Supporting Information

Insight into different-microstructured ZnO/graphene functionalized separators affecting the performance of lithium–sulfur batteries

Nianxiang Shi,[a] Baojuan Xi,[*a] Zhenyu Feng,[a] Fangfang Wu,[a] Denghu Wei,[b] Jing Liu,[c] and Shenglin Xiong[a,*]

[a] Key Laboratory of the Colloid and Interface Chemistry, Ministry of Education, and School of Chemistry and Chemical Engineering, Shandong University, Jinan, 250100, PR China

[b] School of Materials Science and Engineering, Liaocheng University, Liaocheng, Shandong 252059, PR China

[c] College of Materials Science and Engineering, Qingdao University of Science and Technology, Qingdao 266042, China

*Correspondence and requests for materials should be addressed to B. J. Xi (email: bajuanxi@sdu.edu.cn)

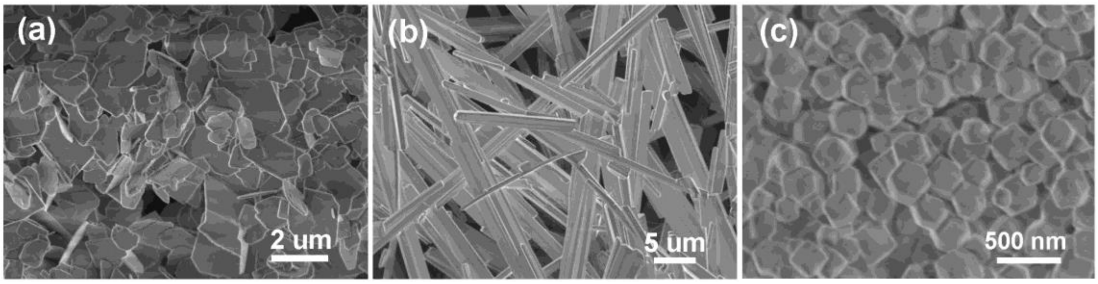

Figure S1. The SEM images of different dimensional ZnO precursors.

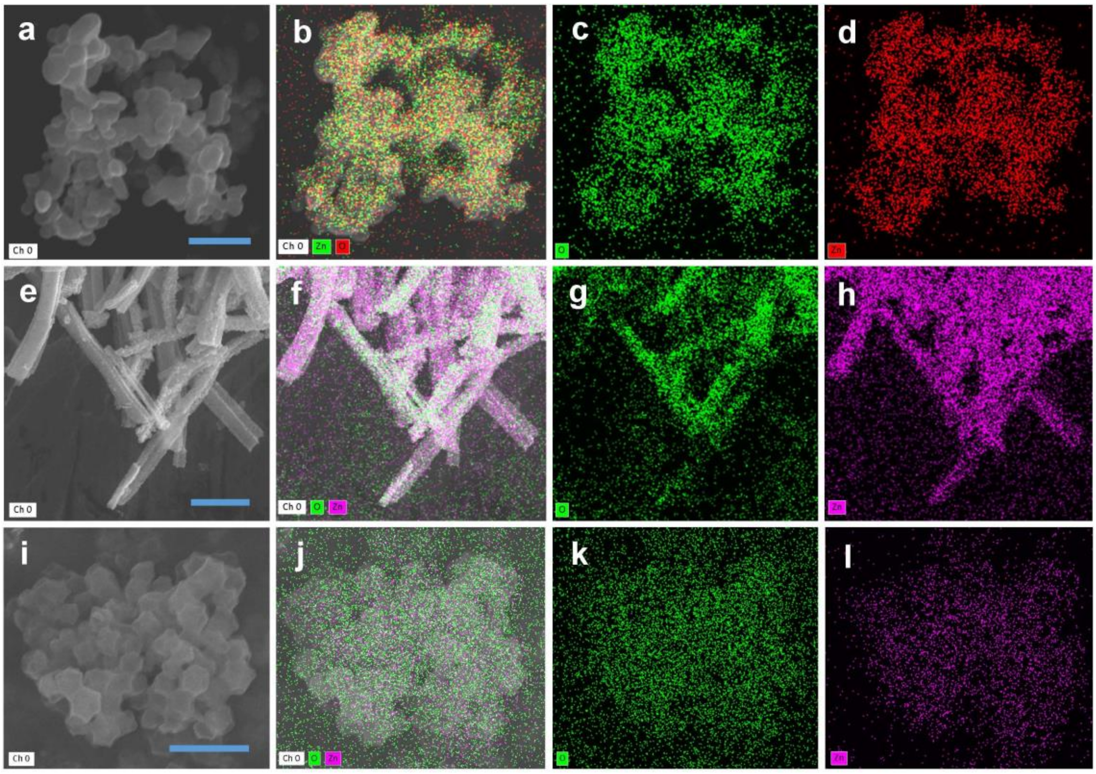

Figure S2. The elemental mappings images of 0D (a-d), 1D (e-h) and 3D (i-l) ZnO. Scale bar: (a) 350 nm (e) 3.5 μm, (i) 500 nm.

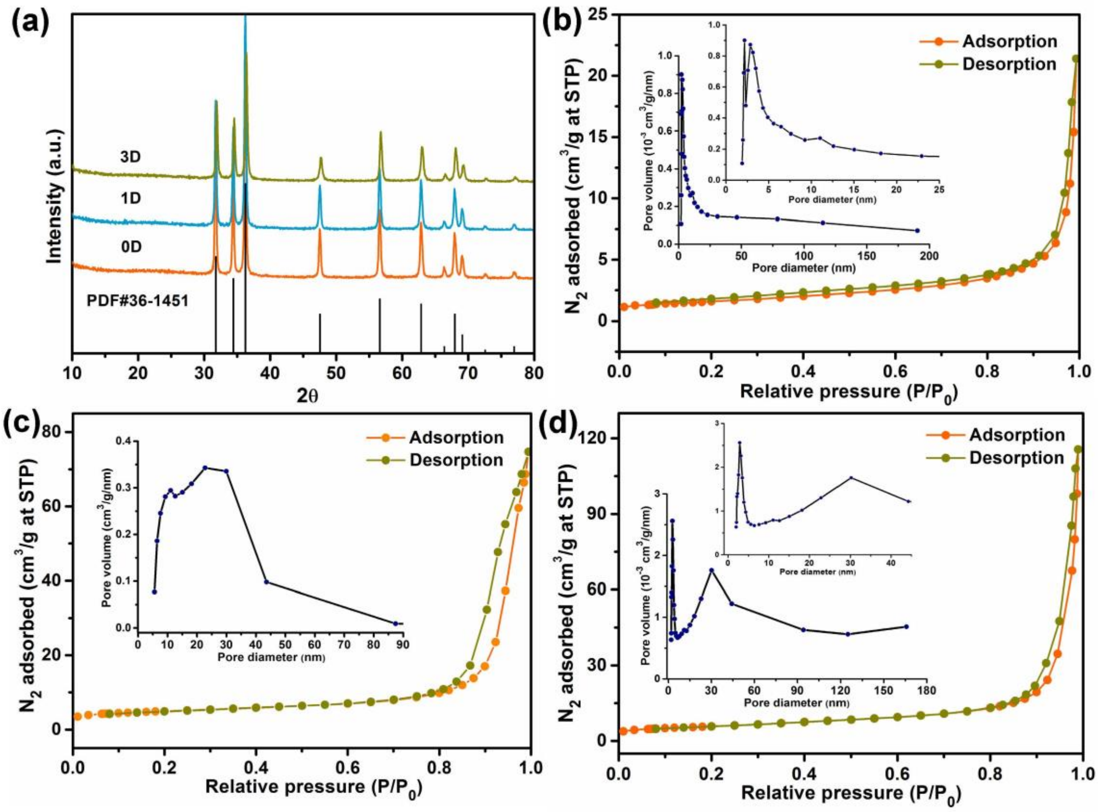

Figure S3. (a) The XRD patterns, (b-d) N_2 adsorption-desorption isotherms and pore-size distribution curves of 0D, 1D and 3D ZnO.

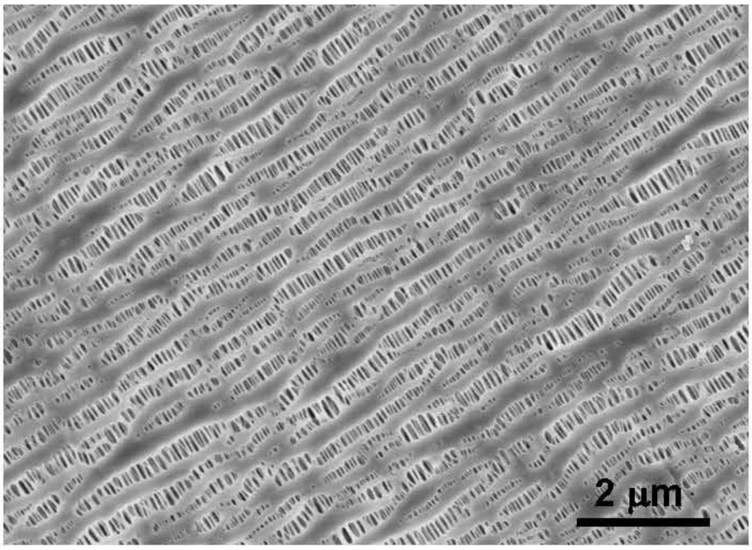

Figure S4. FESEM image of the pristine 2400 Celgard film.

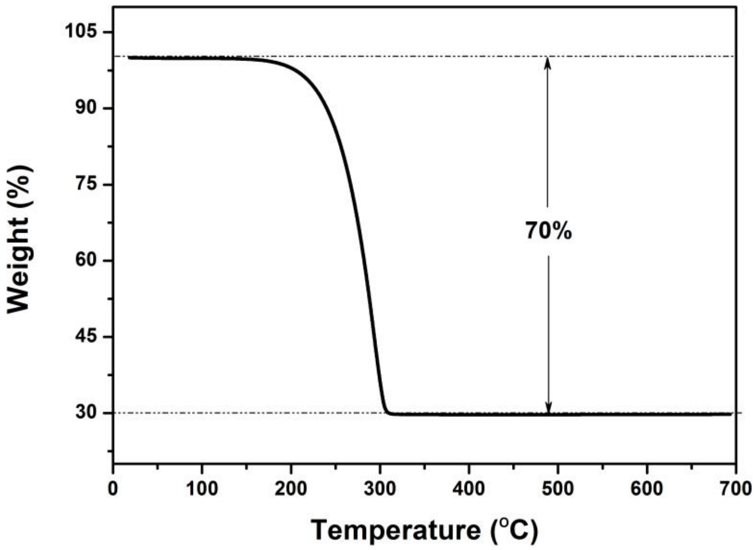

Figure S5. The TGA curve of the composite of carbon black and sulfur.

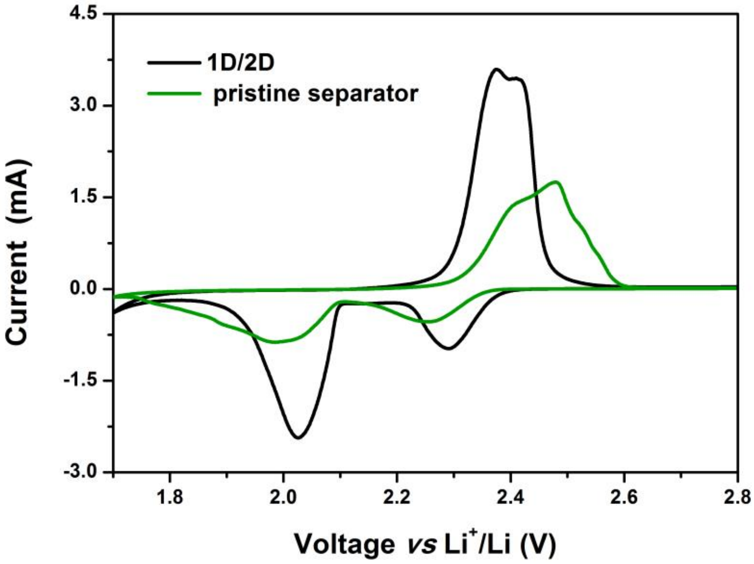

Figure S6. The 2nd cycle CV curves of the batteries with different separators at the scan rate of 0.1 mV s^{-1}.

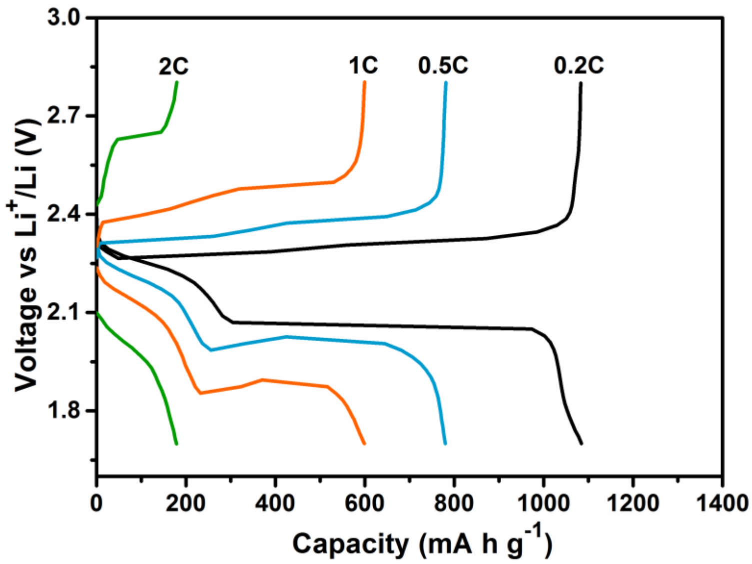

Figure S7. The galvanostatical charge/discharge curves of sulfur cell with the pristine separator.

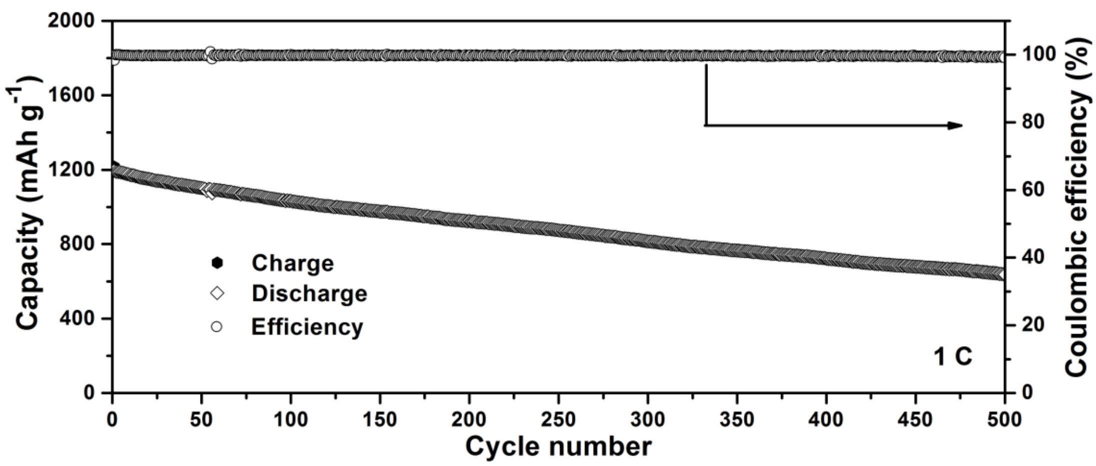

Figure S8. The long cycling performance of 1D/2D cell at the current density of 1 C.

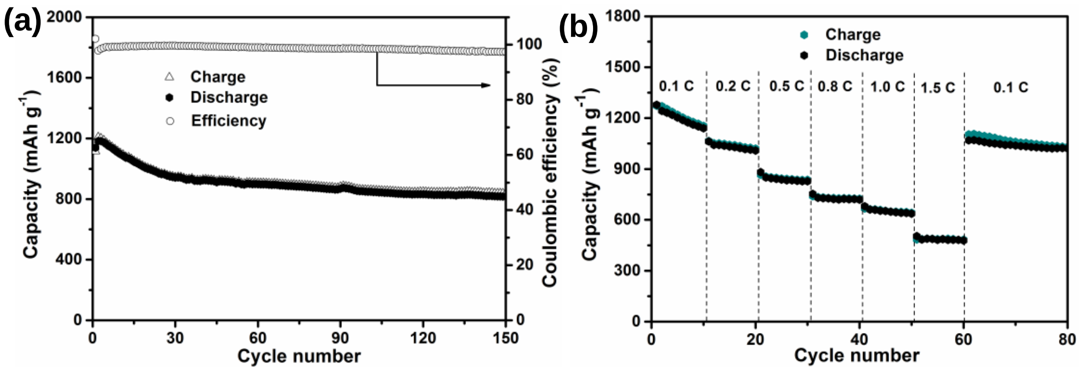

Figure S9. (a) Cycling performance at the current density of 0.2 C and (b) rate capability at various current densities of the sulfur cell with an areal sulfur mass of 3.5 mg/cm^2 and 1D/2D membrane.

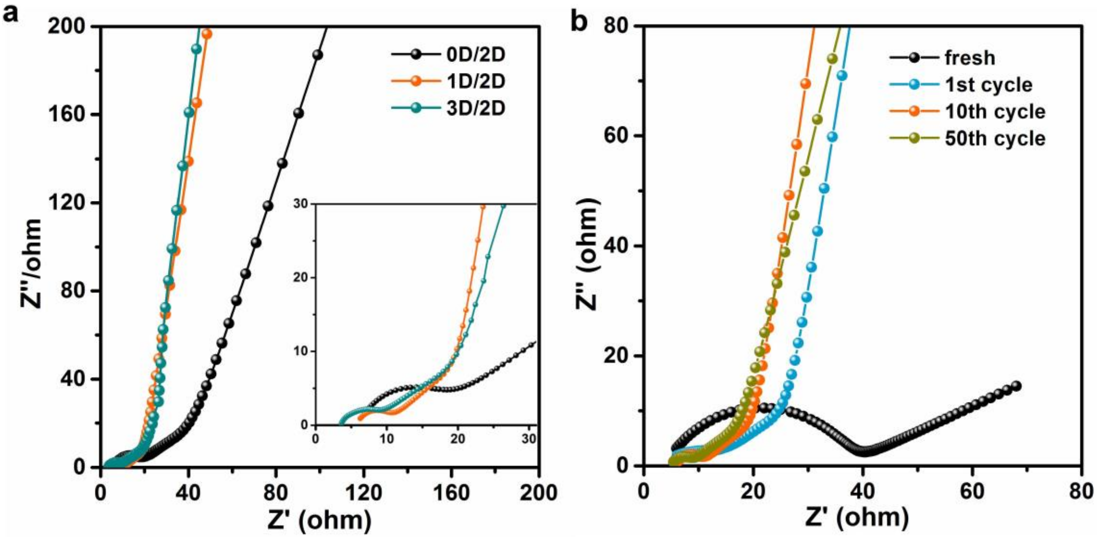

Figure S10. (a) The electrochemical impedance spectra (EIS) of cells with 0D/2D, 1D/2D and 3D/2D separators after 10 cycles at the current density of 0.2 C. (b) The EIS of the cell with 1D/2D separator after different discharge/charge cycles at 0.2 C.

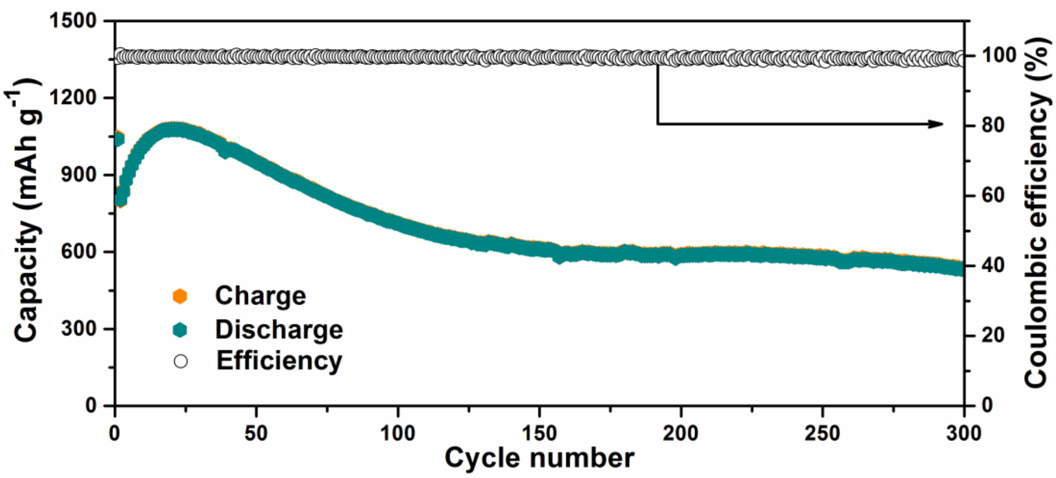

Figure S11. The cycling performance of the cell with 2D graphene coated separator at the current density of 2 C.

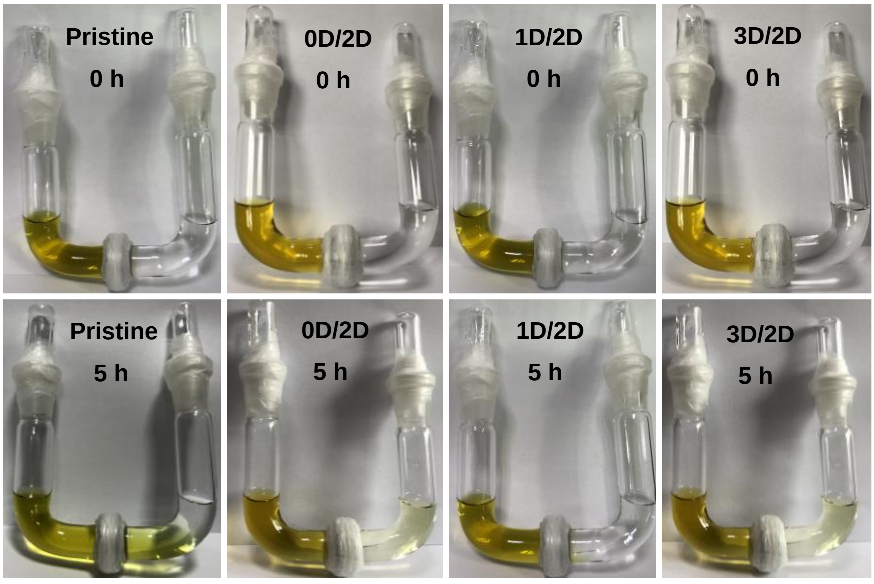

Figure S12. The polysulfide permeability experiments of different functional separators.

Table S1. Comparison of the performance with the recently reported LBSs.

Sample	Coated mass (mg/cm^2)	Discharge capacity	Rate performance	Ref
ZnO/graphene	0.4	927.1 mAh g^{-1} / 200 cycles at 1.0 C 641.6 mAh g^{-1} / 500 cycles at 1.0 C	807.5 mAh g^{-1} at 4.0 C 754.1 mAh g^{-1} at 6.0 C	This work
G-LTO@PP	0.346	697 mAh g^{-1} / 500 cycles at 1.0 C	780 mAh g^{-1} at 1.0 C 709 mAh g^{-1} at 2.0 C	[S1]
PAN/GO		597 mAh g^{-1} / 100 cycles at 0.2 C	448 mAh g^{-1} at 1.0 C 337 mAh g^{-1} at 2.0 C	[S2]
PG	0.54	877 mAh g^{-1} / 150 cycles at 0.5 C	479 mAh g^{-1} at 5.0 C	[S3]
En GPA	1.22	800 mAh g^{-1}/100 cycles at 0.2 C	780 mAh g^{-1} at 2.0 C	[S4]
MBOH/CNT	0.3	785 mAh g^{-1} / 200 cycles at 0.5 C	624 mAh g^{-1} at 4.0 C 500 mAh g^{-1} at 6.0 C	[S5]
HNCF@pδ-MnO_2		856.1 mAh g^{-1} / 200 cycles at 0.5 C	554 mAh g^{-1} at 2.0 C	[S6]
MWCNTs/NCQDs	0.15	650.7 mAh g^{-1} / 500 cycles at 0.5 C	666.7 mAh g^{-1} at 3.0 C	[S7]
rGO@MoS_2	0.24	368 mAh g^{-1} / 500 cycles at 1.0 C	745 mAh g^{-1} at 1.0 C 615 mAh g^{-1} at 2.0 C	[S8]
PG-Fe_3O_4	0.478	659 mAh g^{-1} / 497 cycles at 1.0 C	673 mAh g^{-1} at 1.0 C 589 mAh g^{-1} at 2.0 C	[S9]
Ti_3C_2	0.32	721 mAh g^{-1} / 100 cycles at 0.5 A g^{-1}	476 mAh g^{-1} at 2.0 A g^{-1}	[S10]
phosphorus	0.4	800 mAh g^{-1} / 100 cycles at 0.5 A g^{-1}	725 mAh g^{-1} at 1.8 A g^{-1} 623 mAh g^{-1} at 3.5 A g^{-1}	[S11]
HCCP/rGO		565.2 mAh g^{-1} / 130 cycles at 1.0 A g^{-1}		[S12]
CNT@ZIF	0.9	870 mAh g^{-1} / 100 cycles at 0.2 C	750.5 mAh g^{-1} at 1.0 C 583.2 mAh g^{-1} at 2.0 C	[S13]
CNT/MoP_2		543 mAh g^{-1} / 500 cycles at 0.1 C	521 mAh g^{-1} at 2.0 C 360 mAh g^{-1} at 5.0 C	[S14]
LNS/CB	0.7	838 mAh g^{-1} / 500 cycles at 0.2 C	758 mAh g^{-1} at 2.0 C	[S15]

[S1] Y. Zhao, M. Liu, W. Lv, Y.-B. He, C. Wang, Q. Yun, B. Li, F. Kang, Q.-H. Yang, *Nano Energy* **2016**, *30*, 1.

[S2] J. Zhu, C. Chen, Y. Lu, J. Zang, M. Jiang, D. Kim, X. Zhang, *Carbon* **2016**, *101*, 272.

[S3] P.-Y. Zhai, H.-J. Peng, X.-B. Cheng, L. Zhu, J.-Q. Huang, W. Zhu, Q. Zhang, *Energy Storage Materials* **2017**, *7*, 56.

[S4] R. Song, R. Fang, L. Wen, Y. Shi, S. Wang, F. Li, *J. Power Source* **2016**, *301*, 179.

[S5] L. Kong, H.-J. Peng, J.-Q. Huang, W. Zhu, G. Zhang, Z.-W. Zhang, P.-Y. Zhai, P. Sun, J. Xie, Q. Zhang, *Energy Storage Materials* **2017**, *8*, 153.

[S6] Y. Lai, P. Wang, F. Qin, M. Xu, J. Li, K. Zhang, Z. Zhang, *Energy Storage Materials* **2017**, *9*, 179.

[S7] Y. Pang, J. Wei, Y. Wang, Y. Xia, *Adv. Energy Mater.* **2018**, *8*, 1702288.

[S8] L. Tan, X. Li, Z. Wang, H. Guo, J. Wang, *ACS Appl. Mater. Interfaces* **2018**, *10*, 3707.

[S9] Y. Liu, X. Qin, S. Zhang, G. Liang, F. Kang, G. Chen, B. Li, *ACS Appl. Mater. Interfaces* **2018**, *10*, 26264.

[S10] C. Lin, W. Zhang, L. Wang, Z. Wang, W. Zhao, W. Duan, Z. Zhao, B. Liu, J. Jin, *J. Mater. Chem. A*, **2016**, *4*, 5993.

[S11] J. Sun, Y. Sun, M. Pasta, G. Zhou, Y. Li, W. Liu, F. Xiong, Y. Cui, *Adv. Mater.* **2016**, *28*, 9797.

[S12] Y. Zheng, H. Fan, H. Li, C. Fan, H. Yuan, Z. Yang, K. Huang, W. Li, J. Zhang, *Chem. Eur. J.* **2018**, *24*, 1.

[S13] F. Wu, S. Zhao, L. Chen, Y. Lu, Y. Su, Y. Jia. L. Bao, J. Wang, S. Chen, R. Chen, *Energy Storage Materials* **2018**, *14*, 383.

[S14] Y. Luo, N. Luo, W. Kong, H. Wu, K. Wang, S. Fan, W. Duan, J. Wang, *Small* **2018**, *14*, 1702853.

[S15] Y. Yang, J. Zhang, *Adv. Energy Mater.* **2018**, *8*, 1801778.