Supporting Information

A "boxes in fibers" strategy to construct a necklace-like conductive network for the high-rate and high-loading lithium-sulfur batteries

Shiyuan Zhou,†[a] Jiapeng Liu,†[a] Fanxuan Xie,[a] Yinghao Zhao,[a] Tao Mei,*[a] Zhengbang Wang,[a] and Xianbao Wang*[a]

a Hubei Collaborative Innovation Center for Advanced Organic Chemical Materials, Key Laboratory for the Green Preparation and Application of Functional Materials, Hubei Key Laboratory of Polymer Materials, School of Materials Science and Engineering, Hubei University, Wuhan 430062, PR China. E-mail: wxb@hubu.edu.cn (X. Wang), meitao@hubu.edu.cn (T.Mei); Tel: +86-27-8866 2132, Fax: +86-27- 8866 1729

† These two authors contributed equally to this work.

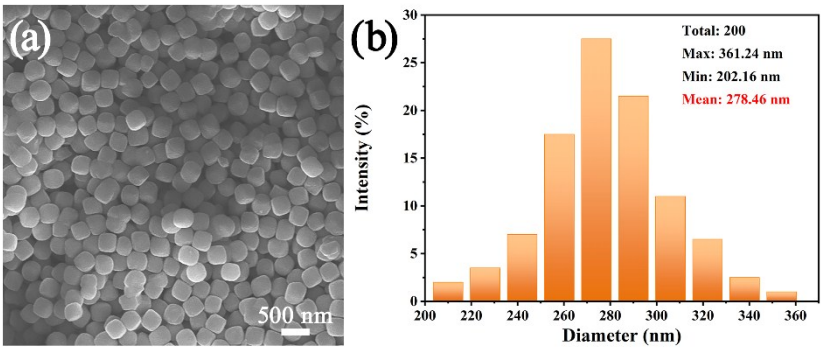

Fig. S1 (a) FESEM image and (b) statistics of the length distributions of Fe_2O_3 nanocubes.

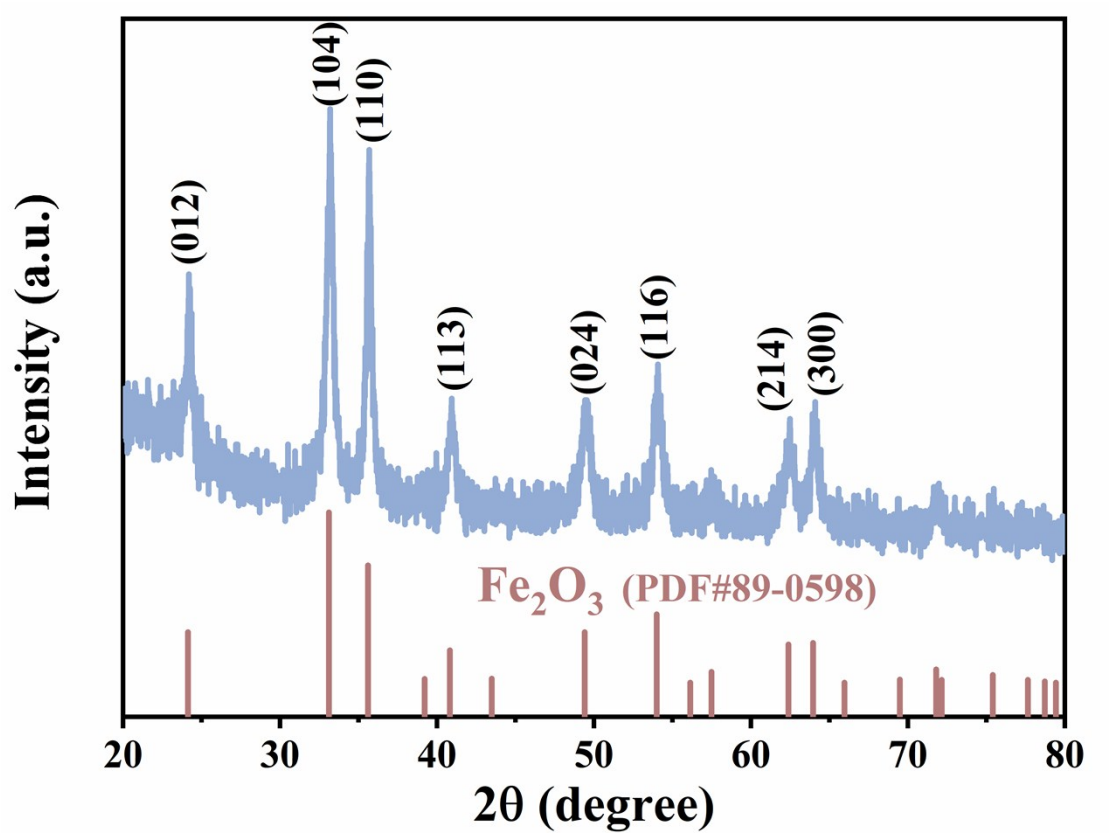

Fig. S2 XRD pattern of Fe_2O_3 nanocubes.

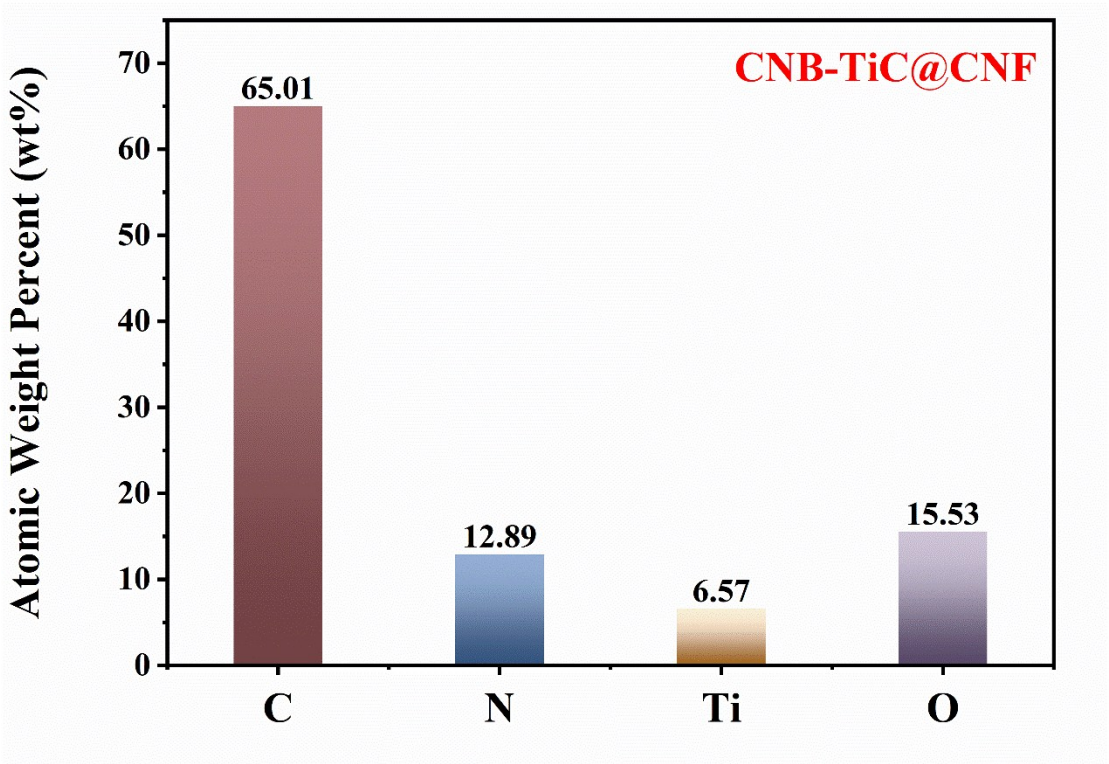

Fig. S3 Atomic weight percent of C, N, Ti, and O in the CNB-TiC@CNF.

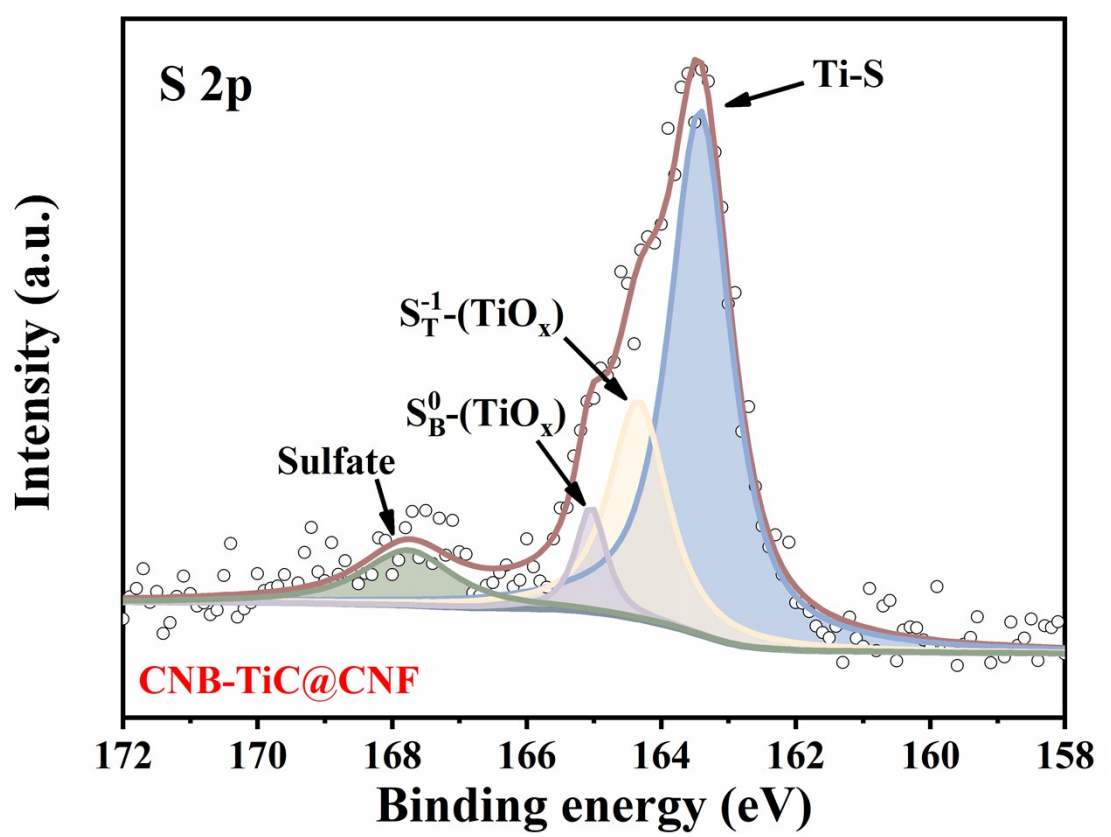

Fig. S4 High-resolution XPS spectrum of S 2p of the CNB-TiC@CNF after adsorption.

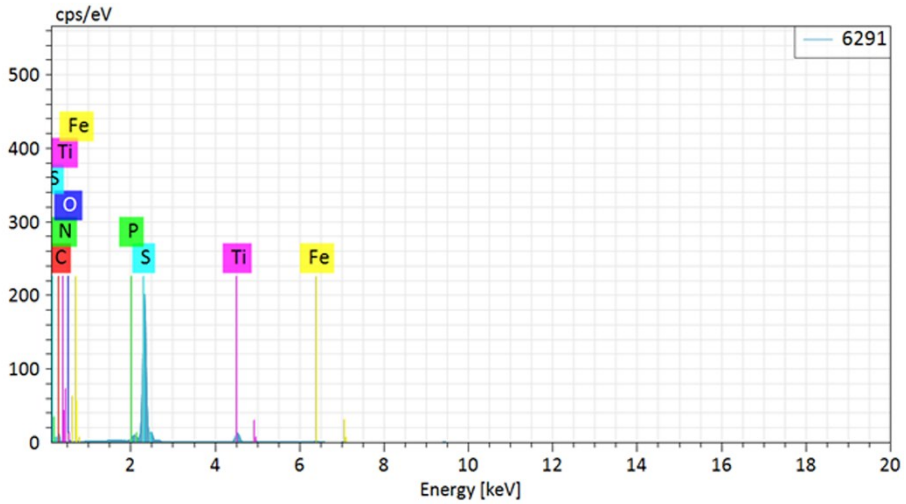

Fig. S5 EDX analysis of the CNB-TiC@CNF/S composite.

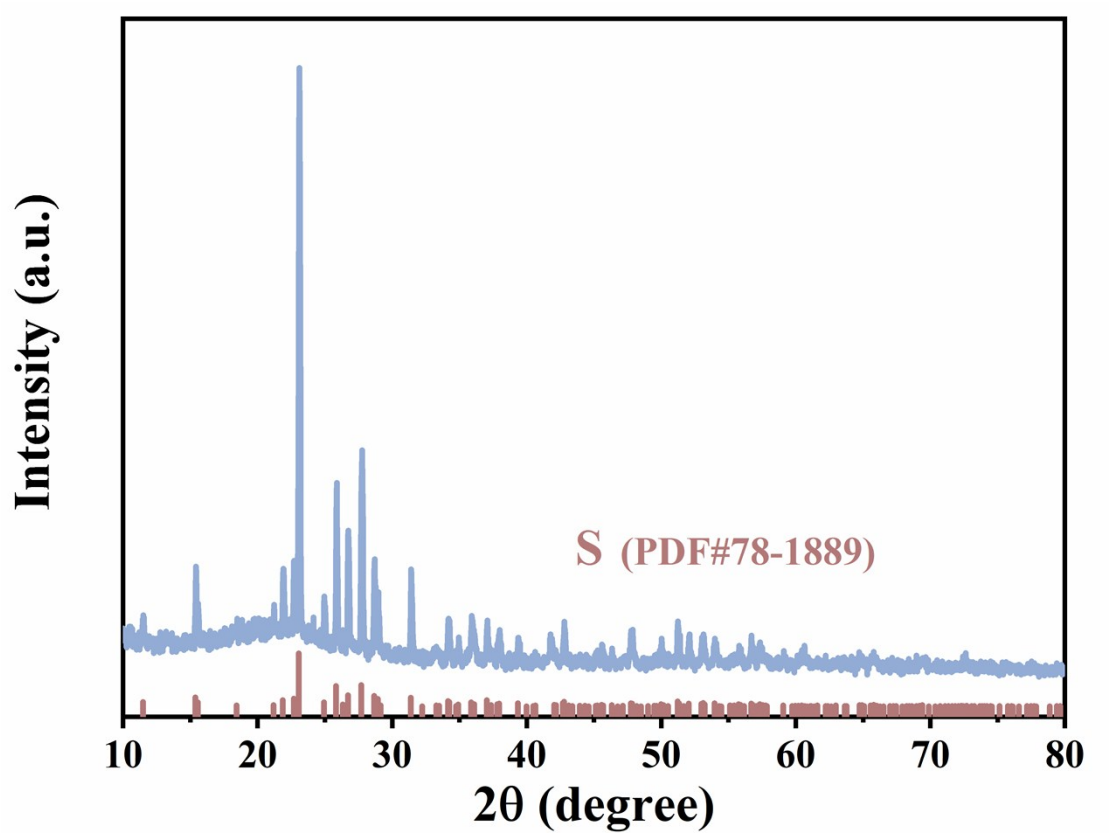

Fig. S6 XRD pattern of the CNB-TiC@CNF/S composite.

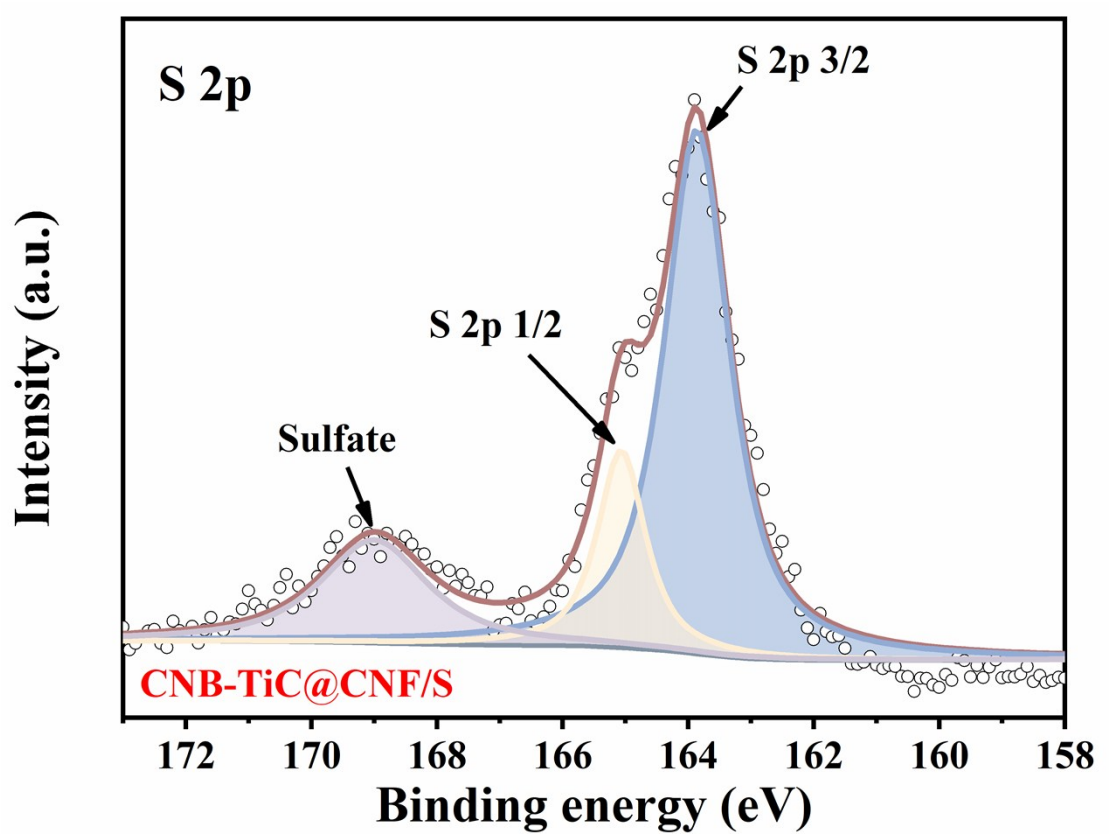

Fig. S7 High-resolution XPS spectrum of S 2p of the CNB-TiC@CNF/S composite.

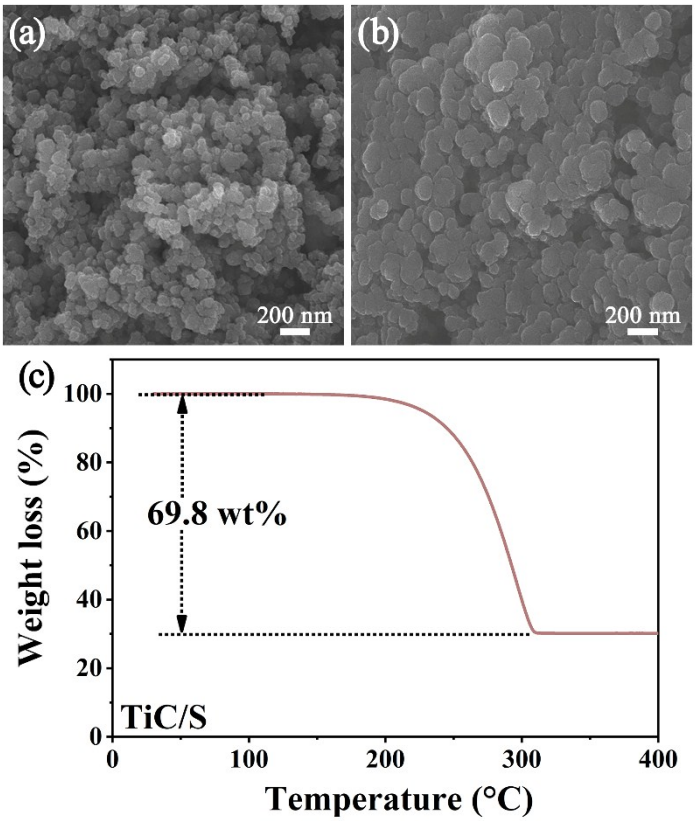

Fig. S8 FESEM images of (a) TiC nanoparticles and (b) the TiC/S composite; (c) TGA curve of the TiC/S composite under an N_2 atmosphere with a heating rate of 10 ℃ min^{-1}.

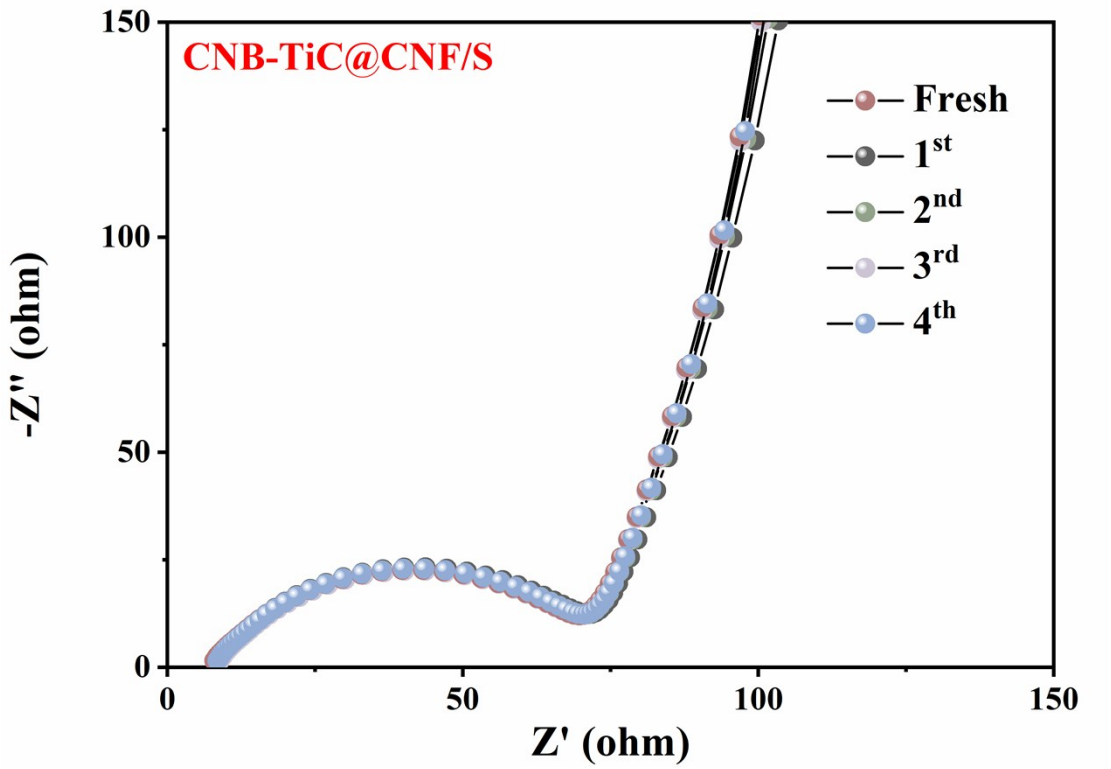

Fig. S9 Nyquist plots of the CNB-TiC@CNF/S cathode.

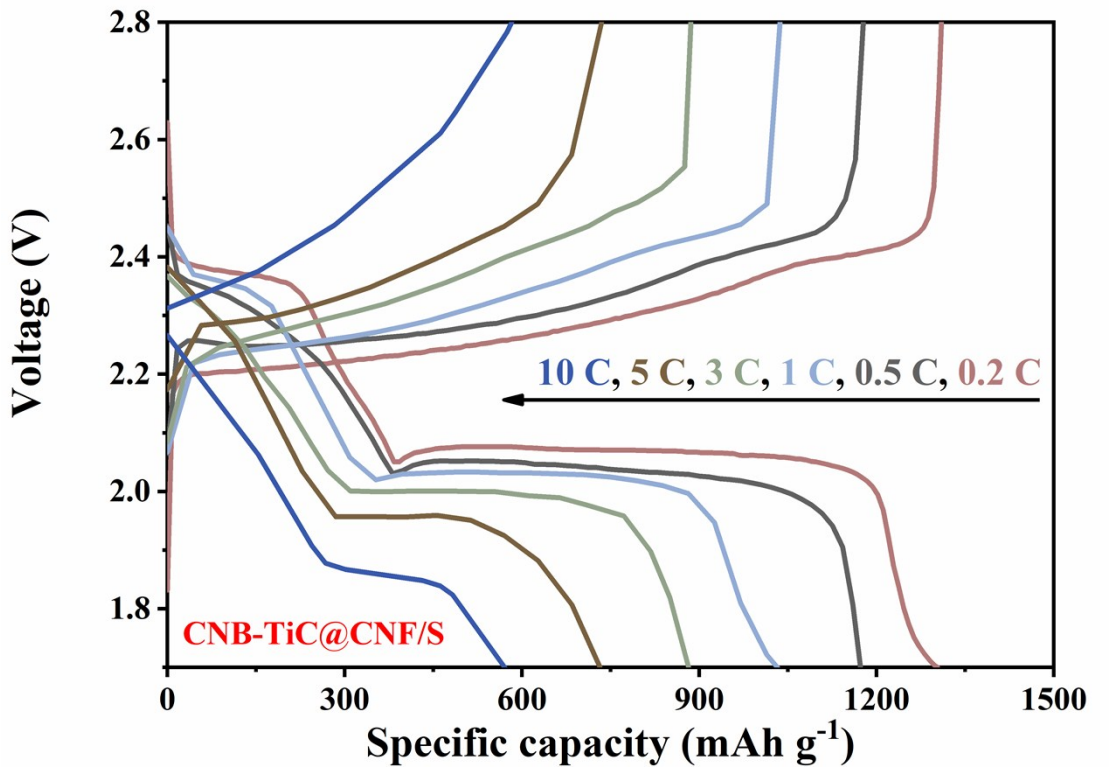

Fig. S10 Galvanostatic charge/discharge profiles of the CNB-TiC@CNF/S cathode with an areal sulfur loading of 2.0 mg cm^{-2} at various rates.

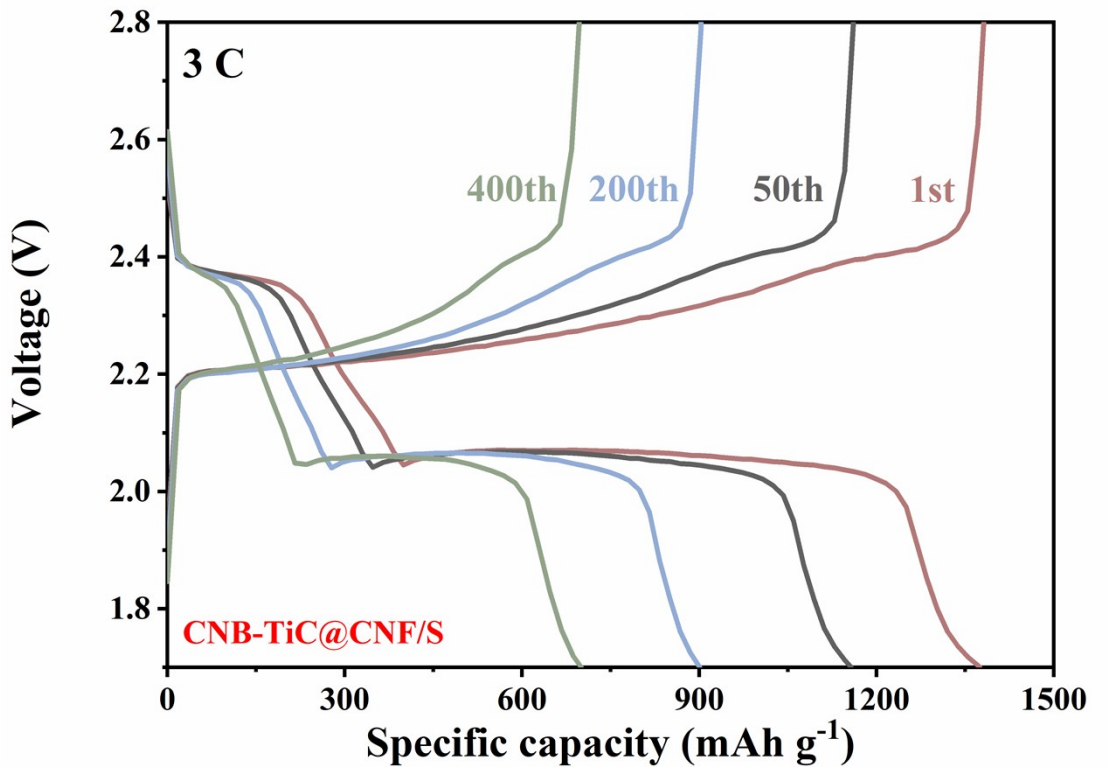

Fig. S11 Galvanostatic charge/discharge profiles of the CNB-TiC@CNF/S cathode with an areal sulfur loading of 2.0 mg cm^{-2} at 3 C.

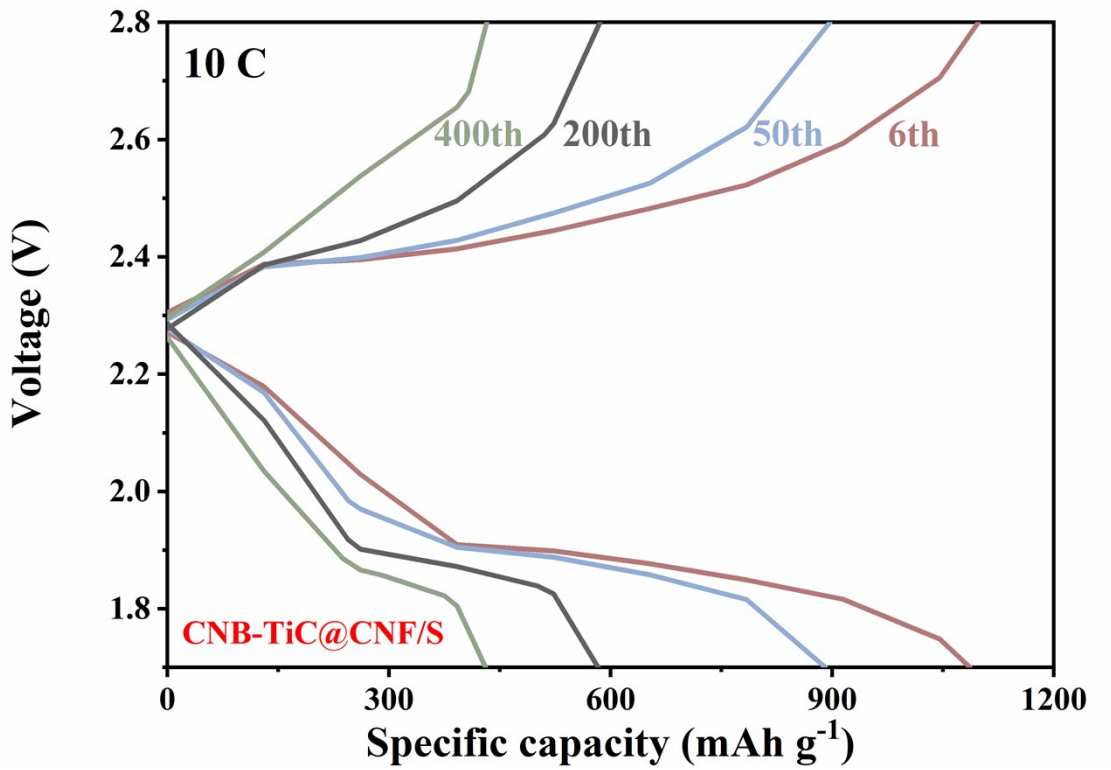

Fig. S12 Galvanostatic charge/discharge profiles of the CNB-TiC@CNF/S cathode with an areal sulfur loading of 2.0 mg cm^{-2} at 10 C.

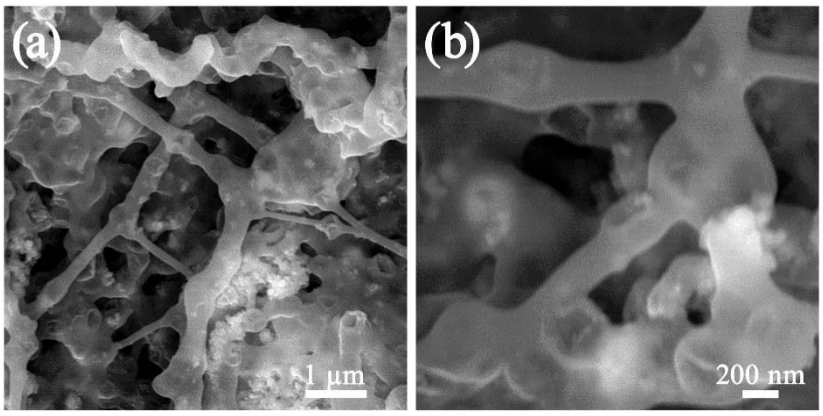

Fig. S13 FESEM images of the CNB-TiC@CNF/S composite cathode after 400 cycles at 3 C.

Electrode description	Sulfur content	Sulfur mass loading (mg cm^{-2})	Cycling stability		Rate capability		Ref.
			Initial/Final/Rate (mAh g^{-1})	Cycles	Initial/Final/Rate (mAh g^{-1})	Cycles	
CNB-TiC@CNF	76.3%	2.0	1450/1363/0.5 C	100	1375/700/3 C	400	
					1087/431/10 C	400	
		9.2	8.3/7.9 mAh cm^{-2}/0.2 C	50			
TiC	69.8%	2.0	1425/1040/0.5 C	100			
TiO@carbon hollow nanospheres	73.0%	5.0	1172/988/0.1 C	100	-/680/0.2 C	400	1
Carbonyl group functionalized porous Ni@carbon nanofibers	81.1%	1.8	1320/1070/0.2 C	100	780/-/3 C	1	2
		4.4	~840/391/0.2 C	200	470/-/3 C	1	
Hierarchical porous carbon fibers	66.0%	2.0	1071/946/0.5 C	100	627/-/2 C	1	3
Porous carbon nanofibers	67.4%	0.8-1.2	500/340/0.5 C	100	280/-/2 C	1	4
Porous carbon nanofibers	80%	1.0	954/795/0.5 C	350	602/601/2 C	350	5
		2.0	788/600/0.5 C	350	NG	NG	
3D porous N@carbon nanofibers	71%	NG	1094/831/0.5 C	300	867/624/1 C	200	6
Honeycomb-like hierarchical porous carbon nanofibers-nanotubes	68.4%	NG	1303/809/0.5 C	300	685/-/2 C	1	7
Binder-free carbon nanofibers/Li_2S_8	32.3%	6.5	-/3.5 mAh cm^{-2}/0.1 C	80	2-3 mAh $^{-2}$/-/0.2 C	1	8
Freestanding Mn_3O_4@carbon nanofibers	50.0%	5.0	728/561/0.5 C	200	NG	NG	9
		6.0	1130/780/0.1 C	100	1180/700/0.2 C	100	

		11	12.3/6.3/0.1 C	100	NG	NG	
CeF_3@porous carbon nanofibers	75.0%	NG	1395/901/0.5 C	500	1169/547/2 C	500	10
Free-standing porous carbon nanofibers	40.0%	0.8	1592/637/50 mA g^{-1}	100	437/-/1000 mA g^{-1}	1	11
SiO_2/activated carbon nanofibers	70.0%	2.0	806/584/0.5 C	300	867/513/1 C	300	12
Yolk-shell carbon fiber network	70.0%	4.0	1083/1041/0.2 C	100	845/700/1 C	500	13
		12.0	-/11.9 mAh cm^{-2}/0.1 C	50	NG	NG	
Stringed "tube on cube" nanohybrid	75.2%	NG	1286/1060/0.2 C	50	~1080/700/1 C	2000	14
		9.2	~7.1/6.8 mAh cm^{-2}/0.2 C	50	NG	NG	
Coaxial carbon@MnO hollow nanfibers	70.0%	2.5	960/908/0.5 C	150	681/338/2 C	1000	15
Double-shelled NiO-$NiCo_2O_4$@carbon	73.0%	NG	1017/717/0.5 C	500	698/-/2 C	1	16
Hollow core-shell interlinked carbon spheres	70.0%	1.0	~1150/960/0.5 C	200	-/730/4 C	200	17
Brain-coral-like hollow CoS_2@carbon	70.0%	1.3 ± 0.2	1546/900/0.1 C	100	600/519/1 C	300	18
Pomegranate-like porous carbon microspheres	70.0%	2.0	932/489/0.5 C	700	723/673/4 C	500	19
MnO_2 nanosheet decorated hollow spheres	75.5%	1.7-2.1	1110/644/0.5 C	1500	~989/555/2 C	750	20

Table S1. The comparisons of electrospun nondoped carbon host materials (blue), electrospun-doped carbon host materials (orange), and non-electrospun hollow carbon host (green) for Li-S batteries.

References

1 Z. Li, B. Y. Guan, J. Zhang and X. W. Lou, *Joule*, 2017, **1**, 576-587.

2 Q. Li, J. Guo, J. Zhao, C. Wang and F. Yan, *Nanoscale*, 2019, **11**, 647-655.

3 Z. Gong, Q. Wu, F. Wang, X. Li, X. Fan, H. Yang and Z. Luo, *RSC Adv.*, 2016, **6**, 37443-37451.

4 L. Huang, J. Cheng, G. Qu, X. Li, Y. Hu, W. Ni, D. Yuan, Y. Zhang and B. Wang, *RSC Adv.*, 2015, **5**, 23749-23757.

5 W. Kang, L. Fan, N. Deng, H. Zhao, Q. Li, M. Naebe, J. Yan and B. Cheng, *Chem. Eng. J.*, 2018, **333**, 185-190.

6 Y. Liang, N. Deng, J. Ju, X. Zhou, J. Yan, C. Zhong, W. Kang and B. Cheng, *Electrochim. Acta*, 2018, **281**, 257-265.

7 N. Deng, W. Kang, J. Ju, L. Fan, X. Zhuang, X. Ma, H. He, Y. Zhao and B. Cheng, *J. Power Sources*, 2017, **346**, 1-12.

8 D.-H. Lim, M. Agostini, F. Nitze, J. Manuel, J.-H. Ahn and A. Matic, *Sci. Rep.*, 2017, **7**, 6327.

9 X. Chen, L. Yuan, Z. Hao, X. Liu, J. Xiang, Z. Zhang, Y. Huang and J. Xie, *ACS Appl. Mater. Inter.*, 2018, **10**, 13406-13412.

10 N. Deng, J. Ju, J. Yan, X. Zhou, Q. Qin, K. Zhang, Y. Liang, Q. Li, W. Kang and B. Cheng, *ACS Appl. Mater. Inter.*, 2018, **10**, 12626-12638.

11 L. Zeng, F. Pan, W. Li, Y. Jiang, X. Zhong and Y. Yu, *Nanoscale*, 2014, **6**, 9579-9587.

12 J. Li, Y. Guo, P. Wen, J. Zhu, Z. Liu and Y. Qiu, *J. Electroanal. Chem.*, 2018, **823**, 287-295.

13 L. Lin, F. Pei, J. Peng, A. Fu, J. Cui, X. Fang and N. Zheng, *Nano Energy*, 2018, **54**, 50-58.

14 G. Li, W. Lei, D. Luo, Y. Deng, Z. Deng, D. Wang, A. Yu and Z. Chen, *Energ. Environ. Sci.*, 2018, **11**, 2372-2381.

15 L. Ni, G. Zhao, Y. Wang, Z. Wu, W. Wang, Y. Liao, G. Yang and G. Diao, *Chem-Asian J.*, 2017, **12**, 3128-3134.

16 L. Hu, C. Dai, H. Liu, Y. Li, B. Shen, Y. Chen, S.-J. Bao and M. Xu, *Adv. Energy Mater.*, 2018, **8**, 1800709.

17 Q. Sun, B. He, X.-Q. Zhang and A.-H. Lu, *ACS Nano*, 2015, **9**, 8504-8513.

18 S.-D. Seo, D. Park, S. Park and D.-W. Kim, *Adv. Funct. Mater.*, 2019, **29**, 1903712.

19 S. Liu, T. Zhao, X. Tan, L. Guo, J. Wu, X. Kang, H. Wang, L. Sun and W. Chu, *Nano Energy*, 2019, **63**, 103894.

20 X. Wang, G. Li, J. Li, Y. Zhang, A. Wook, A. Yu and Z. Chen, *Energ. Environ. Sci.*, 2016, **9**, 2533-2538.