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

Supporting Information

Fe_9S_{10}-decorated N, S co-doped graphene as a new and efficient electrodecatalyst for oxygen reduction and oxygen evolution reactions

Xiu-Xiu Ma[a], Yan Su[a], Xing-Quan He[a]*1

[a]*School of Materials Science and Engineering, Changchun University of Science and Technology, Jinlin, 130022, RP. China.*

[1]*Corresponding author: hexingquan@hotmail.com

Tel:+86 431 85583430

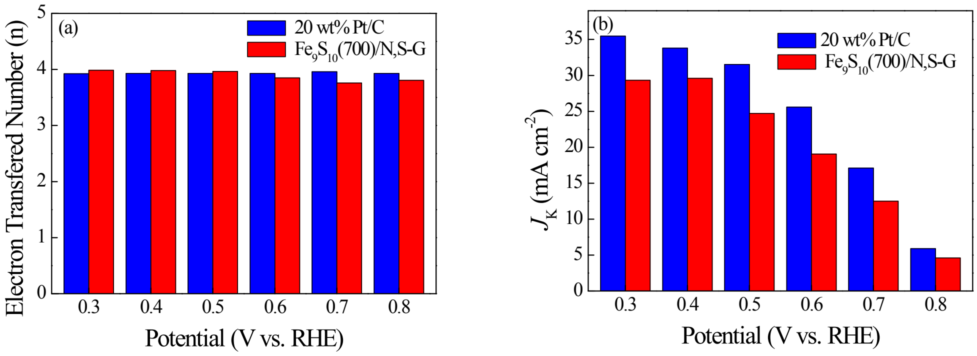

Figure S1. (a) Electron transferred number and (b) kinetic current density for 20 wt% Pt/C and Fe_9S_{10}(700)/N,S-G in the tested kinetic potentials (0.3–0.8 V vs. RHE).

Table S1 The ORR parameters of the electrodecatalyst compared with the state-of-the-art ORR catalysts in literatures

Catalyst	E_o [V vs. RHE]	$E_{1/2}$ [V vs. RHE]	J [mA cm^{-2}]	Reference
Fe_9S_{10}(700)/N,S-G	0.959	0.800	-5.73	This work
HNCS71	0.970	0.820	-6.50	[1]
FePc/C(600)	0.926	0.859	-5.60	[2]
$(FeP)_n$-CNTs	0.880	0.760	-4.70	[3]
Fe/Co-CMP-800	0.880	0.760	-4.80	[4]
Co_xC/C	0.934	0.760	-4.20	[5]
Fe–N_x/HPC	0.935	0.880	-5.00	[6]
CoP-CMP800	0.830	0.870	-4.62	[7]
Fe–N–C/VA-CNT	0.970	0.790	-6.00	[8]
FeCo-NC	1.050	0.840	-5.00	[9]
Fe-N-C/850	0.960	0.600	-4.20	[10]
Fe/Fe_3C@N–C–NaCl	0.970	0.869	-5.00	[11]
Fe-N-C	1.040	0.880	-5.60	[12]
Fe-CNT-PA	0.925	0.795	-6.82	[13]
Fe–N–C	0.990	0.784	-6.50	[14]
P-CNCo-20	0.925	0.845	-6.00	[15]

Table S2 The OER parameters of the electrodecatalyst compared with the state-of-the-art ORR catalysts in literatures

Catalysts	η_{10} [mV]	Tafel slope [mV dec^{-1}]	Reference
Fe_9S_{10}(700)/N,S-G	400	71	This work
N-MGF	402	67	[16]
FeP@NPCs	300	80	[17]
Co_2P@N,P -PCN/CNTs	300	72	[18]
NiFeO@MnO_x	400	42	[19]
N-Co_9S_8/G	409	82.7	[20]
CoMnO@CN	290	97	[21]
N,P-GCNS	340	-	[22]
Co_xS_y@C-1000	470	-	[23]
Fe_3O_4@Co_9S_8/rGO	320	65.5	[24]
Co_9S_8 @MoS_2 /CNFs	430	61	[25]
echo-MWCNTs	360	41	[26]

Notes and references

[1] J. Sanetuntikula, C. Chuaichamb, Y. W. Choic and S. Shanmugam, *J. Mater. Chem. A*, 2015, DOI: 10.1039/C5TA02677F.

[2] H. A. Miller, M. Bellini, W. Oberhauser, X. Deng, H. Q. Chen, Q. G. He, M. Passaponti, M. Innocenti, R. Yang, F. F. Sun, Z. Jiang and F. Vizza, *Phys. Chem. Chem. Phys.*, 2016, DOI: 10.1039/C6CP06798K.

[3] H. X. Jia, Z. J. Sun, D. C. Jiang, S. F. Yang and P. W. Du, *Inorg. Chem. Front.*,

2016, **3**, 821–827.

[4] S. Brüller, H. W. Liang, U. I. Kramm, J. W. Krumpfer, X. L. Feng and K. Müllen, *J. Mater. Chem. A*, 2015, **3**, 23799–23808.

[5] L. S. Chen, X. Z. Cui, Q. S. Wang, X. H. Zhang, G. Wan, F. M. Cui, C. Y. Wei and J. L. Shi, *Dalton Transactions*, 2015, DOI: 10.1039/C5DT03337C.

[6] Z. P. Zhang, X. J. Gao, M. L. Dou, J. Ji and F. Wang, *J. Mater. Chem. A*, 2016, DOI: 10.1039/c6ta09124e.

[7] Z. S. Wu, L. Chen, J. Z. Liu, K. Parvez, H. W. Liang, J. Shu, H. Sachdev, R. Graf, X. L. Feng and K. Müllen, *Adv. Mater.*, 2014, **26**, 1450–1455.

[8] S. Yasuda, A. Furuya, Y. Uchibori, J. Kim and K. Murakoshi, *Adv. Funct. Mater.,* 2016, **26**, 738–744.

[9] Z. P. Zhang, M. L. Dou, H. J. Liu, L. M. Dai and F. Wang, *Small*, 2016, **12**, 4193–4199.

[10] A. H. A. M. Videla, L. Osmieri, M. Armandi and S. Specchia, *Electrochimica Acta*, 2015, **177**, 43–50.

[11] Y. Z. Chen, C. M. Wang, Z. Y. Wu, Y. J. Xiong, Q. Xu, S. H. Yu and H. L. Jiang, *Adv. Mater.*, 2015, **27**, 5010–5016.

[12] W. Luo, T. Liu, P. P. Zhao, X. Hua, S. L. Chen and G. Z. Cheng, *J. Mater. Chem. A*, 2016, DOI: 10.1039/C6TA03265F.

[13] G. Yang, W. Choi, X. Pub and C. Yu, *Energy Environ. Sci.*, 2015, **8**, 1799−1807.

[14] J. K. Li, S. Ghoshal, W. T. Liang, M. T. Sougrati, F. Jaouen, B. Halevi, S. McKinney, G. McCool, C. R. Ma, X. X. Yuan, Z. F. Ma, S. Mukerjee and Q. Y. Jia,

Energy Environ. Sci., 2016, DOI: 10.1039/C6EE01160H.

[15] Y. Zhang, L. B. Huang, W. J. Jiang, X. Zhang, Y. Y. Chen, Z. D. Wei, L. J. Wan and J. S. Hu, *J. Mater. Chem. A*, 2016, **4**, 7781–7787.

[16] C. L. Zhang, B. W. Wang, X. C. Shen, J. W. Liu, X. K. Kong, S. S. C. Chuang, D. Yang, A. G. Dong and Z. M. Peng, *Nano Energy*, 2016, **30**, 503–510.

[17] R. Z. Zhang, C. M. Zhang and W. Chen, *J. Mater. Chem. A*, 2016, DOI: 10.1039/C6TA08363C.

[18] X. Z. Li, Y. Y. Fang, F. Li, M. Tian, X. F. Long, J. Jin and J. T. Ma, *J. Mater. Chem. A*, 2016, **4**, 15501–15510.

[19] Y. Cheng, S. Dou, M. Saunders, J. Zhang, J. Pan, S. Y. Wang and S. P. Jiang, *J. Mater. Chem. A*, 2016, **4**, 13881–13889.

[20] S. Dou, L. Tao, J. Huo, S. Y. Wang and L. M. Dai, *Energy Environ. Sci.,* 2016, **9**, 1320–1326.

[21] J. Li, Y. C. Wang, T. Zhou, H. Zhang, X. H. Sun, J. Tang, L. J. Zhang, A. M. Al-Enizi, Z. Q. Yang and G. F. Zheng, *J. Am. Chem. Soc.*, 2015, **137**, 14305−14312.

[22] R. Li, Z. D. Wei and X. L. Gou, *ACS Catal.*, 2015, **5**, 4133−4142.

[23] B. L. Chen, R. Li, G. P. Ma, X. L. Gou, Y. Q. Zhu and Y. D. Xia, *Nanoscale*, 2015, **7**, 20674–20684.

[24] J. Yang, G. X. Zhu, Y. J. Liu, J. X. Xia, Z. Y. Ji, X. P. Shen and S. K. Wu, *Adv. Funct. Mater.,* 2016, DOI: 10.1002/adfm.201600674.

[25] H. Zhu, J. F. Zhang, R. P. Yanzhang, M. L. Du, Q. F. Wang, G. H. Gao, J. D. Wu, G. M. Wu, M. Zhang, B. Liu, J. M. Yao and X. W. Zhang, *Adv. Mater.*, 2015, **27**,

4752–4759.

[26] X. Y. Lu, W. L. Yim, B. H. R. Suryanto and C. Zhao, *J. Am. Chem. Soc.*, 2015, **137**, 2901−2907.