Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Mesoporous-Silica Induced Doped Carbon Nanotubes Growth From Metal-Organic Frameworks

Huang Zhou[a], Daping He[ab]*, Ibrahim Saana Amiinu[a], Jinlong Yang[a], Zhe Wang[a], Jian Zhang[a], Qirui Liang[a], Shuai Yuan[a], Jiawei Zhu[a], Shichun Mu[a]*

[a]State Key Laboratory of Advanced Technology for Materials Synthesis and Processing, Wuhan University of Technology, Wuhan 430070, China
E-mail: msc@whut.edu.cn, hedaping@whut.edu.cn
[b]Hubei Engineering Research Center of RF-Microwave Technology and Application, School of Science, Wuhan University of Technology, Wuhan 430070, China

*Address correspondence to: msc@whut.edu.cn,hedaping@whut.edu.cn

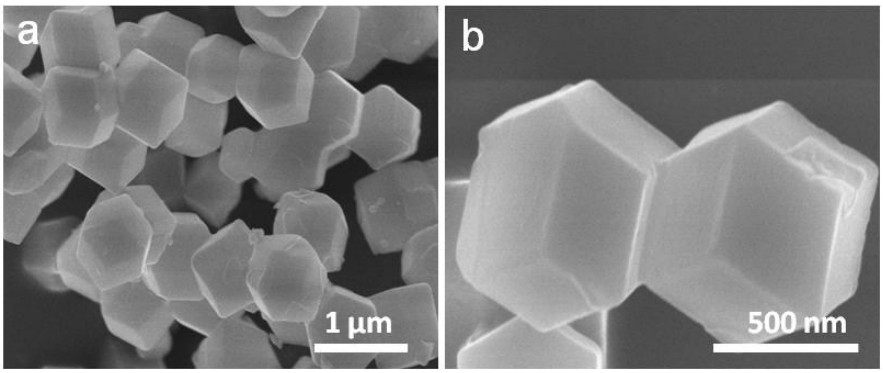

Figure S1 FESEM images of as-prepared

ZIF-67 precursors.

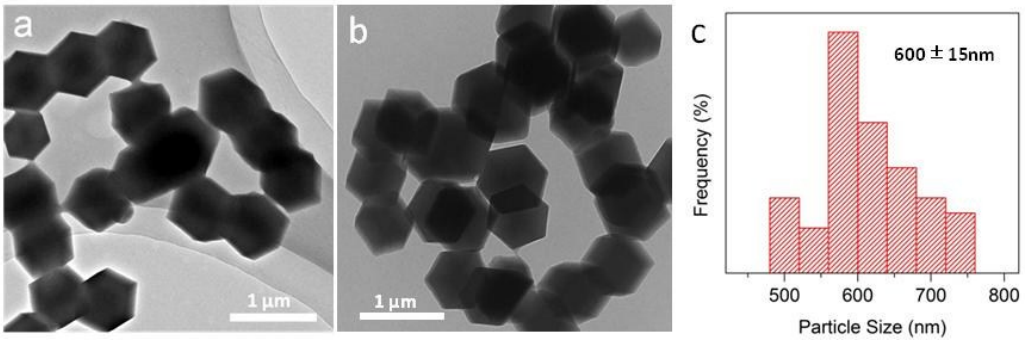

Figure S2 TEM images (a, b) and particle-size distribution (c) of ZIF-67 precursors.

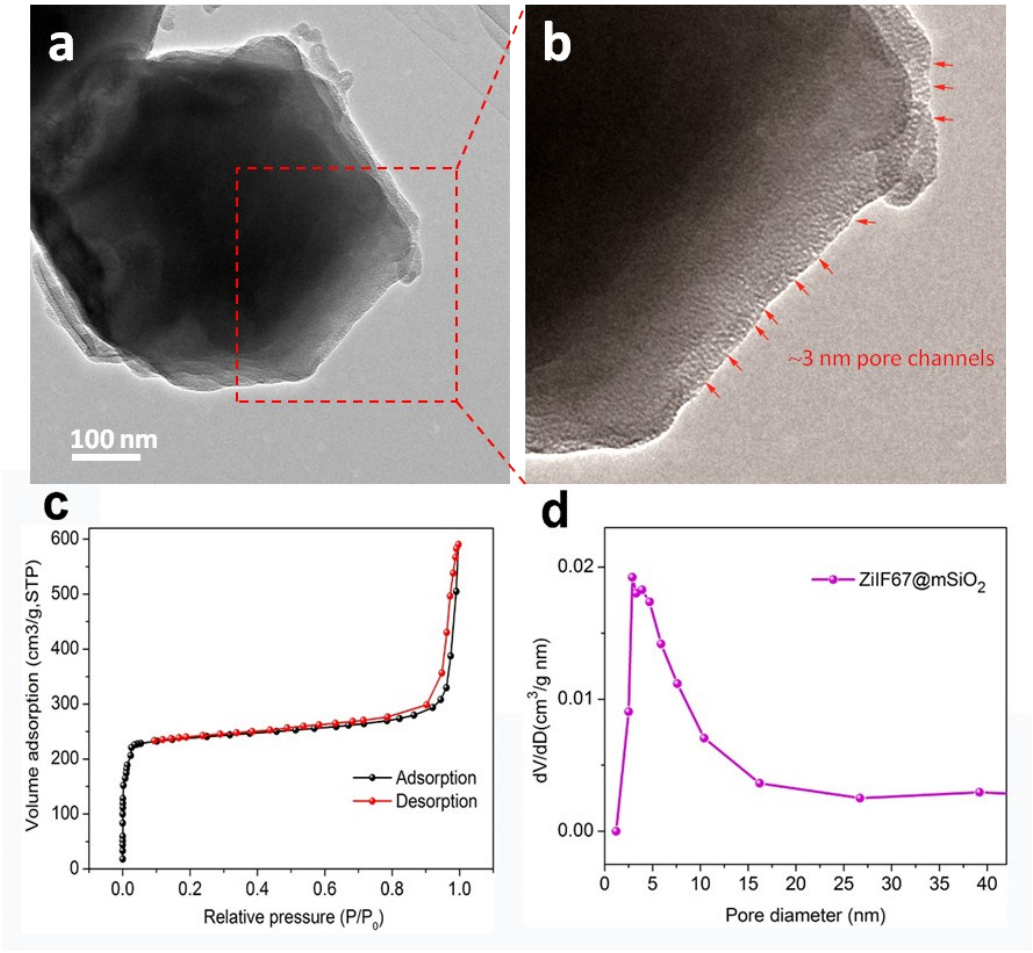

Figure S3 (a) TEM images,(b)HR-TEM image (c) N_2 adsorption–desorption isotherms, and (d) pore-size distribution curves of as-prepared ZIF-67@$mSiO_2$.

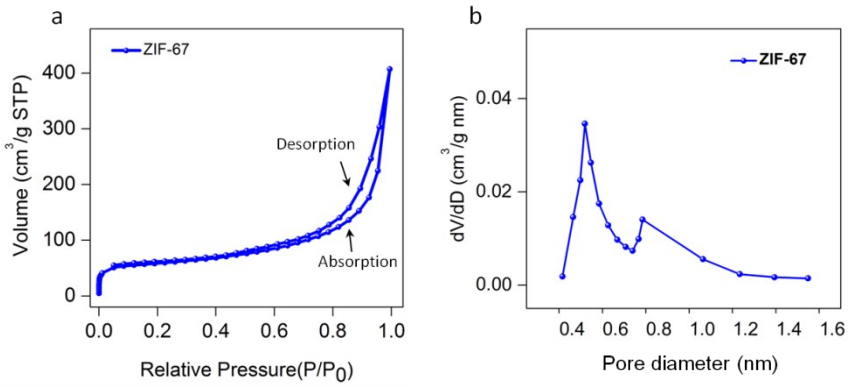

Figure S4 (a) N_2 adsorption–desorption isotherms, and (b) pore-size distribution curves of ZIF-67.

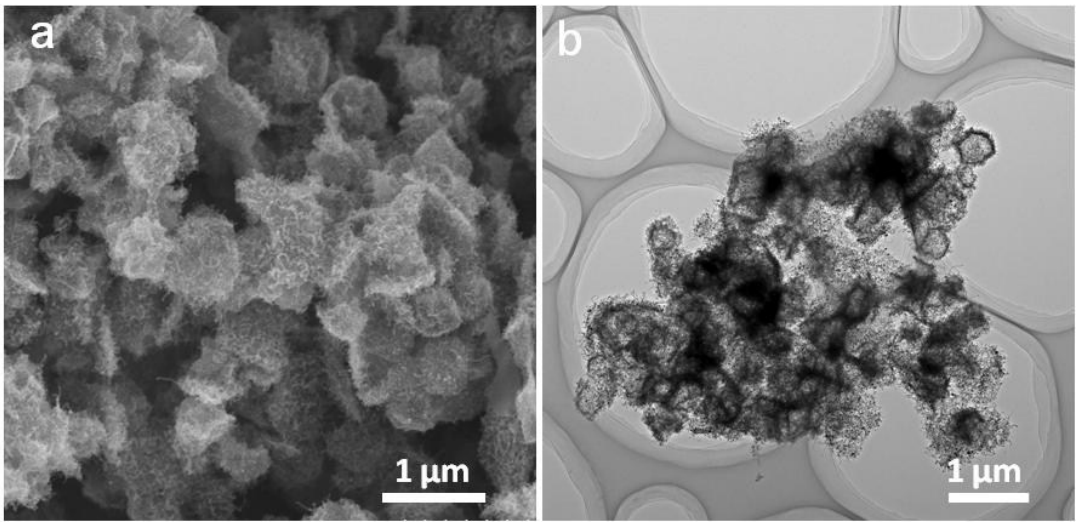

Figure S5 FESEM (a) and TEM (b) image of as-prepared

of Co/N-CNTs.

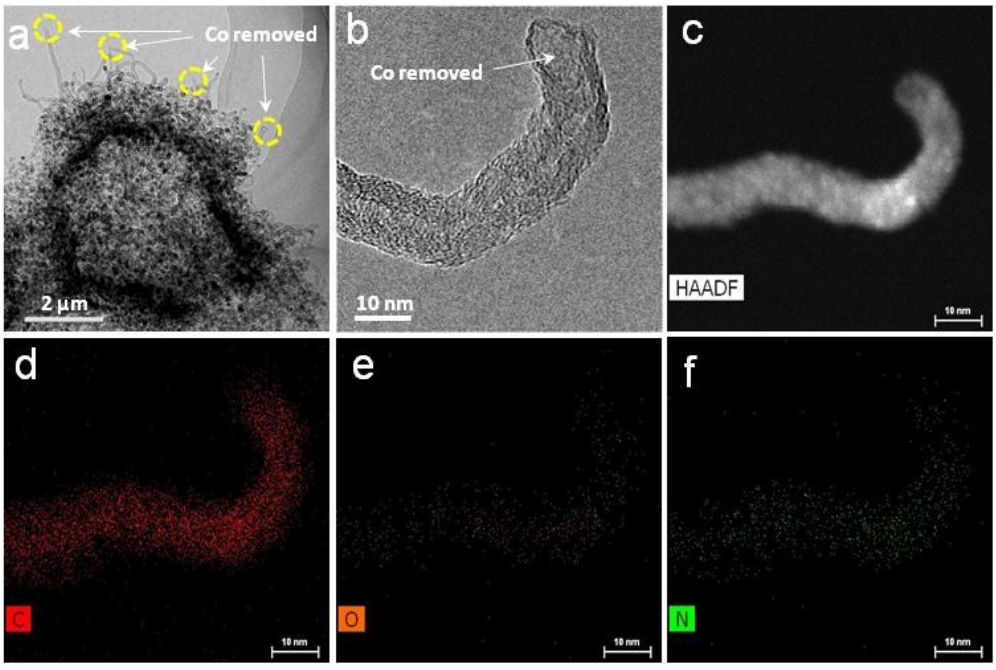

Figure S6 TEM image of (a) Co/N-CNTs (with Co nanoparticles partially removed by HF), HRTEM (b) and HAADF (c) image of a single CNT with Co removed and (d-f) the corresponding EDS mapping images.

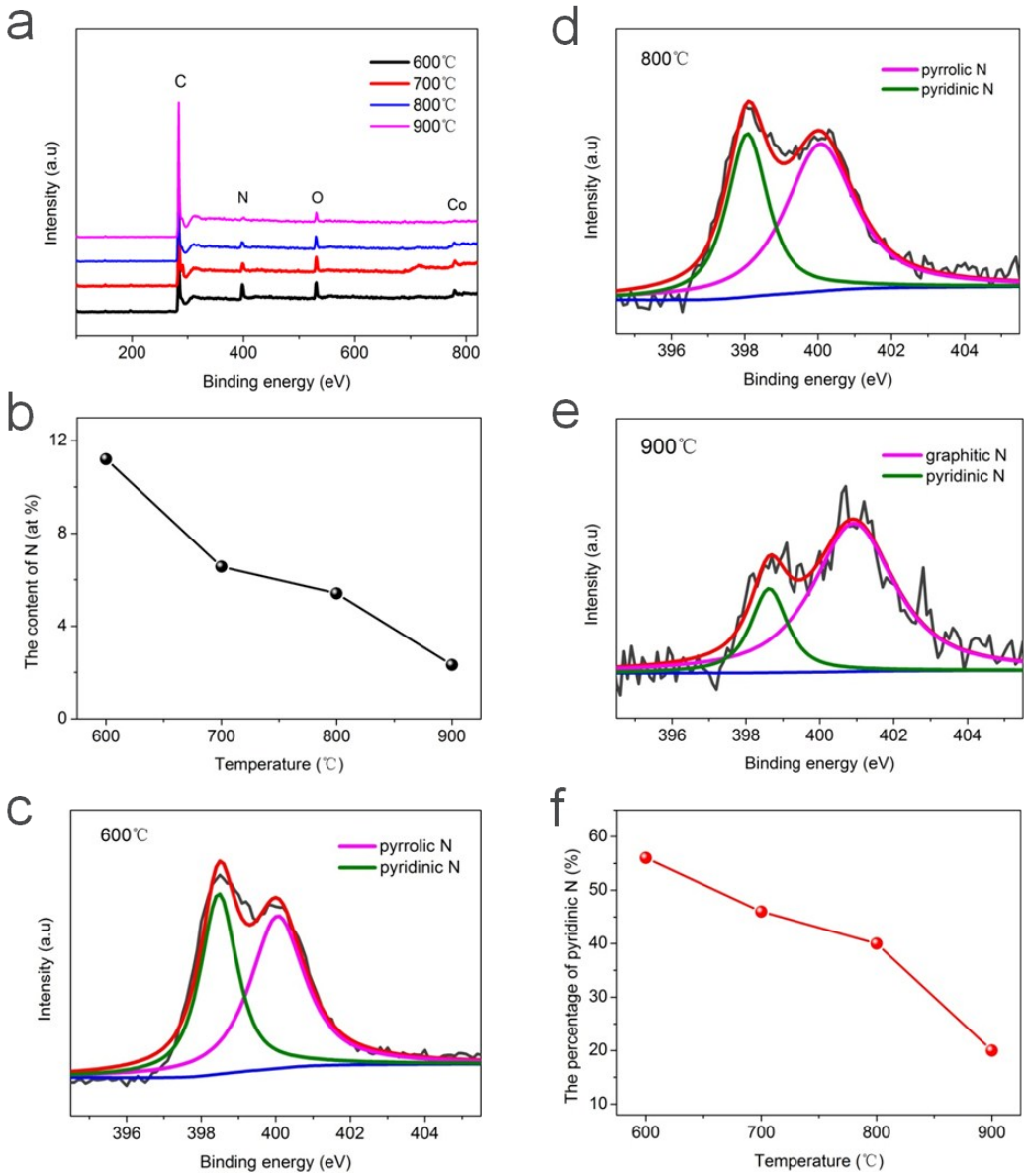

Figure S7 (a) X-Ray photoelectron spectroscopy (XPS) spectra of Co/N-CNTs obtained at different temperatures;(b) The total N content obtained from XPS;N1s XPS spectra of Co/N-CNTs obtained at different temperatures: (c) 600℃; (d) 800℃ and (e) 900℃; (f) The percentage of pyridinic N of Co/N-CNTs obtained at different temperatures.

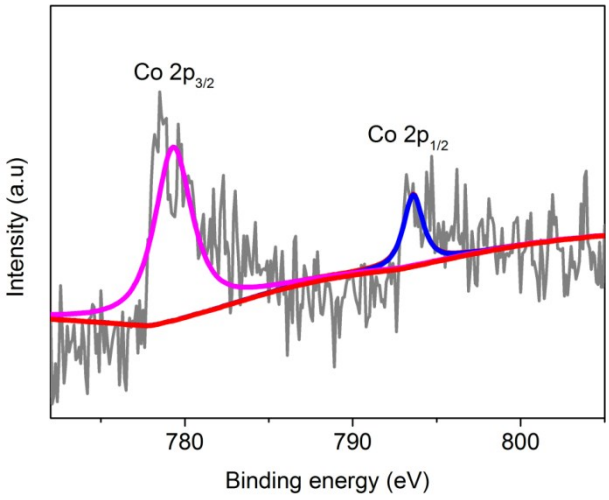

Figure S8 Co 2p XPS spectrum of Co/N-CNTs obtained at 700℃.

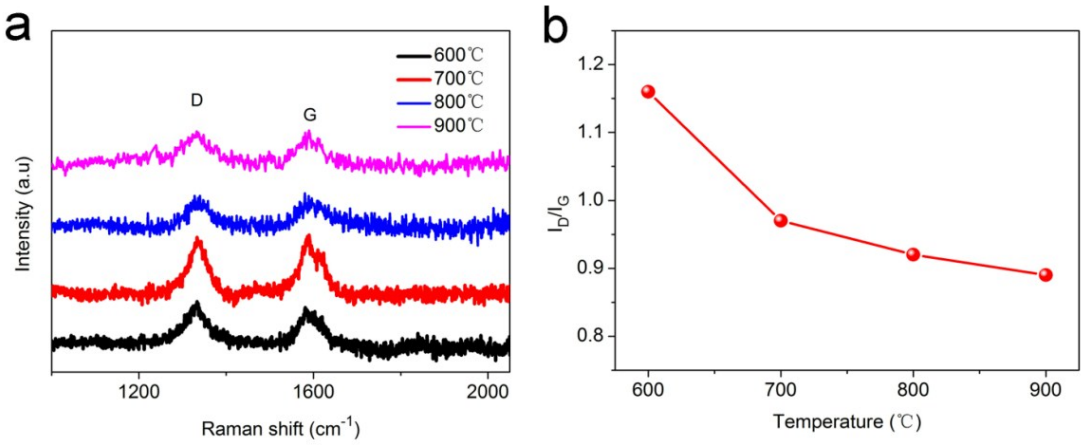

Figure S9 (a) Raman spectra of Co/N-CNTs synthesized at different pyrolysis temperatures (600-900℃) and (b) the corresponding I_D/I_G value.

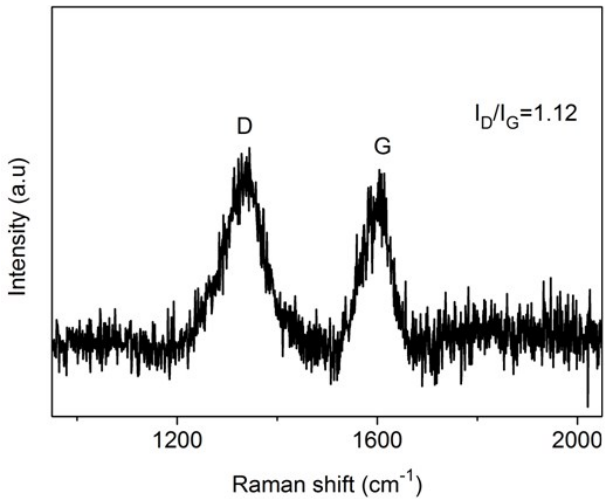

Figure S10 Raman spectra of Co NP/N-C synthesized at 700℃.

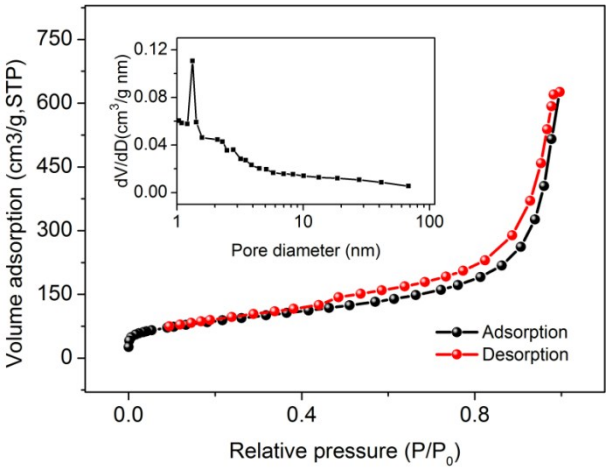

Figure S11 N_2 adsorption–desorption isotherms. The inset image shows the pore-size distribution calculated using the Barrett–Joyer–Halenda (BJH) method.

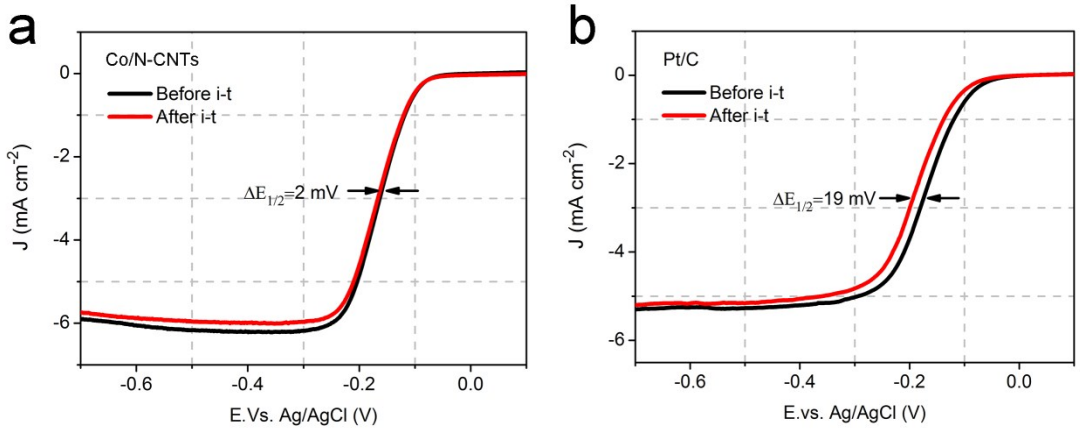

Figure S12 Stability of (a) Co/N-CNTs and (b) Pt/C symbolized by $\Delta E_{1/2}$ before and after the i–t test.

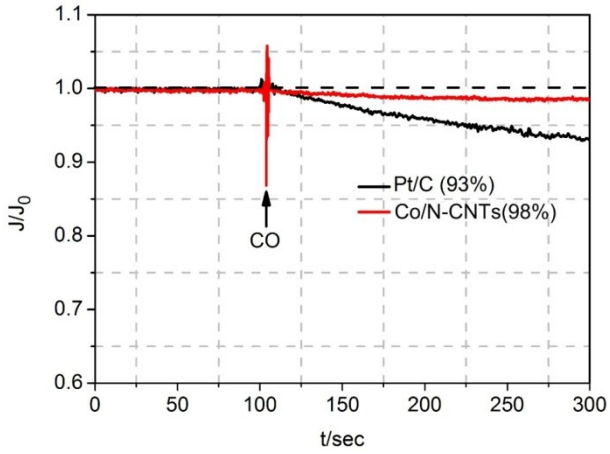

Figure S13 The i-t chronoamperometric responses for Co/N-CNTs and Pt/C in CO and O_2-saturated solution (V_{CO}/V_{O2}=10%) during a constant potential at -0.35 V at a rotation rate of 1,600 rpm in 0.1 M KOH

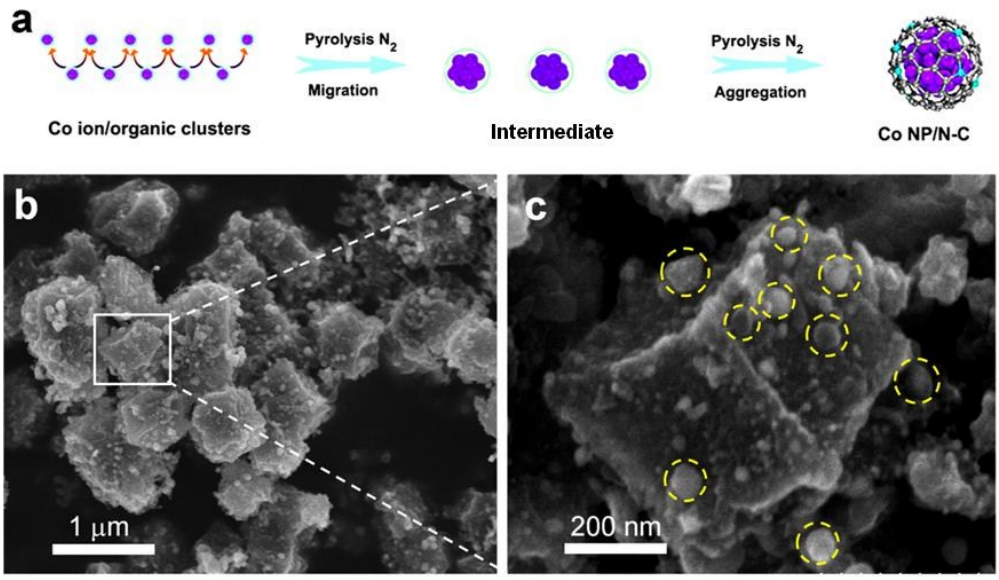

Figure S14 Formation mechanic (a), Low-magnification (b) and (c) high-magnification FESEM images of Co NP/N-C synthesized at 700℃without $mSiO_2$ protection.

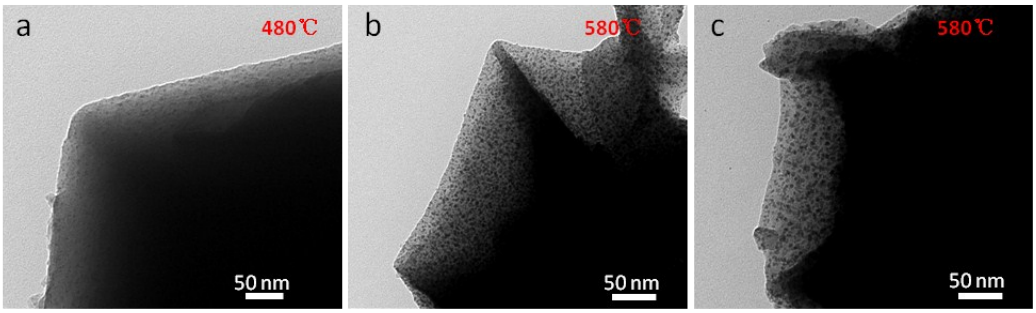

Figure S15 TEM images (a,b) of ZIF-67@$mSiO_2$ after pyrolysis at different temperatures in argon for 0.5 h ($mSiO_2$ shell was removed by 1 M NaOH before characterization).And TEM image of ZIF-67 without $mSiO_2$ protection after pyrolysis at 580℃in argon for 0.5h.

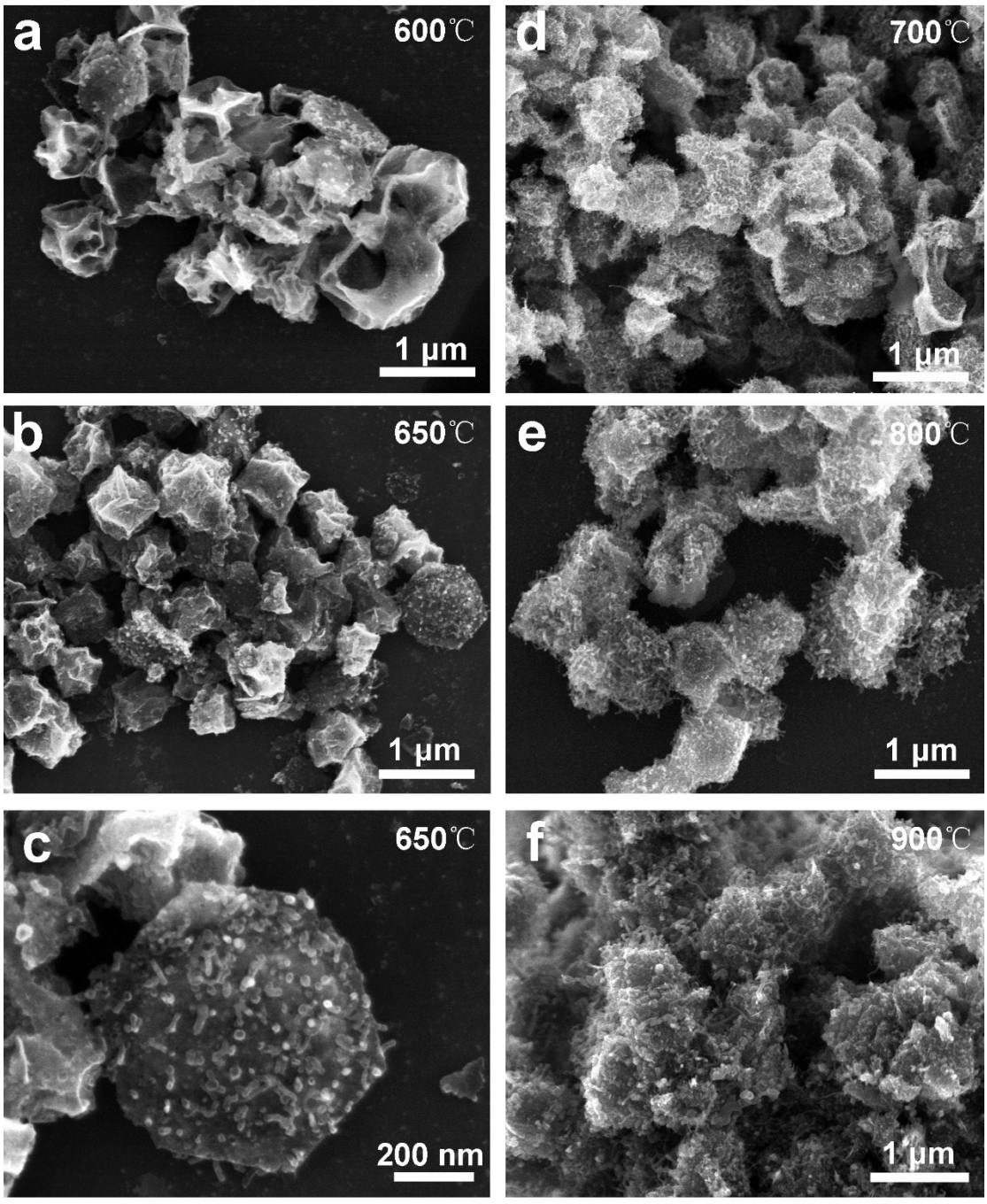

Figure S16 FESEM images of Co/N-CNTs synthesized at different pyrolysis temperatures (600-900℃).

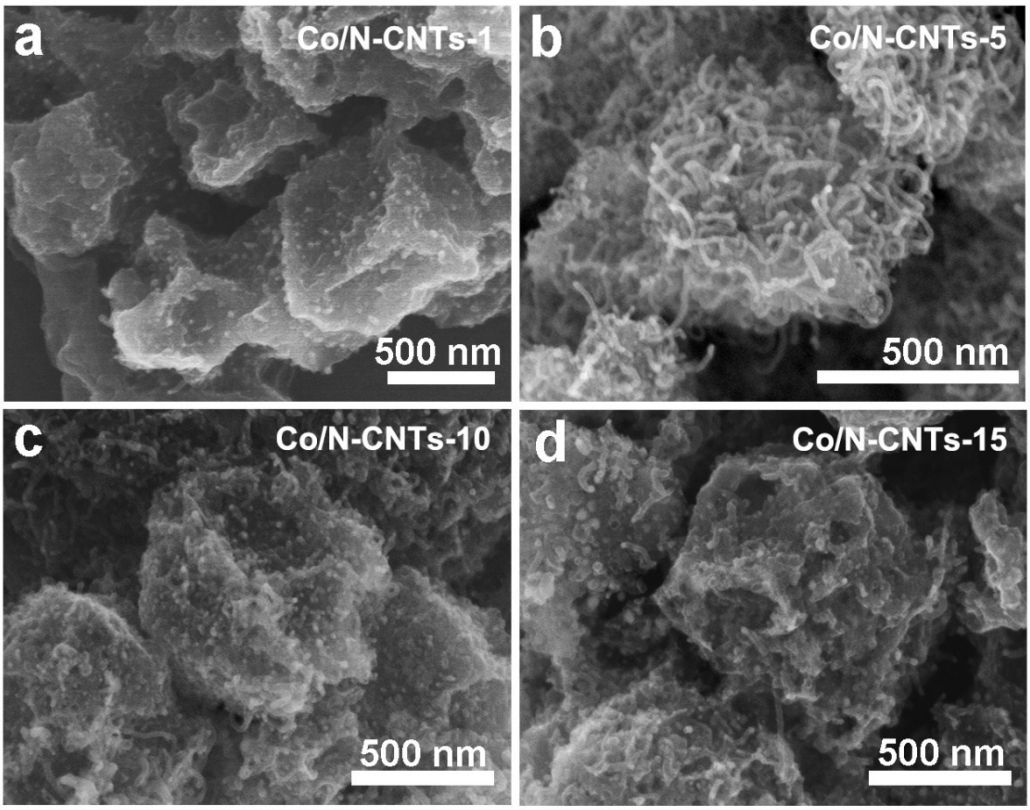

Figure S17 FESEM images of Co/N-CNTs-x (x indicates relative mass of $mSiO_2$) obtained by pyrolyzed different mass of $mSiO_2$ coated ZIF-67 at 700℃after HF etching.

Table S1 Comparison of ORR performance of all catalysts in this work with correlative literature values.

Catalyst	Eonset (V vs Ag/AgCl)	$E_{1/2}$ (V vs Ag/AgCl)	J (mA cm^{-2})	Ref.
Co/N-CNTs	-0.005	-0.154	~5.82	This work
Co,N-CNF	−0.082	−0.155	~5.71	*Adv. Mater.* **2015**, 28(8):1712-1712.
P-Z8-Te-1000	*-0.161*	*-0.161*	~5.70	*J. Am. Chem. Soc* **2014**, 136, 14385-14388.
Co@N-PGCS	-0.075	-0.151	~5.60	*Nanoscale* **2016**, 8, 13311-13320.
N-CNT aerogels	−0.055	−0.263	~4.80	*small* 2015, *11, 3903–3908*
EDA-NCNT	/	-0.150	~4.91	*J. Phys. Chem. C* **2009**, 113, 21008–21013
Py-NCNT	/	-0.330	~1.57	*J. Phys. Chem. C* **2009**, 113, 21008–21013
Co3O4/rmGO	/	0.83 (V vs RHE)	/	*Nat. Mater.* **2011,** *10,* 780-786.
NCNTFs	/	0.87 (V vs RHE)	~5.40	*Nat. Energy* **2016**, *1*, 15006
N-CNTs-550	/	0.86 (V vs RHE)	~5.20	*J. Am. Chem. Soc.* **2017**, *139*, 8212-8221.
N-CNTs-435	/	0.81 (V vs RHE)	~5.20	*J. Am. Chem. Soc.* **2017**, *139*, 8212-8221.