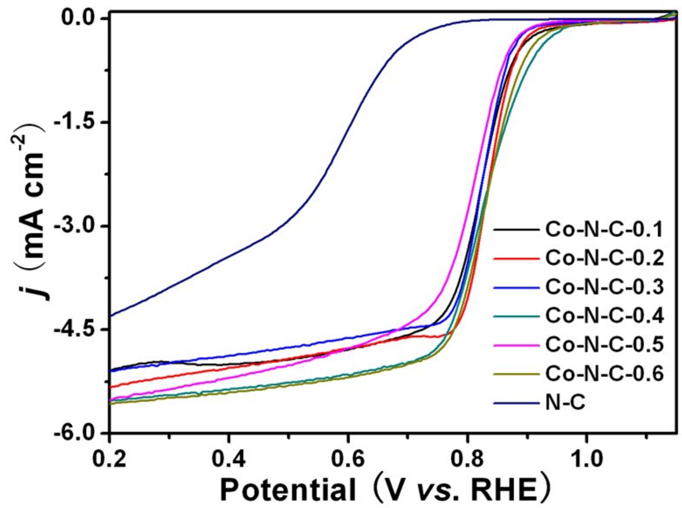


Fig. S13 LSV results of the as-prepared samples. (in O_2 saturated 0.1 M KOH solution at a rotation rate of 1600 rpm)

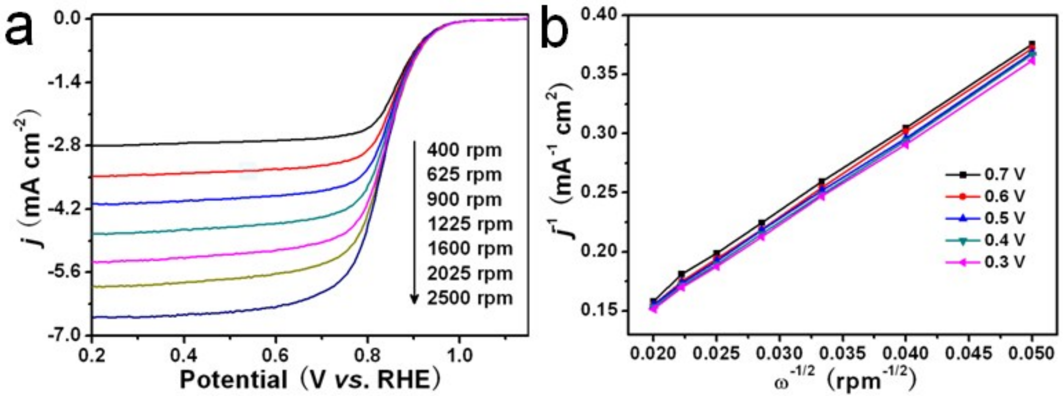


Fig. S14 (a) LSV results of the commercial Pt/C at different rotation rates. (b) corresponding K-L plots.

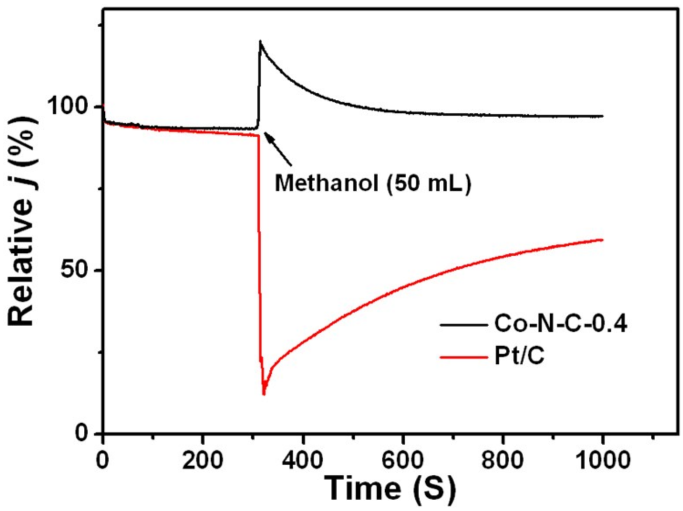


Fig. S15 Chronoamperometric response at 0.6 V in O_2 saturated 0.1 M KOH solution with the adding of 50 ml methanol.

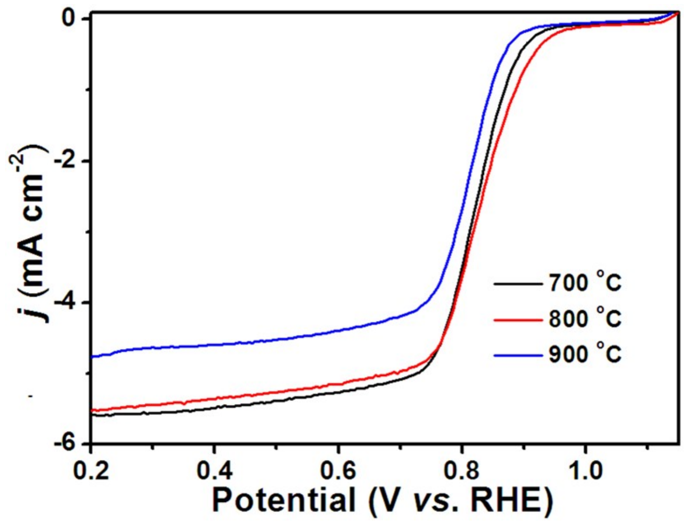


Fig. S16 LSV curves of the as-prepared Co-N-C-0.4 obtained at different temperatures. (in O_2 saturated 0.1 M KOH solution at a rotation rate of 1600 rpm).

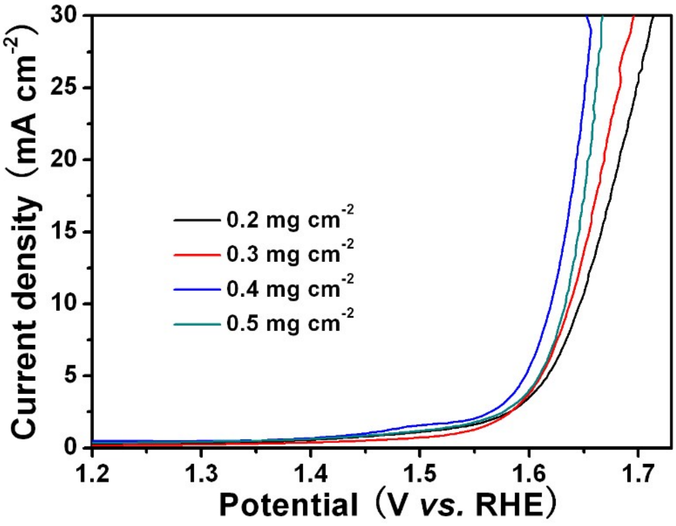


Fig. S17 LSV results of the as-prepared Co-N-C-0.4 catalyst with different loading amount. (in O_2 saturated 0.1 M KOH solution at a rotation rate of 1600 rpm)

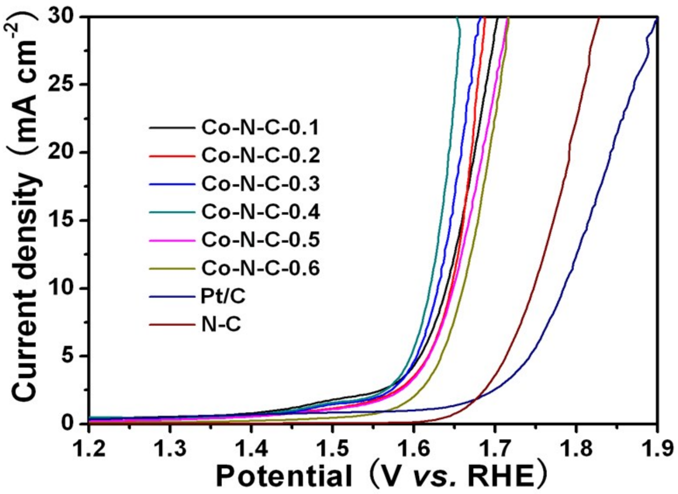


Fig. S18 LSV results of the as-prepared catalyst. (in O_2 saturated 0.1 M KOH solution at a rotation rate of 1600 rpm)

Table S1 Comparison of various carbon based materials for ORR.

Catalysts	Loading (mg cm^{-2})	Onset potential (V)	Half-wave potential (V)	n	References
N/Co-doped PCP//NRGO	0.714	0.97	0.86	3.9	*Adv. Funct. Mater.* **2015**, 25, 872
N/Co-doped PCP-RGO	0.714	0.94	N/A	3.3	*Adv. Funct. Mater.* **2015**, 25, 872
Fe_3C/C	0.6	1.05	0.83	3.9	Angew. Chem. Int. Ed. **2014**, 53, 3675
FeN_x/C catalyst	0.6	0.94	0.82	N/A	*J. Am. Chem.Soc.* **2014**, 136, 10882
Co_3O_4/N-rmGO	0.17	0.88	0.83	3.9	*Nat. Mater.* **2011**,10, 780
Co@NG	1.08	0.9	0.83	3.9	*Adv. Funct. Mater.* **2016**, 26, 4397
Co/N-CNTs	0.2	0.94	0.84	3.9	*J. Mater. Chem. A*, **2016**, 4, 1694
Fe/N-CNTs	0.2	0.96	0.82	3.8	*J. Mater. Chem. A*, **2016**, 4, 1694
Co-N-C	0.283	0.98	0.87	4.0	*ACS Catal.* **2015**, 5, 7068
Fe-N-CC	0.1	0.94	0.83	3.7	*ACS Nano*, **2016**, *10*, 5922
LDH@ZIF-67-800	0.2	0.94	0.83	4.0	*Adv. Mater.* **2016**, *28*, 2337
Co@Co_3O_4@C-CM	0.1	0.93	0.81	3.8	*Energy Environ. Sci.* **2015**, *8*, 568
N-Carbon nanotube frameworks	0.2	0.97	0.87	3.97	*Nat. Energy*. **2016**, 1, 15006.
N,P-codoped ordered mesoporous carbon	0.3	0.95	0.82	3.7	*Angew. Chem.Int. Ed.* **2015**,54,9230
Co_xZn_{100-x}-NPCs	0.1	0.9	N/A	3.9	*ACS Appl. Mater. Interfaces*. **2015**, 7, 4048
Co-N-C	0.25	0.98	0.84	3.9	This work

Table S2 Comparison of various carbon based materials for OER.

Catalysts	**Loading ($mg\ cm^{-2}$)**	**Onset Potential (V)**	**Tafel ($mV\ decade^{-1}$)**	**Potential (V) @ 10 $mA\ cm^{-2}$**	**References**
N/Co-doped MOF derived carbon/NRGO	0.36	N/A	292	1.66	*Adv. Funct. Mater.* **2015**, 25, 872
ZIF-derived carbon	0.36	N/A	393	1.75	*Adv. Funct. Mater.* **2015**, 25, 872
Ni-Co mixed oxide porous cubes	N/A	N/A	59	1.66	*Adv. Mater.* **2016,** 28, 4601
$Mn_3O_4/CoSe_2$	0.2	N/A	49	1.68	*J. Am. Chem. Soc..* **2012**, 134, 2930
N-CNT/graphene	0.24	1.52	82	1.63	*Small* ***2014,*** 10, 2251
N, O-dual dopedCNTs	1.75	1.55	141	1.8 @ 14.8 $mA\ cm^{-2}$	*Adv. Mater.* **2014**, 26, 2925
N-Carbon nanotube frameworks	0.2	1.47	93	1.60	*Nat. Energy*. **2016**, 1, 15006.
$Co(OH)_2$	0.1	N/A	62	1.68	*ACS Appl. Mater. Interfaces 2015, 7, 12930*
Co-N-C	0.4	1.55	110	1.62	This work