Electronic Supplementary Information

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Sustainable synthesis nitrogen-doped porous carbon with improved electrocatalytic performance for hydrogen evolution

Xinxin Sang [a], Jianping Chen [a], Mingxiao Jing [a], Gang Shi [a], Caihua Ni [a], Dawei Wang [a], Wei Jin [a, b, *]

[a] The Key Laboratory of Synthetic and Biological Colloids, Ministry of Education, School of Chemical and Material Engineering, Jiangnan University, Wuxi, Jiangsu 214122, China

[b] Institute of Process Engineering, Chinese Academy of Sciences, 1th Bei-er-tiao Zhongguancun, Beijing 100190, People's Republic of China

* Corresponding authors E-mail: wjin@ipe.ac.cn

S1. Instrumentation.

The instruments used in this study were as follows: Fourier transform infrared (FT-IR) spectra were recorded on an Agilent Cary 660 FT-IR spectrometer in the 4000-400 cm^{-1} region. Scanning electron microscopy (SEM) images were recorded on a SUPERSCAN SSX-550 electron microscope (Shimadz, Japan) operating at 20 kV. Quadrasorb SI-MP system was used to measure the nitrogen sorption-isotherms at liquid nitrogen (77 K) temperature. The specific surface areas were evaluated using the Brunauer-Emmett-Teller (BET) method and the pore distribution was calculated by the BJH method from adsorption branches of isotherms. The elemental contents of C, H, and N in UiO-66 were determined using Flash EA1112 from Thermo. X-ray photoelectron spectroscopy (XPS) data were obtained with an ESCALab220i-XL electron spectrometer from VG Scientific using 300 W AlKa radiation. The base pressure was about 3×10^{-9} mbar. The binding energies were referenced to the C 1s line at 284.8 eV from adventitious carbon.

S2. Characterization Section

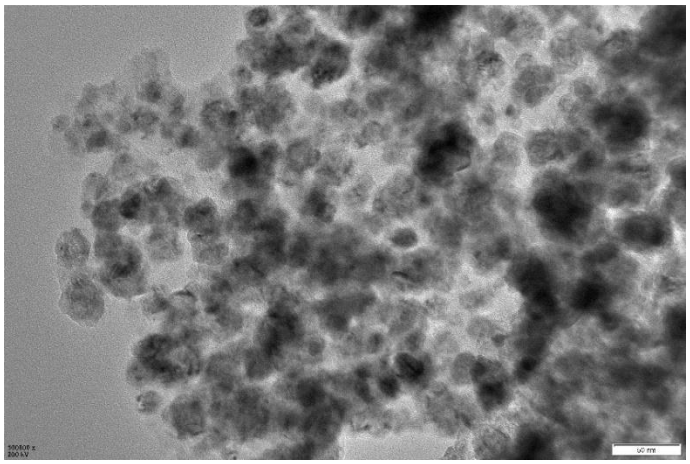

Fig. S1 TEM image of Co-NC-ZR-600.

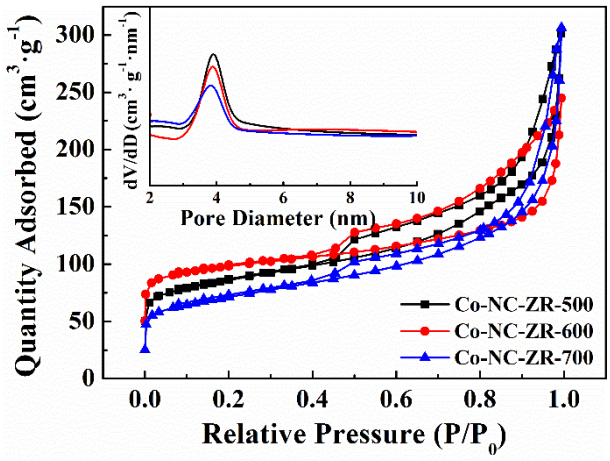

Fig. S2 (a) Nitrogen adsorption and desorption isotherms for Co-CN nanocomposites at different temperature, and the insert is the pore size distribution.

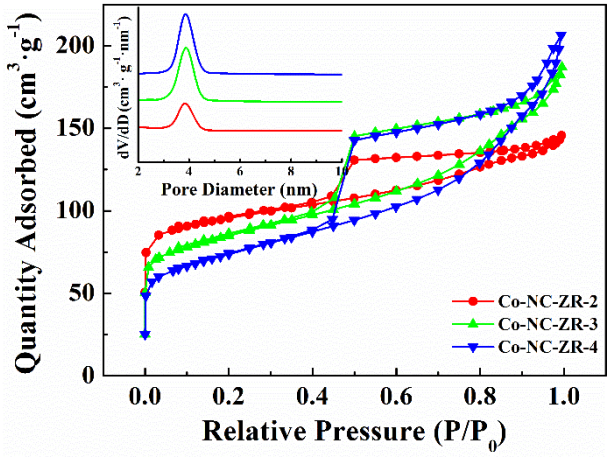

Fig. S3 Nitrogen adsorption and desorption isotherms for Co-CN nanocomposites with different RF content, and the insert is the pore size distribution.

Table S1 elemental contents, BET surface area, pore volume and pore width of the Co-NCs.

Sample	C(%)[a]	N(%)[a]	Co(Atomic %)[b]	S_{BET} ($m^2\ g^{-1}$)	Pore volume ($cm^3\ g^{-1}$)	Pore width/nm
Co-NC-Z	24.38	3.46	3.59	134.02	0.219	3.9
Co-NC-ZR-500	52.40	4.01	0.75	280.80	0.379	3.9
Co-NC-ZR-600	45.10	3.12	1.68	308.07	0.466	3.9
Co-NC-ZR-700	33.68	2.8	1.84	236.45	0.474	3.9
Co-NC-ZR-2	57.65	3.86	1.65	300.17	0.225	3.9
Co-NC-ZR-3	57.90	1.48	0.82	277.39	0.289	3.9
Co-NC-ZR-4	61.84	1.02	0.55	245.59	0.319	3.9

[a] obtained from elemental analysis, [b] obtained from XPS

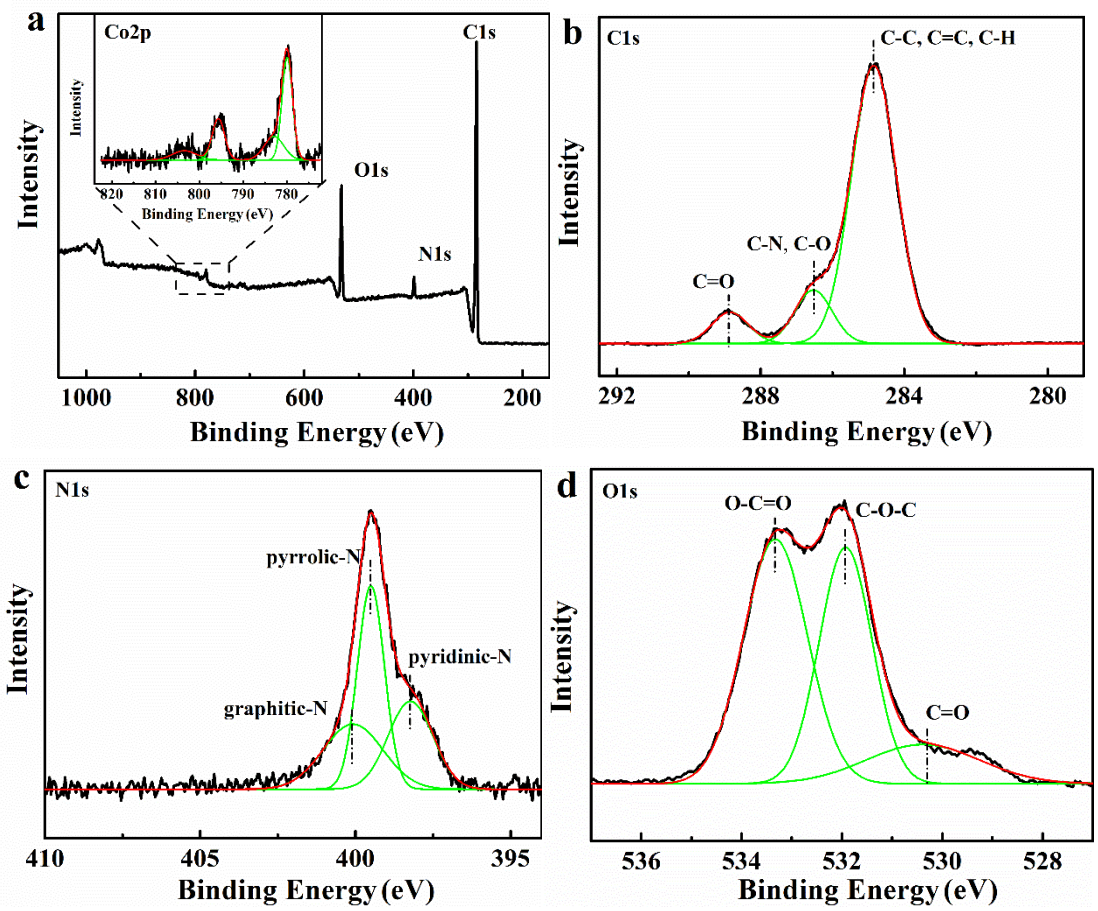

Fig. S4. XPS spectrum of Co-NC-Z (a), the insert is curve fitting of Co 2p; the curve fitting of C 1s (b), N 1s (c) and O 1s (d).

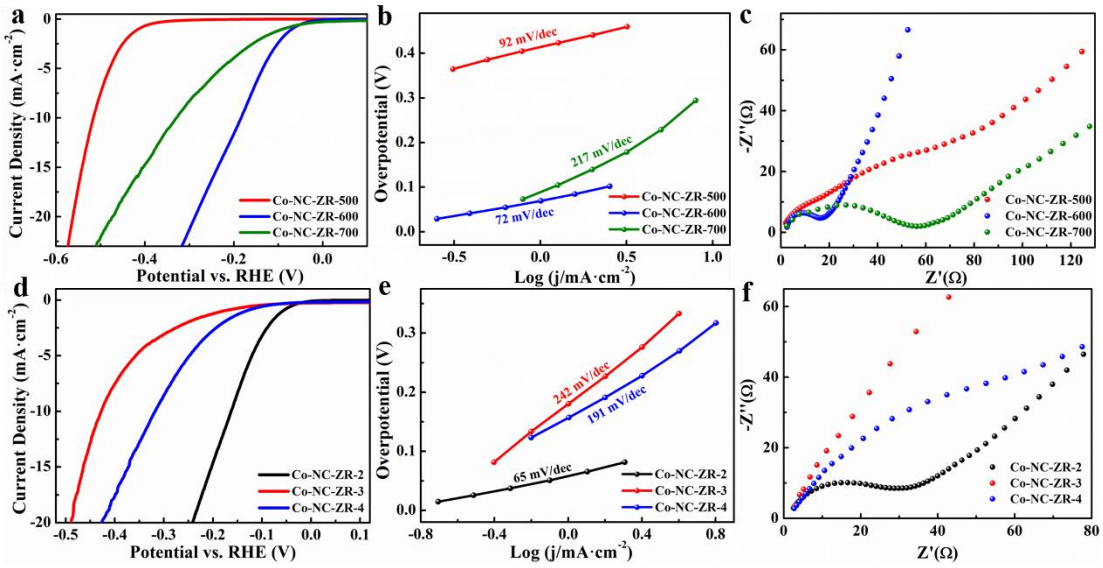

Fig. S5 (a, d) Linear sweep voltammograms, (b, e) Tafel plots and (c, f) Electrochemical impedance spectra (EIS) of Co-NC-ZR with different carbonization temperature and RF content recorded at open-circuit potential.

Table S2 Comparison of hydrogen evolution activities of different electrocatalysts

Electrocatalyst	Electrolyte	Onset potential (mV)	Tafel slope (mV per decade)	Ref.
Co-NC-ZR-600	0.5 M H_2SO_4	57	72	This work
Co-NC-ZR-2	0.5 M H_2SO_4	45	65	This work
FeCo@N-doped carbon nanotubes	0.1 M H_2SO_4	70	74	1
nitrogen-doped graphene/cobalt embedded porous carbon polyhedron	0.5 M H_2SO_4	58	126	2
Co-embedded N-rich carbon nanotubes	0.5 M H_2SO_4	89	82	3
Au@NC	0.5 M H_2SO_4	53	99	4
Co@N-C_{600}	0.5 M H_2SO_4	51	97	5
NiS	0.5 M H_2SO_4	--	96	6
TiC-C microsphere	0.1 M $HClO_4$	320	95.6	7

References

1. J. Deng, P. Ren, D. Deng, L. Yu, F. Yang, X. Bao, *Energy Environ. Sci.*, 2014, **7**, 1919-1923.

2. Y. Hou, Z. Wen, S. Cui, S. Ci, S. Mao, J. Chen, *Adv. Funct. Mater.*, 2015, **25**, 872-882.

3. X. Dai, Z. Li, Y. Ma, M. Liu, K. Du, H. Su, H. Zhuo, L. Yu, H. Sun, X. Zhang, *ACS Appl. Mater. Interfaces*, 2016, **8**, 6439-6448.

4. W. Zhou, T. Xiong, C. Shi, J. Zhou, K. Zhou, N. Zhu, L. Li, Z. Tang, S. Chen, *Angew. Chem. Int. Ed.*, 2016, **55**, 8416-8420.

5. J. Yu, G. Li, H. Liu, A. Wang, L. Yang, W. Zhou, Y. Hu, B. Chu, *Int. J. Hydrog. Energy*, 2018, 43, 12110-12118.

6. A. Wang, H. Li, J. Xiao, Y. Lu, M. Zhang, K. Hu, K. Yan, *ACS Sustainable Chem. Eng.*, 2018, **6**, 15995-16000.

7. Y. Wang, H. Deng, C. Ye, K. Hu, K. Yan, *J. Alloy. Compd.*, 2019, **775**, 348-352.