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

Supporting information

Ultrathin Carbon Coated CoO Nanosheet Arrays as Efficient Electrocatalysts for Hydrogen Evolution Reaction

Weiyang Jin,[a,b] Xiaoliang Guo,[a,b] Jun Zhang,*[,a,b] Lekai Zheng,[a,b] Fang Liu,[a,b] Yongchuan Hu,[a,b] Jing Mao,[c] Hui Liu,*[,a] Yanming Xue,[a,b] Chengchun Tang[a,b]

[a]School of Material Science and Engineering, Hebei University of Technology, Dingzigu Road 1, Tianjin 300130, P. R. China

[b]Hebei Key Laboratory of Boron Nitride Micro and Nano Materials, Guangrongdao Road 29, Tianjin 300130, P. R. China

[c]School of Materials Science and Engineering, Tianjin University, Tianjin Haihe Education Park, Tianjin 300072, PR China

E-mail address: junnano@gmail.com (J. Zhang), liuhuihebut@163.com (H. Liu)

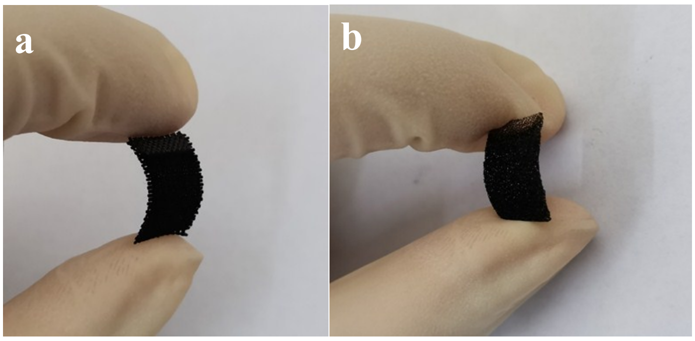

Figure. S1 The photographs of C@CoO/CC and C@CoO/NF under bending.

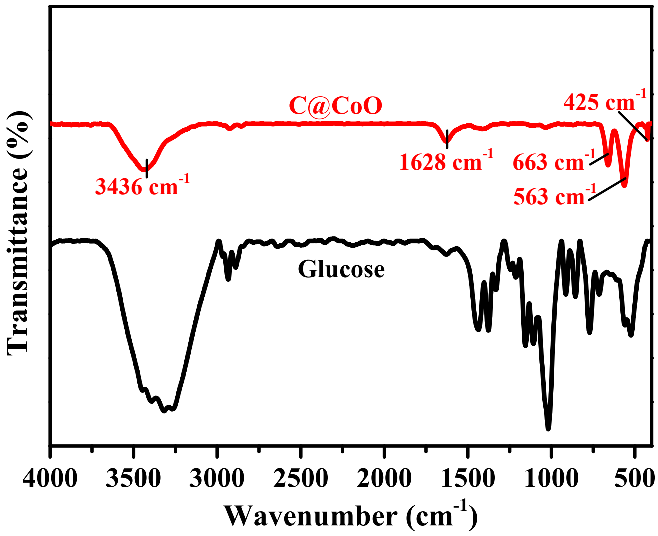

Figure. S2 The FTIR spectra of C@CoO and glucose.

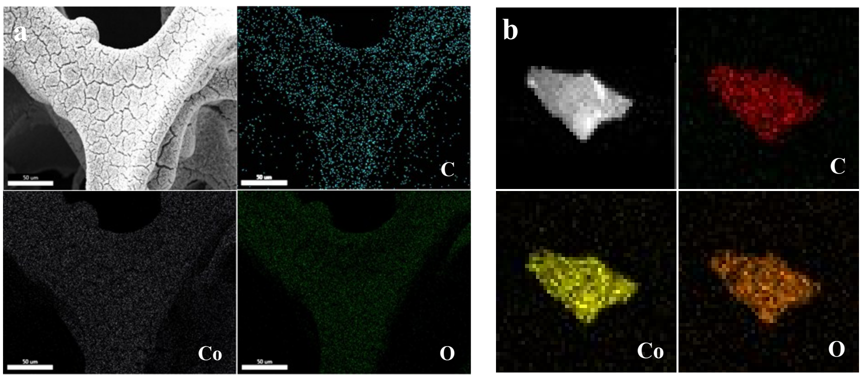

Figure. S3 (a) SEM image of C@CoO/NF and corresponding elemental mappings for C, Co and O atoms. (b) TEM image of C@CoO and corresponding elemental mappings for C, Co and O atoms.

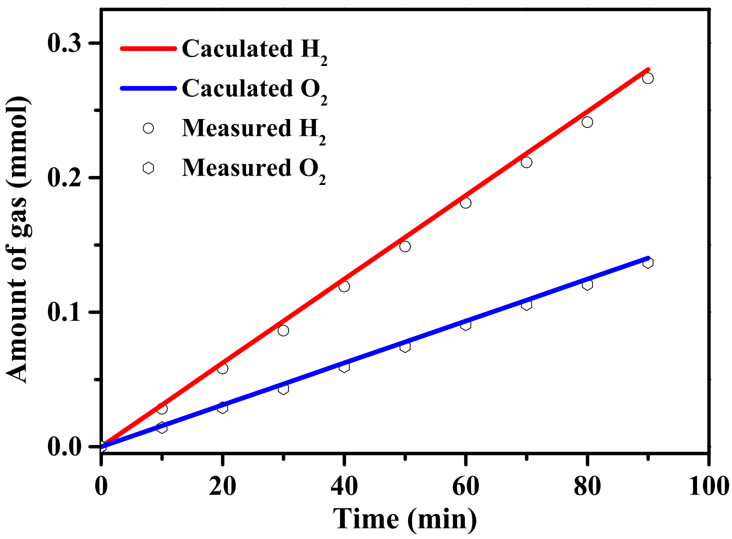

Figure. S4 The amount of gas theoretically calculated and experimentally measured versus time on cathode (C@CoO/CC) and anode (Carbon rod).

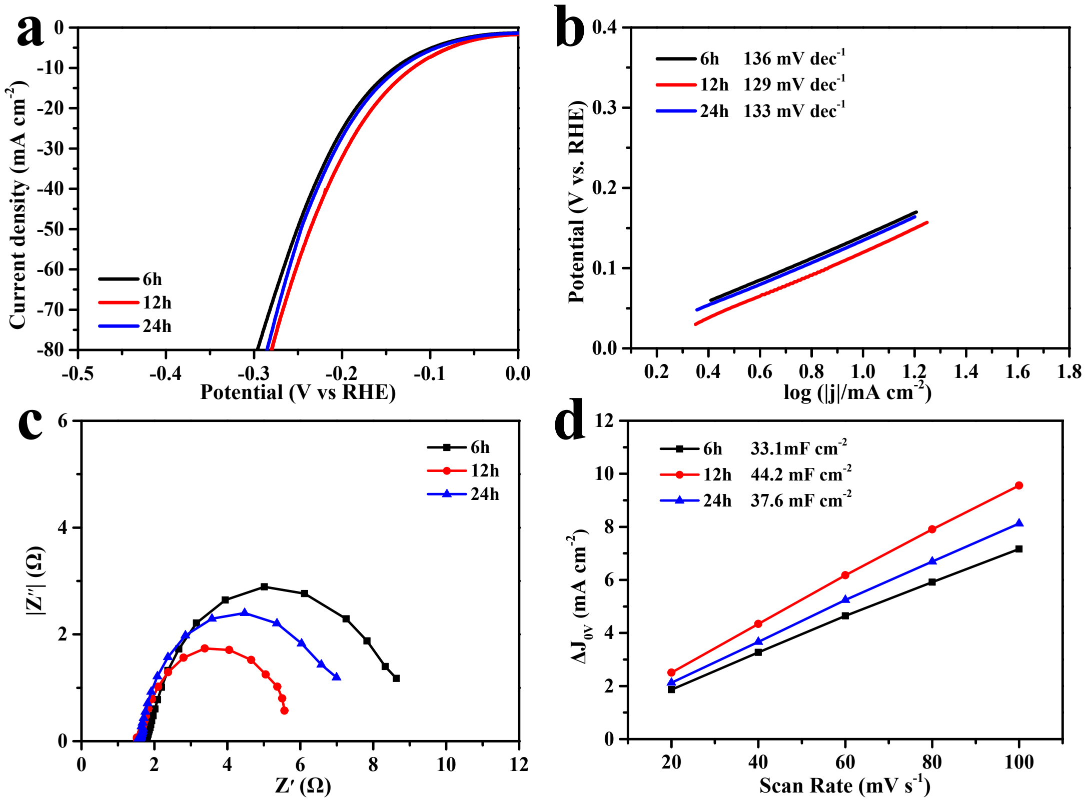

Figure. S5 (a) LSV curves of the C@CoO/CC prepared under different conditions with a scan rate of 2 mV s^{-1} for HER in 1.0 M KOH. (b) The corresponding Tafel plots derived from (a). (c) Nyquist plots for HER tested at -0.15 V (vs. RHE). (d) The double layer capacity C_{dl} of electrocatalysts.

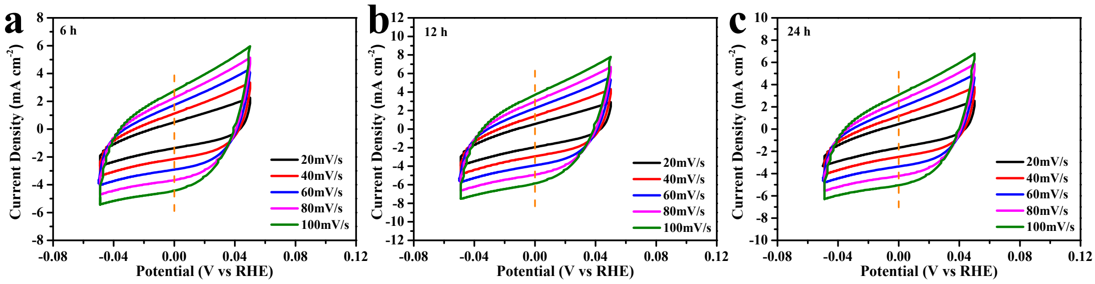

Figure S6. Different scan rates of CVs of C@CoO/CC prepared under different conditions.

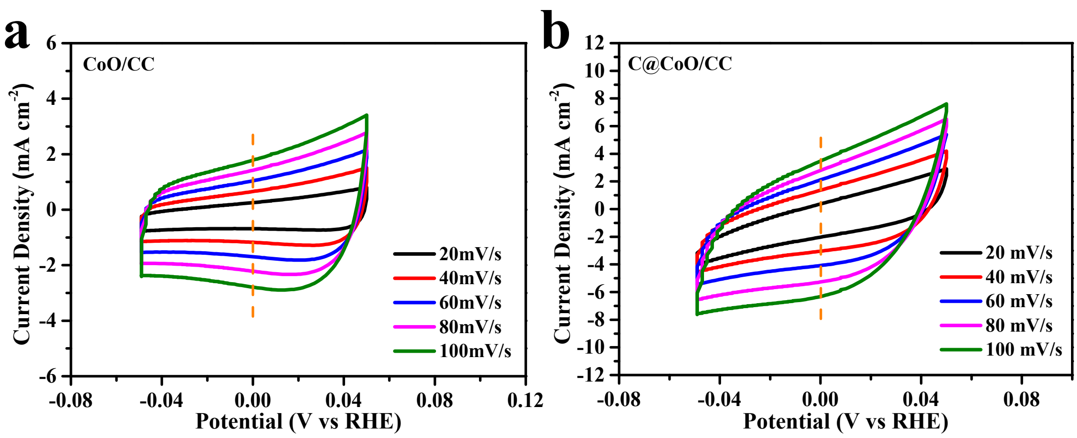

Figure S7. Different scan rates of CVs of (a) CoO/CC and (b) C@CoO/CC.

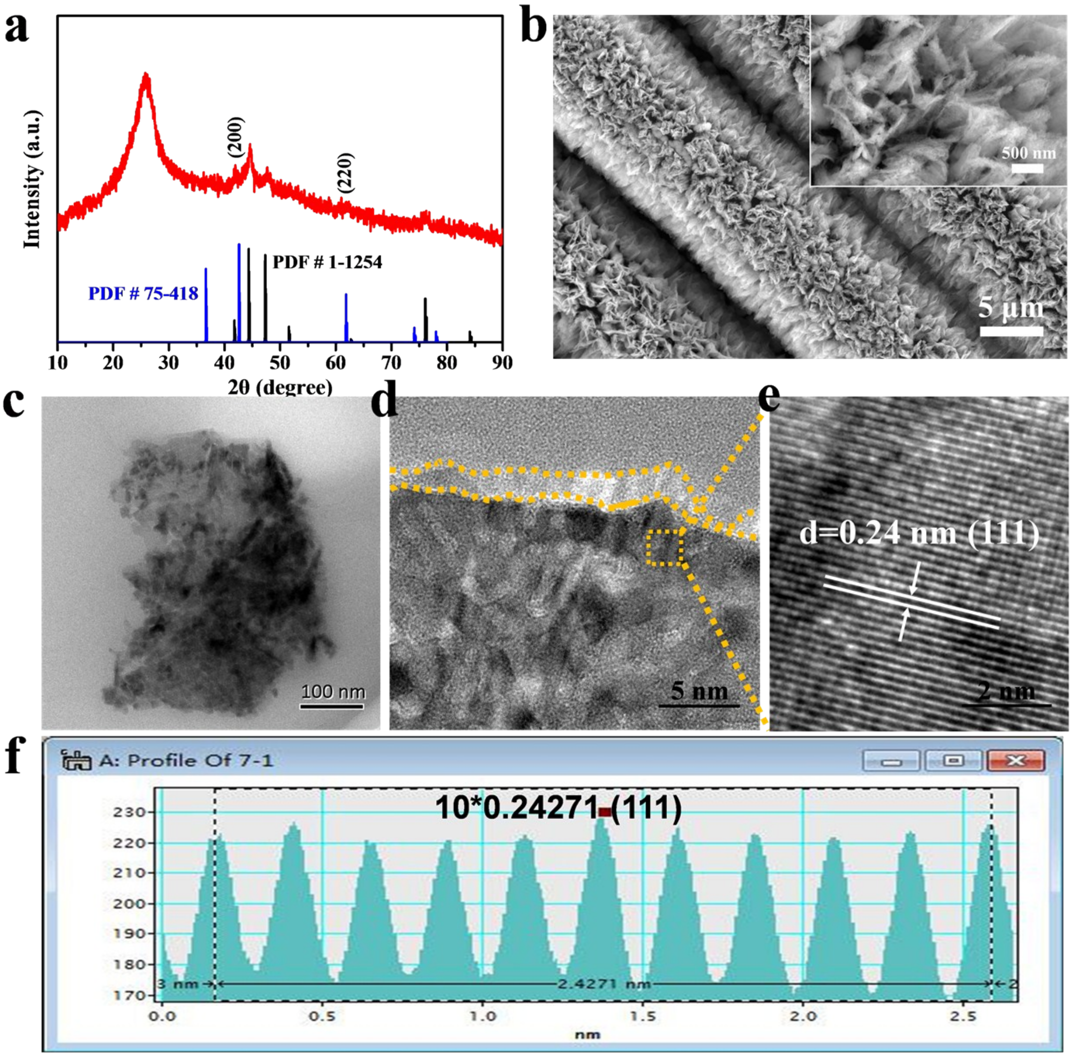

Figure S8. (a) The XRD pattern, (b) SEM, (c) TEM and (d, e) HRTEM images of C@CoO/CC after long-term durability test. (f) the screenshot of ten times for lattice spacing.

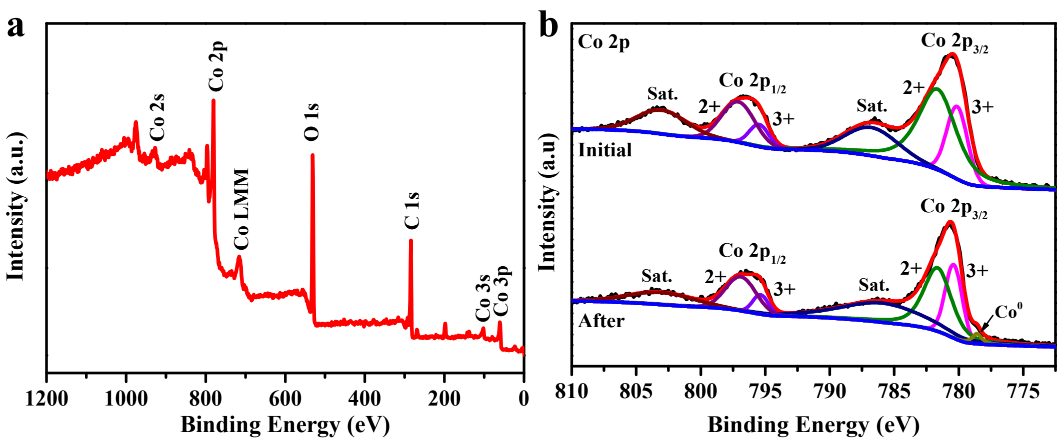

Figure S9. (a) XPS survey spectra and (b) Co 2p for C@CoO after long-term durability test.

Table S1. Comparison of HER performances of C@CoO/CC with previously reported transition metal oxide-based HER electrocatalysts.

Catalyst	Substrate	Electrolyte	η *@-10mA cm⁻²* (mV vs RHE)	Tafel slope (mV dec^{-1})	Ref.
C@CoO	CC[a]	1M KOH	-120	129	This work
Ni/NiO-CNT	GCE[b]	1M KOH	~ -100	82	1
$NiCo_2O_4$@NiO@Ni	NF[c]	1M KOH	-124	58	2
Ni-NiO/N-rGO	NF	1M KOH	-135	46	3
Co_3O_4-MTA	NF	1M KOH	-190 (20 mA cm^{-2})	98	4
CoO/MoS_2	CC	1M KOH	-173	83	5
Cu_2O/Co_3O_4/DC	GCE	0.5M H_2SO_4	-160	73	6
FeCoO	NF	1M KOH	-205	118	7
Co_3O_4@BNC	GCE	1M KOH	-178	100.3	8
NiFe LDH	NF	1M NaOH	-210	-	9
CoO/MoO_x	NF	1M KOH	-163	44	10
Co/CoO/BC	GCE	1M KOH	-210	93.3	11
Co_3O_4	NF	1M KOH	-225	53	12
NiO/Co_3O_4	GCE	1M KOH	>-600	61	13
Co_3O_4/MoS_2	NF	1M KOH	-205	128	14
C-Co_3O_4	TM[d]	1M KOH	-163	89	15
Co_3O_4/Co_4N	CC	1M KOH	-90	58	16

CC[a]: Carbon cloth; GCE[b]: Glassy carbon electrode; NF[c]: Ni foam; TM[d]: Ti mesh

Reference

1. M. Gong, W. Zhou, M.-C. Tsai, J. Zhou, M. Guan, M.-C. Lin, B. Zhang, Y. Hu, D.-Y. Wang, J. Yang, S. J. Pennycook, B.-J. Hwang and H. Dai, *Nat. Commun.*, 2014, **5**, 4695.
2. L. Wang, C. Gu, X. Ge, J. Zhang, H. Zhu and J. Tu, *Part. Part. Sys. Charact.*, 2017, **34**, 1700228.
3. X. Liu, W. Liu, M. Ko, M. Park, M. G. Kim, P. Oh, S. Chae, S. Park, A. Casimir, G. Wu and J. Cho, *Adv. Funct. Mater.*, 2015, **25**, 5799-5808.
4. Y. P. Zhu, T. Y. Ma, M. Jaroniec and S. Z. Qiao, *Angew. Chem. Int. Ed.*, 2017, **56**, 1324-1328.
5. P. Cheng, C. Yuan, Q. Zhou, X. Hu, J. Li, X. Lin, X. Wang, M. Jin, L. Shui, X. Gao, R. Nötzel, G. Zhou, Z. Zhang and J. Liu, *J. Phys. Chem. C*, 2019, **123**, 5833-5839.
6. W. Jin and J. Chen, *New J. Chem.*, 2018, **42**, 19400-19406.
7. H. A. Bandal, A. R. Jadhav, A. H. Tamboli and H. Kim, *Electrochim. Acta*, 2017, **249**, 253-262.
8. D. Tang, X. Sun, H. Yu, W. Zhang, L. Zhang, X. Li, Z.-A. Qiao, J. Zhu and Z. Zhao, *Dalton Trans.*, 2019, **48**, 7261-7266.
9. J. Luo, J.-H. Im, M. T. Mayer, M. Schreier, M. K. Nazeeruddin, N.-G. Park, S. D. Tilley, H. J. Fan and M. Grätzel, *Science*, 2014, **345**, 1593.
10. X. Yan, L. Tian, S. Atkins, Y. Liu, J. Murowchick and X. Chen, *ACS Sustainable Chem. Eng.*, 2016, **4**, 3743-3749.
11. M. Yang, D. Wu and D. Cheng, *Int. J. Hydrogen Energy*, 2019, **44**, 6525-6534.
12. R. Li, D. Zhou, J. Luo, W. Xu, J. Li, S. Li, P. Cheng and D. Yuan, *J. Power Sources*, 2017, **341**, 250-256.
13. A. QayoomMugheri, AneelaTahira, U. Aftab, M. IshaqAbro, S. R. Chaudhry, L. Amaral and Z. H. Ibupoto, *Electrochim. Acta*, 2019, **306**, 9-17.
14. A. Muthurasu, V. Maruthapandian and H. Y. Kim, *Appl. Catal. B: Environ.*, 2019, **248**, 202-210.
15. D. Yan, R. Chen, Z. Xiao and S. Wang, *Electrochim. Acta*, 2019, **303**, 316-322.
16. B. Liu, J. Cheng, H.-Q. Peng, D. Chen, X. Cui, D. Shen, K. Zhang, T. Jiao, M. Li, C.-S. Lee and W. Zhang, *J. Mater. Chem. A*, 2019, **7**, 775-782.