Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Supporting Information for

Fe^{3+}-Co^{2+} Species Loaded on Carbon as Effective Pre-catalyst for Oxygen Evolution

Xueyang Wang,[a] Yuanjun Liu,[b,*] Tiange Wei,[a] Xuefeng Song,[a] Xiaofang Cheng,[b] Xiaoping Shen,[a] Guoxing Zhu[a,*]

[a]School of Chemistry and Chemical Engineering, Jiangsu University, Zhenjiang, 212013, China.

E-mail: zhuguoxing@ujs.edu.cn

[b]School of Environmental and Chemical Engineering, Jiangsu University of Science and Technology, Zhenjiang 202018, China. E-mail:liuyuanjun@just.edu.cn

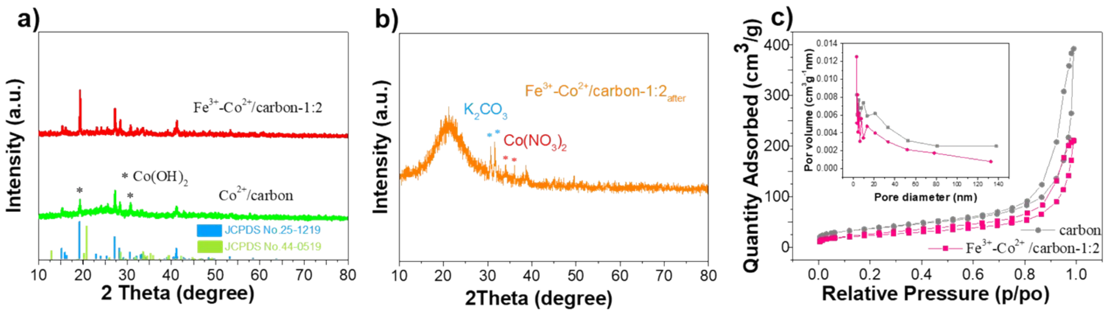

Fig. S1. XRD patterns for a) the typical samples including Fe^{3+}-Co^{2+}/carbon-1:2, Co^{2+}/carbon and the standard patterns for $Co(NO_3)_2 \cdot 6H_2O$ (JCPDS No.25-1219), $Fe_4(OH)_{11}NO_3 \cdot 2H_2O$ (JCPDS No. 44-0519) and b) Fe^{3+}-Co^{2+}/carbon-1:2$_{after}$. c) Nitrogen adsorption-desorption isotherms for carbon and Fe^{3+}-Co $^{2+}$/carbon-1:2 (The inset figure shows the pore size distribution).

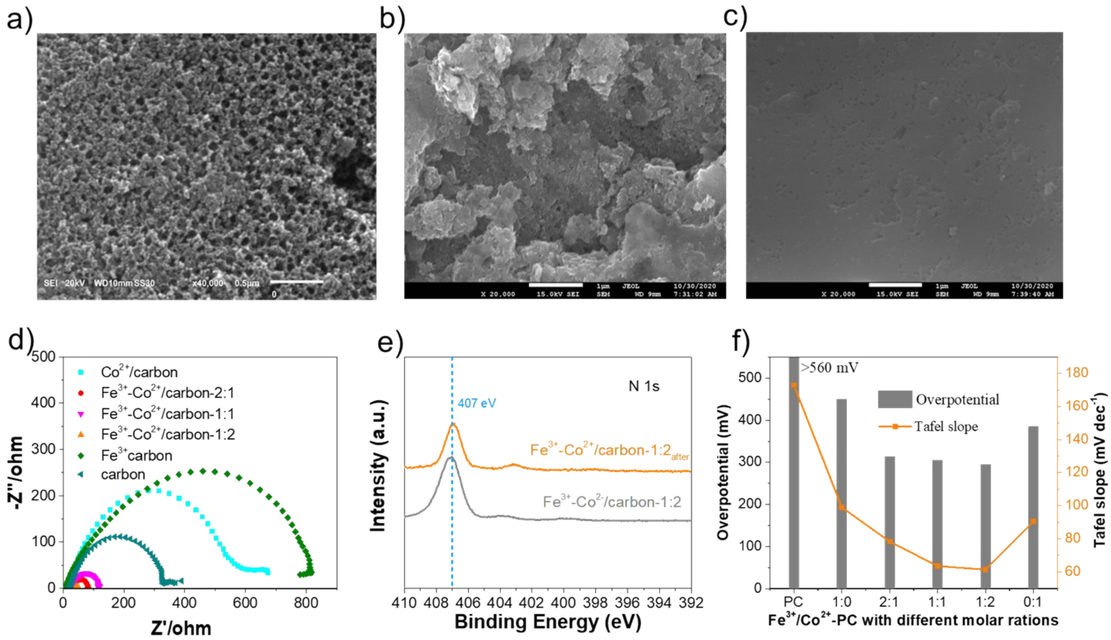

Fig. S2. a~c) SEM images of the porous carbon, Fe^{3+}-Co^{2+}/carbon-1:2 and Fe^{3+}-Co^{2+}/carbon-1:2$_{after}$. d) Nyquist plots obtained at overpotential of 295 mV from all samples. e) XPS spectrum of N 1s for Fe^{3+}-Co^{2+}/carbon-1:2 and Fe^{3+}-Co^{2+}/carbon-1:2_{after} products. f) comparision results of the overpotential and Tafel slope values.

Table S1. Fe and Co contents in the Fe^{3+}-Co^{2+}/carbon composites determined by ICP-OES.

Products	Fe content		Co content		Metal content (Fe+Co) wt%	Fe^{3+}:Co^{2+} molar ratios
	mol%	wt%	mol%	wt%		
Fe^{3+}-Co^{2+}/carbon-2:1	2.97	11.81	1.63	6.84	18.65	1.8:1
Fe^{3+}-Co^{2+}/carbon-1:1	2.23	8.85	2.47	10.31	19.16	1:1.1
Fe^{3+}-Co^{2+}/carbon-1:2	1.43	5.63	3.41	14.18	19.81	1:2.3
Fe^{3+}-Co^{2+}/carbon-1:2_{after}	0.53	2.34	0.93	4.33	6.67	1:1.7

Detailed metal content testing procedures are as follows: Firstly, 5 mg of the sample was dissolved in 6 mol/L HCL solution and stirred for 24 h. The solution was filtered and was diluted to a final volume of 100 mL. The corresponding solution was used for ICP analysis.

Table S2. Comparisons of the OER performance for different catalysts.

Catalysts	Electrolyte	Overpotential at 10 mA•cm^{-2}	Tafel slope (mV•dec^{-1})	Refs.
AB-Fe^{3+}/Co^{2+}-Nafion	1M KOH	330	55	[1]
$NiCoO_2$@CFP	1M KOH	303	57	[2]
NiO/CoN PINWs	1M KOH	300	35	[3]
Co_3O_4/NPC	1M KOH	390	58	[4]
$NiCoSe_2$/NF	1M KOH	183	88	[5]
Fe–Co–P/C	1M KOH	151	77.78	[6]
CP/CTs/Co-S	1M KOH	513	131	[7]
NF@NC-$CoFe_2O_4$ powders	1M KOH	350	74	[8]
$CoFe_2O_4$/PANI-MWCNTs	1M KOH	314	30.6	[9]
Fe_3O_4@NiSx/rGO	1M KOH	330	35.5	[10]
$NiCo_2O_3$@OMC	1M KOH	281	96.8	[11]
Fe^{3+}-Co^{2+}/carbon-1:2	1M KOH	295	61.3	This work

Table S3. Comparison of the TOF values of the different OER catalysts.

Catalysts	Current density at overpotential of 295 mV (mA/cm^2)	TOF (s^{-1})
Fe^{3+}/carbon	0.28	0.0008
Fe^{3+}-Co^{2+}/carbon-2:1	5.01	0.0140
Fe^{3+}-Co^{2+}/carbon-1:1	8.34	0.0229
Fe^{3+}-Co^{2+}/carbon-1:2	10	0.0260
Co^{2+}/carbon	0.63	0.0020

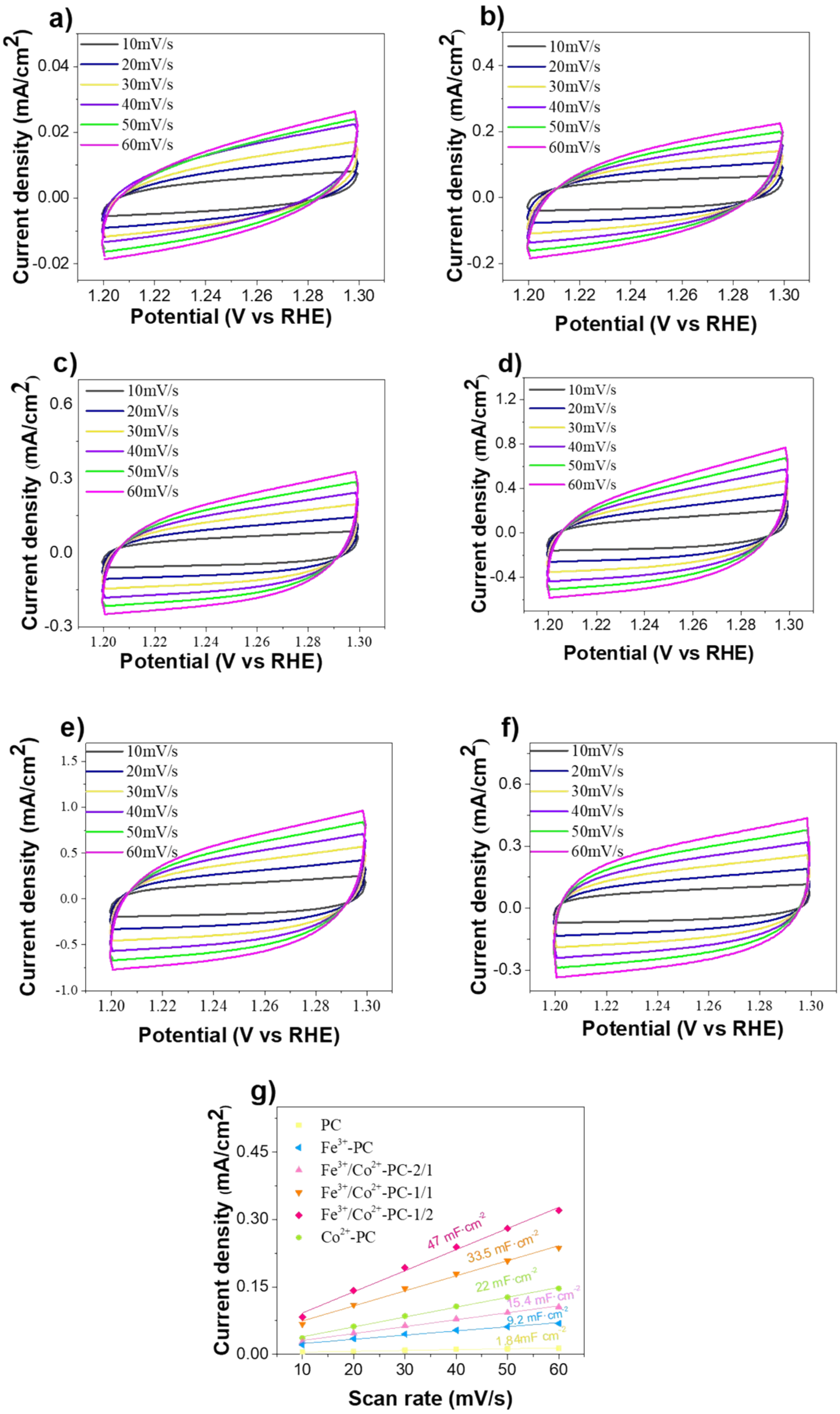

Fig. S3. a-f) CV curves of the carbon and Fe^{3+}-Co^{2+}/carbon composites (Fe^{3+}:Co^{2+} = 1:0, 2:1, 1:1, 1:2, and 0:1) g) Estimation of C_{dl} by plotting the current density vs scan rate to fit a linear regression for all samples.

References：

[1] Y. Yu, Y. Liu, S. Ju, X. Shen, Z. Ji, L. Kong, G. Zhu, Inorg. Chem. Commun., 111, (2020), 107674.

[2] Y. Yang, M. Zhou, W. Guo, X. Cui, Y. Li, F. Liu, P. Xiao, Y. Zhang, Electrochim. Acta, 174, (2015), 246-253.

[3] J. Yin, Y. Li, F. Lv, Q. Fan, Y. Zhao, Q. Zhang, W. Wei, F. Cheng, P. Xi, S. Guo, ACS Nano, 11, (2017), 2275-2283.

[4] J. Sun, Y. Yang, J. Wang, Z. Zhang, J. Guo, J. Alloy. Compd., 827, (2020), 154308.

[5] A. Kamran. J. Jae, K. Minsoo, J. Junkyeong, Y. Yeonjin, C. Seung-Hyun, ACS Sustain. Chem. Eng., 6, (2018), 7735-7742.

[6] X. Li, X. Qian, Y. Xu, H. Wu, Y. Dan, L. Chen, Q. Yu, Electrochim. Acta, 321, (2019), 134646.

[7] J. Wang, H. Zhong, Z. Wang, F. Meng, X. Zhang, ACS Nano, 10, (2016), 2342-2348.

[8] X. Lu, L.Gu, J. Wang, J. Wu, P. Liao, G. Li, Adv. Mater., 29, (2017), 1604437.

[9] Y. Liu, J. Li, F. Li, W. Li, H. Yang, X. Zhang, Y. Liu, J. Ma, J. Mater. Chem. A, 4, (2016), 4472-4478.

[10] G. Zhu, X. Xie, X. Li, Y. Liu, X. Shen, K. Xu, S. Chen, ACS Appl. Mater. Interf., 10, (2018), 19258.

[11] Y. Zhang, X. Wang, F. Luo, Y. Tan, L. Zeng, B. Fang, A. Liu, Appl. Catal. B-Environ., 256, (2019), 117852.