Electronic Supplementary Material (ESI) for Inorganic Chemistry Frontiers.

Supporting Information

Dipolar and Catalytic Effect of Fe_3O_4 Based Nitrogen Doped Hollow Carbon Sphere Framework for High Performance Lithium Sulfur Batteries

Shungui Deng,[a,b] Qihua Li, [b] Yanhua Chen, [c] Chao Wang, [b] Hongbin Zhao, [a] Jiaqiang Xu,[a] Jinghua Wu*[b,d] and Xiayin Yao [b,d]*

[a]NEST Lab. Department of Chemistry, College of Science, Shanghai University, Shanghai 200444, P. R. China

[b]Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo 315201, Zhejiang, P. R. China

[c]Zhejiang Fashion Institute of Technology, Ningbo 315211, Zhejiang, P. R. China

[d]Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing 100049, P. R. China

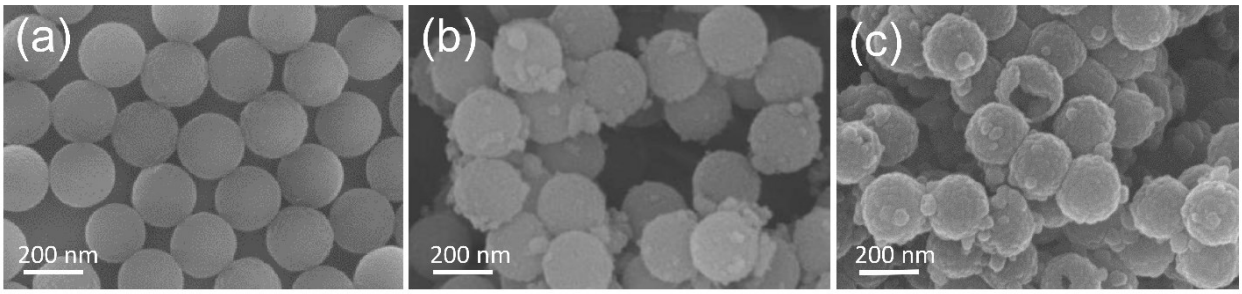

Fig. S1 SEM image of (a) polystyrene microspheres, (b) Fe^{3+}@polydopmine/polystyrene spheres, (c) hollow Fe_3O_4@carbon spheres.

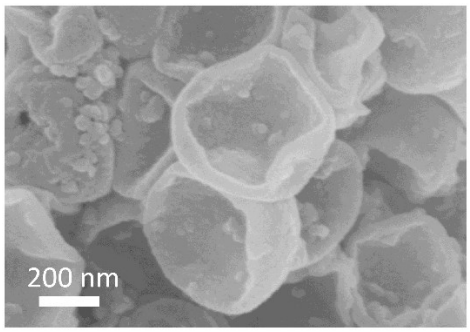

Fig. S2 The morphology of NC.

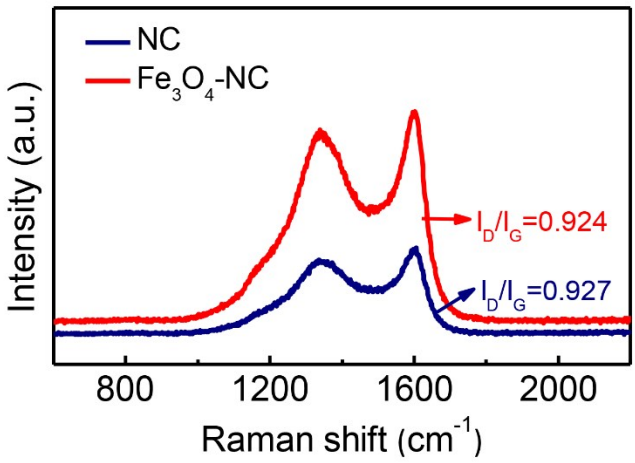

Fig. S3 Raman spectra of NC and Fe_3O_4-NC.

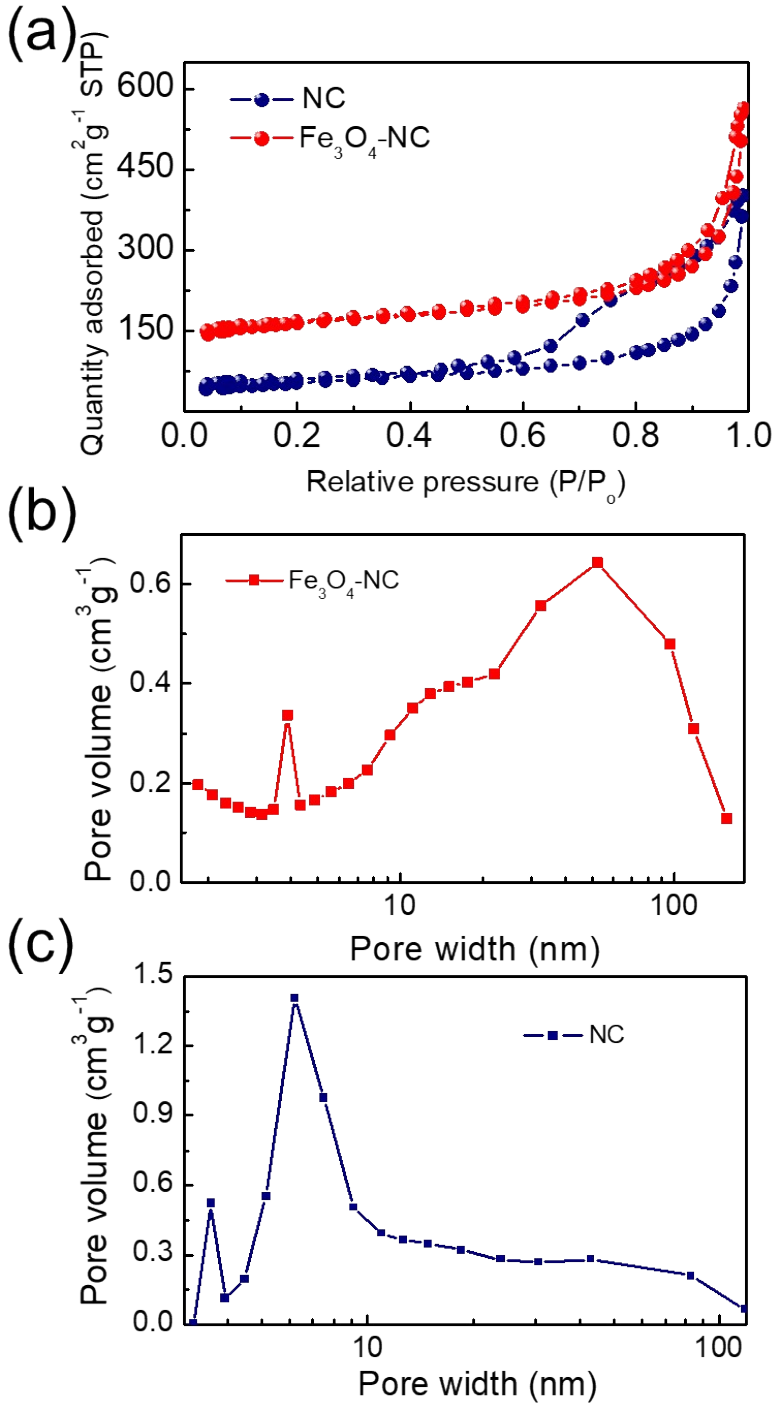

Fig. S4 (a) N_2 sorption isotherms at 77 K of NC and Fe_3O_4-NC. (b, c) BJH model for pore size distribution of Fe_3O_4-NC and NC.

.

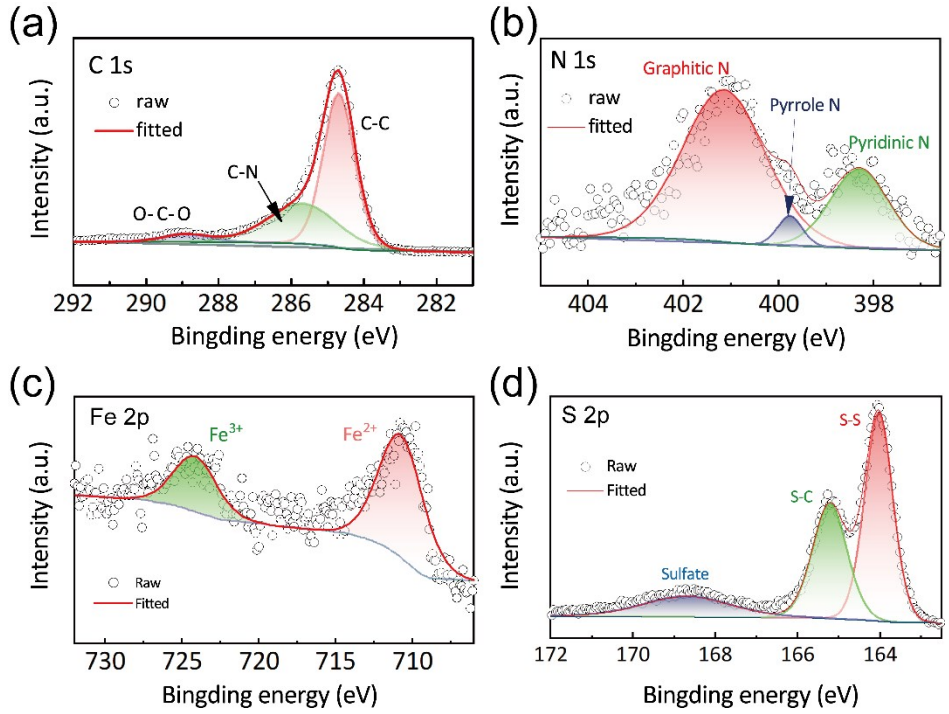

Fig. S5 High-resolution XPS spectra of (a) C 1s , (b) N 1s, (c) Fe 2p and (d) S 2p.

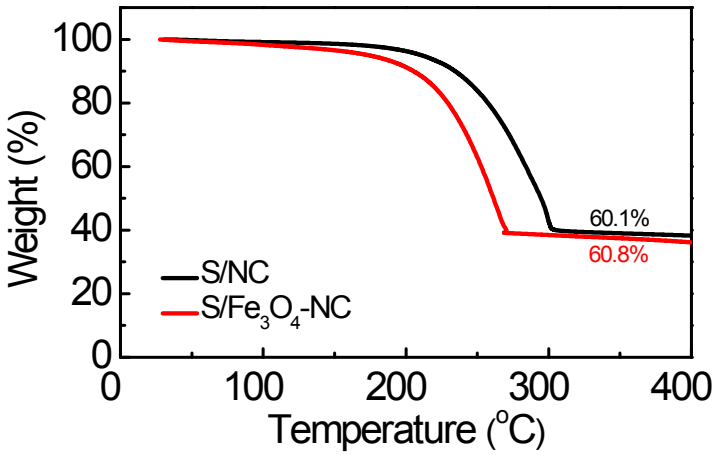

Fig. S6 TG curves of pure sulfur for S/NC and S/Fe_3O_4-NC with different sulfur contents.

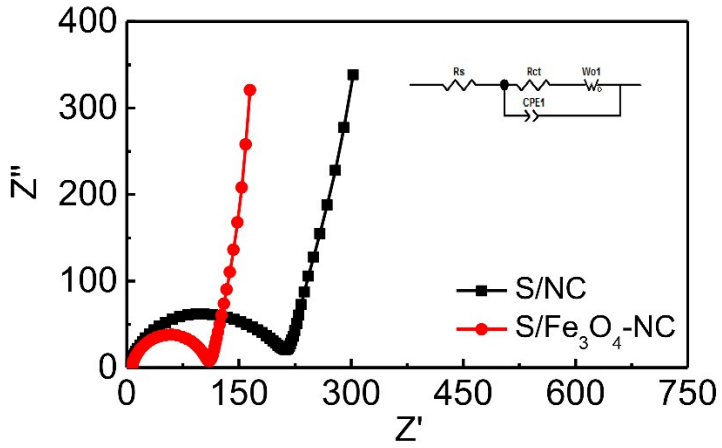

Fig. S7 EIS plots of S/NC, S/Fe_3O_4-NC and the relevant equivalent circuit.

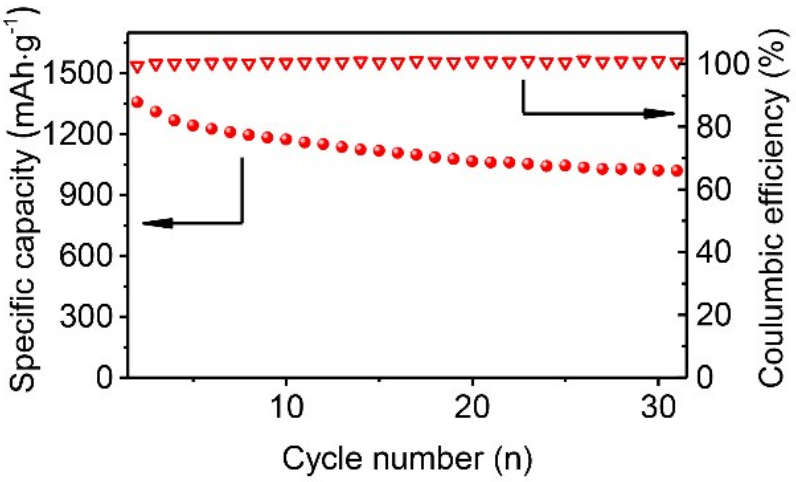

Fig. S8 Cycling performance of S/Fe_3O_4-NC electrode at 0.1 A g^{-1}.

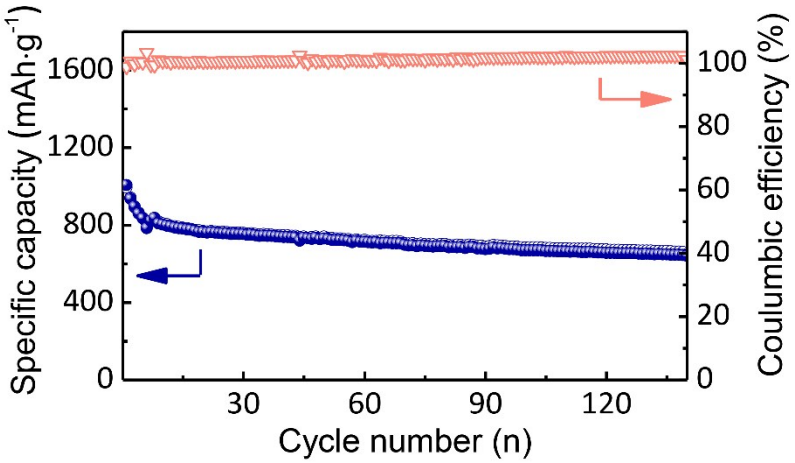

Fig. S9 Cycling performances of S/Fe_3O_4-NC electrode with 2.5 mg cm^{-2} sulfur loading at current density of 0.2 A g^{-1}.

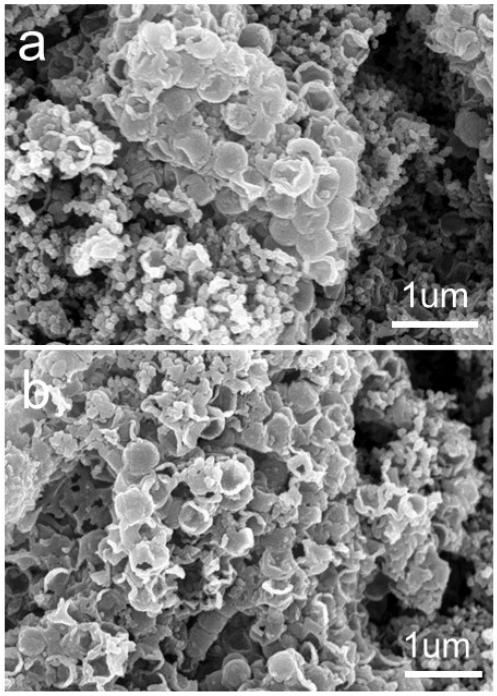

Fig. S10 SEM of S/Fe_3O_4-NC electrode (a) before and (b) after 500 cycling.

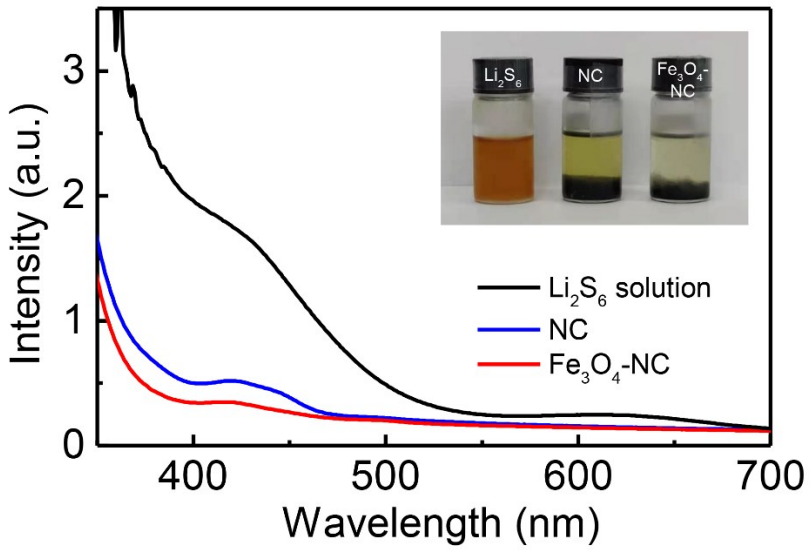

Fig. S11 UV-Vis spectra and digital photograph of the blank Li_2S_6 solution, Li_2S_6 solution with NC after 24h and Li_2S_6 solution with Fe_3O_4-NC after 24 h.

Table S1 BET parameters of NC and Fe_3O_4-NC.

Material	BET surface area (m^2g^{-1})	Total pore volume (cm^3g^{-1})	Average pore diameter (nm)
NC	190	0.61	16.42
Fe_3O_4-NC	559	0.71	14.32

Table S2 Parameters of the equivalent circuit corresponding to EIS measurement.

Electrodes	R_s (Ω)	R_{ct} (Ω)
S/NC	4.616	174.5
S/Fe_3O_4-NC	1.843	96.9

Table S3 A brief comparison of cycling performance of different carbon host.

Sulfur host	Current density (sulfur loading)	Capacity retained (cycle)	Ref.
Crumpled graphene-encapsulated sulfur[1]	0.5 C (0.5mg cm^{-2})	432mAh g^{-1} (500^{th} cycle)	1
Multifunctional hollow spheres[2]	0.2 C (2.25 mg cm^{-2})	605 mAh g^{-1} (300^{th} cycle)	2
three-dimensional ordered porous carbon bulk networks[3]	1 C (2 mg cm^{-2})	455mAh g^{-1} (400^{th} cycle)	3
Hollow N-doped Carbon Polyhedrons[4]	1 C (1.0 mg cm^{-2})	404 mAh g^{-1} (500^{th} cycle)	4
"Brain-Coral-Like" Mesoporous Hollow CoS_2@N-Doped Carbon Nanoshells[5]	1 C (75wt% sulfur content)	519mAh g^{-1} (300^{th} cycle)	5
SnO_2/C hybrid hollow spheres[6]	1 C (0.96 mg cm^{-2})	478 mAh g^{-1} (600^{th} cycle)	6
hollow porous carbon sphere @ MXene composites[7]	1 C (1.0 mg cm^{-2})	495mAh (500^{th} cycle)	7
Fe_3O_4 @N-doped hollow carbon spheres	1 A g^{-1} (1.5 mg cm^{-2})	528mAh g^{-1} (500^{th} cycle)	This work

References

1. X. Hu, K. Leng, C. Zhang and J. Luo, Crumpled graphene-encapsulated sulfur for lithium-sulfur batteries, *Rsc Advances*, 2018, **8**, 18502-18507.
2. P. Li, J. Deng, J. Li, M. Zeng, L. Wang and J. Guo, Multifunctional hollow spheres as sulfur hosts for high-performance Li-S batteries, *Journal of Materials Science*, 2020, **55**, 3964-3973.
3. H. Gu, R. Zhang, P. Wang, S. Xie, C. Niu and H. Wang, Construction of three-dimensional ordered porous carbon bulk networks for high performance lithium-sulfur batteries, *Journal of Colloid and Interface Science*, 2019, **533**, 445-451.
4. D.-H. Yang, H.-Y. Zhou, H. Liu and B.-H. Han, Hollow N-doped Carbon Polyhedrons with Hierarchically Porous Shell for Confinement of Polysulfides in Lithium-Sulfur Batteries, *Iscience*, 2019, **13**, 243-253.
5. S.-D. Seo, D. Park, S. Park and D.-W. Kim, "Brain-Coral-Like" Mesoporous Hollow CoS2@N-Doped Graphitic Carbon Nanoshells as Efficient Sulfur Reservoirs for Lithium-Sulfur Batteries, *Adv. Funct. Mater.*, 2019, **29**, 1903712.
6. Q. Xiao, K. Wang, X. Wang, S. Huang, N. Cai and N. Li, Solvent-free template synthesis of SnO2/C hybrid hollow spheres for superior lithium-sulfur batteries, *Materials Chemistry and Physics*, 2020, **239**, 122070.
7. Q. Qi, H. Zhang, P. Zhang, Z. Bao, W. Zheng, W. Tian, W. Zhang, M. Zhou and Z. Sun, Self-assembled sandwich hollow porous carbon sphere @ MXene composites as superior LiS battery cathode hosts, *2d Materials*, 2020, **7**, 025049.