Electronic Supplementary Information

Sulfur-$FePO_4$-C Nanocomposite Cathode for Stable and Anti-Self-Discharge Lithium-Sulfur Battery

Ying Pang,[a] Yunping Wen,[a] Wangyu Li,[a] Yunhe Sun,[a] Tiancheng Zhu,[a] Yonggang Wang,†[a] Yongyao Xia,†[a]

Department of Chemistry and Shanghai Key Laboratory of Molecular Catalysis and Innovative Materials, Institute of New Energy, *iChEM* (Collaborative Innovation Center of Chemistry for Energy Materials), Fudan University, Shanghai 200433, China

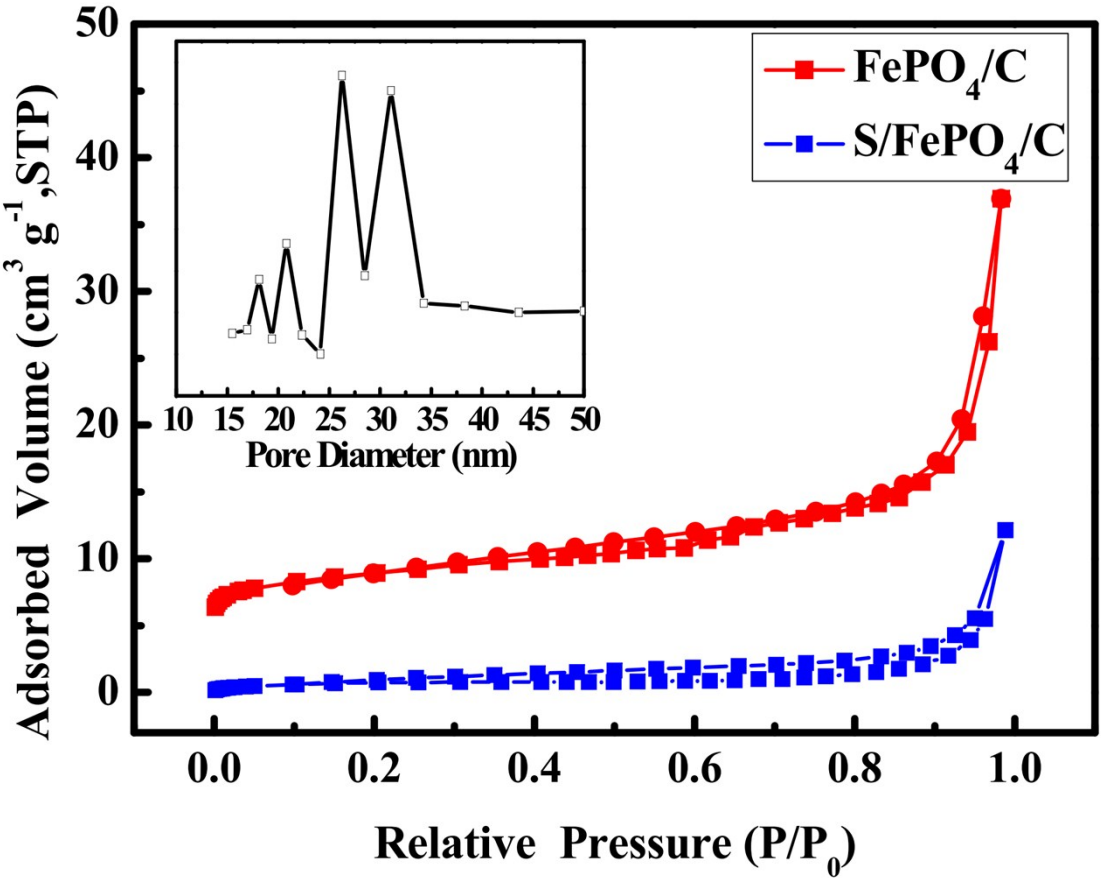

Figure S1. N_2 adsorption/desorption isotherms of $FePO_4$/C nanocomposite (red) and S/$FePO_4$/C nanocomposite (blue). The illustration is pore-size-distribution of $FePO_4$/C nanocomposite.

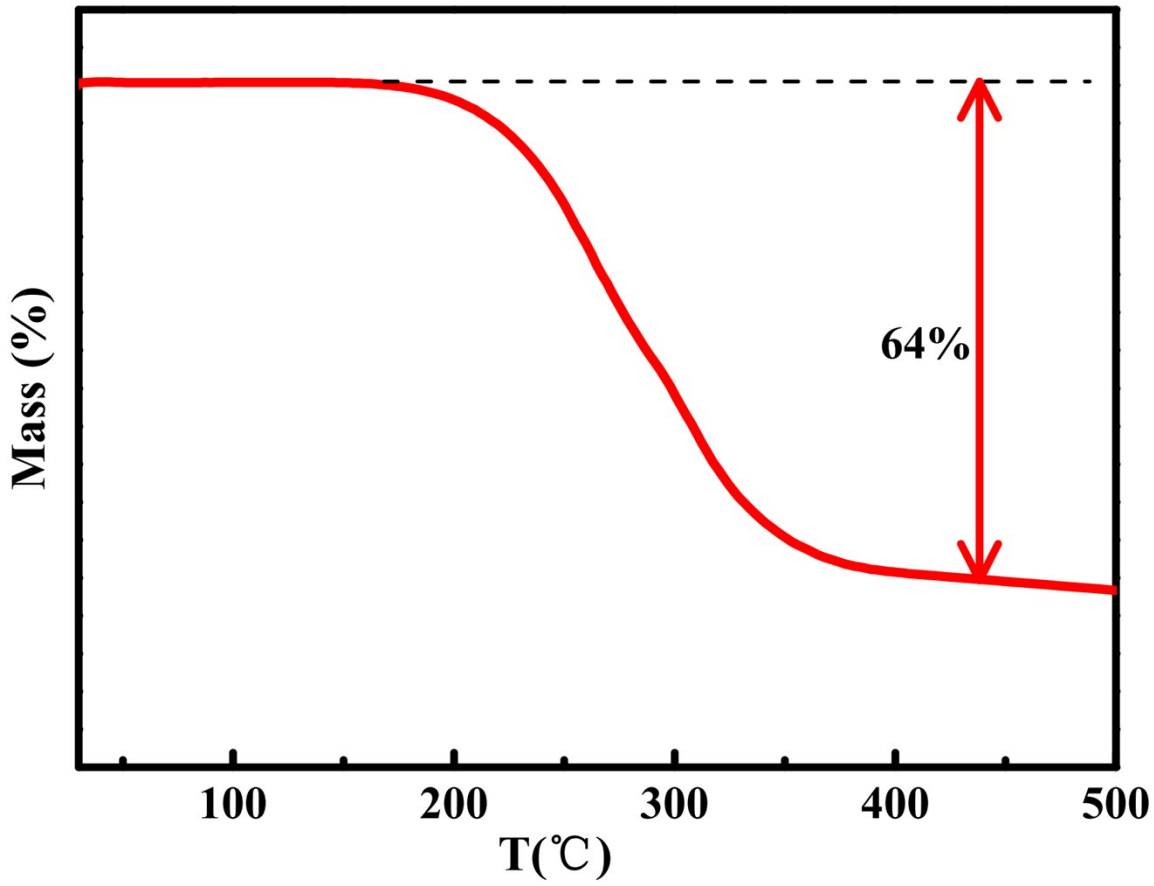

Figure S2. Thermo-gravimetric (TG) analysis of S/$FePO_4$/C nanocomposite with sulfur content of 64 wt%.

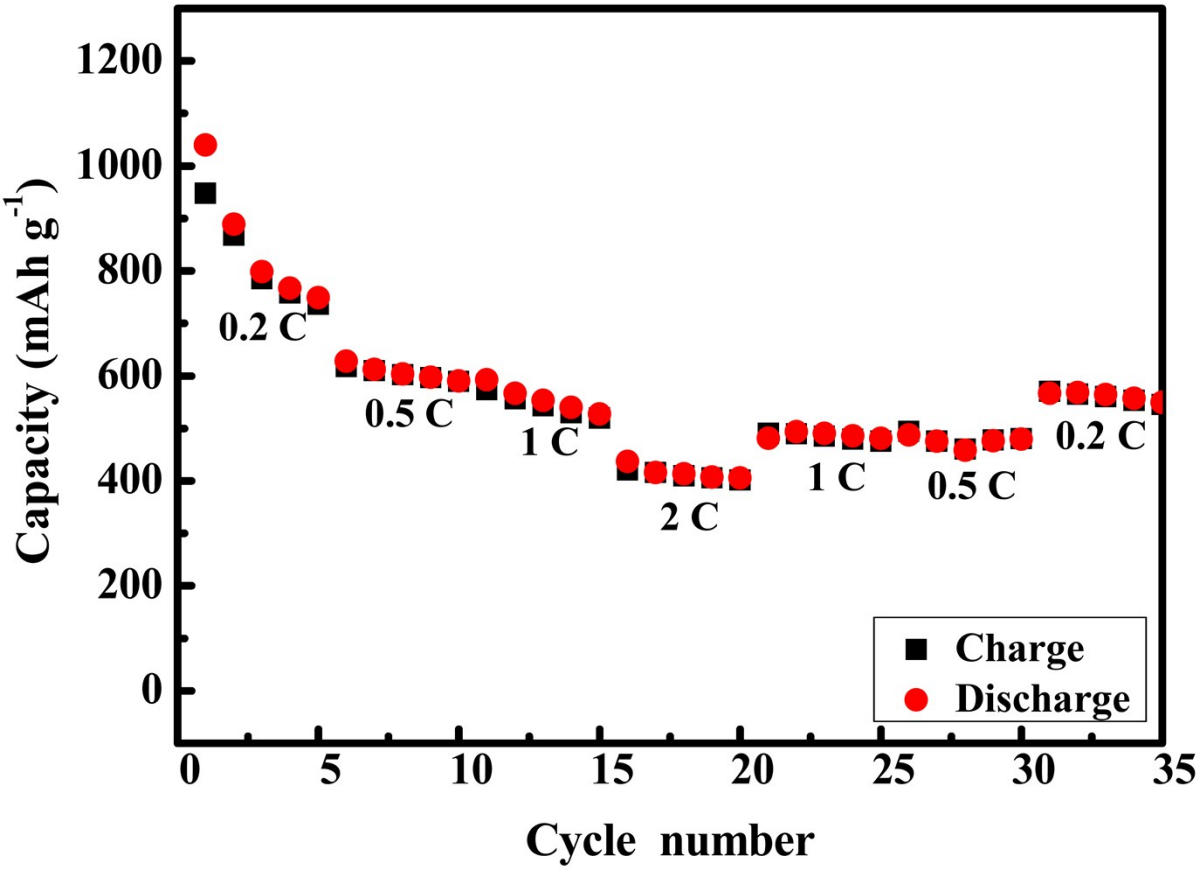

Figure S3. Rate performance of S/$FePO_4$/C-64 wt% at various current densities from 0.1 C to 2 C.

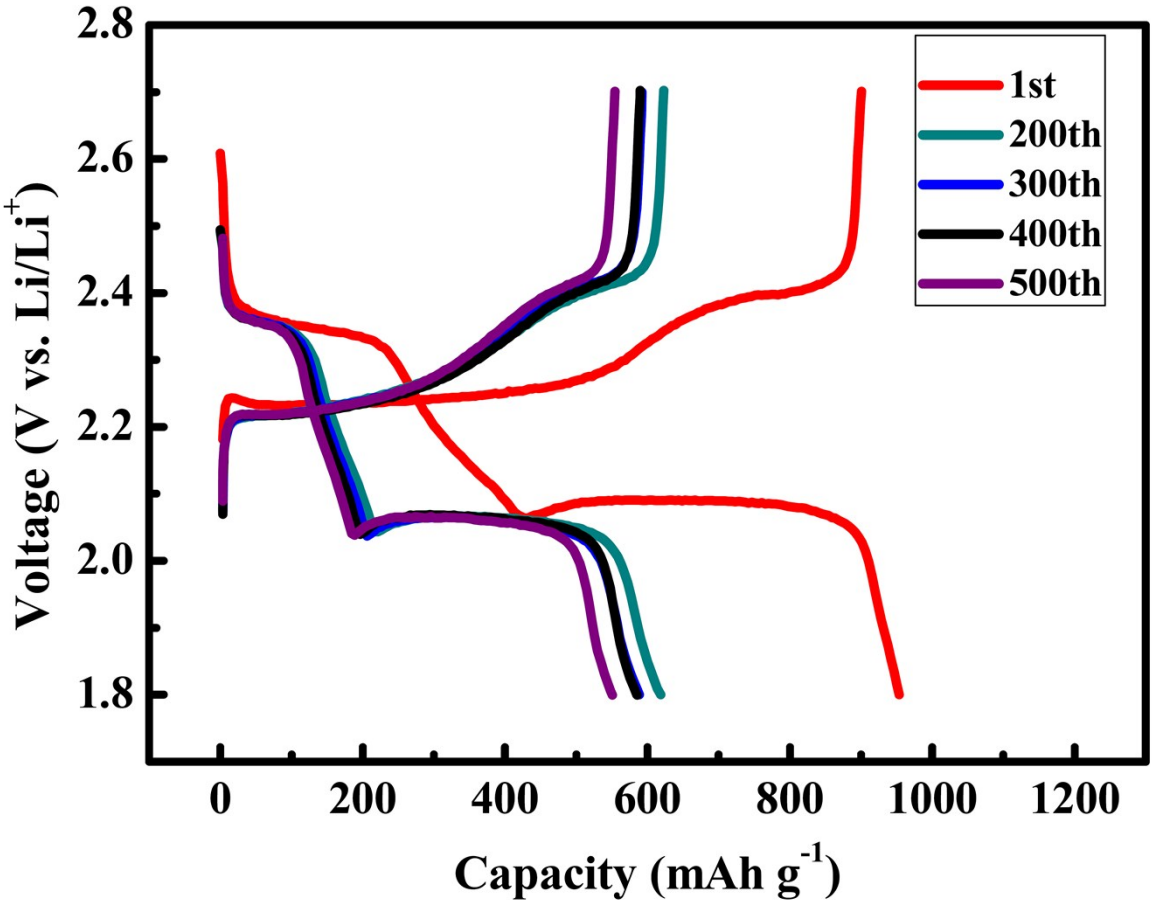

Figure S4. Charge-discharge profiles for selected cycles of S/$FePO_4$/C-64 wt% at 0.5 C.

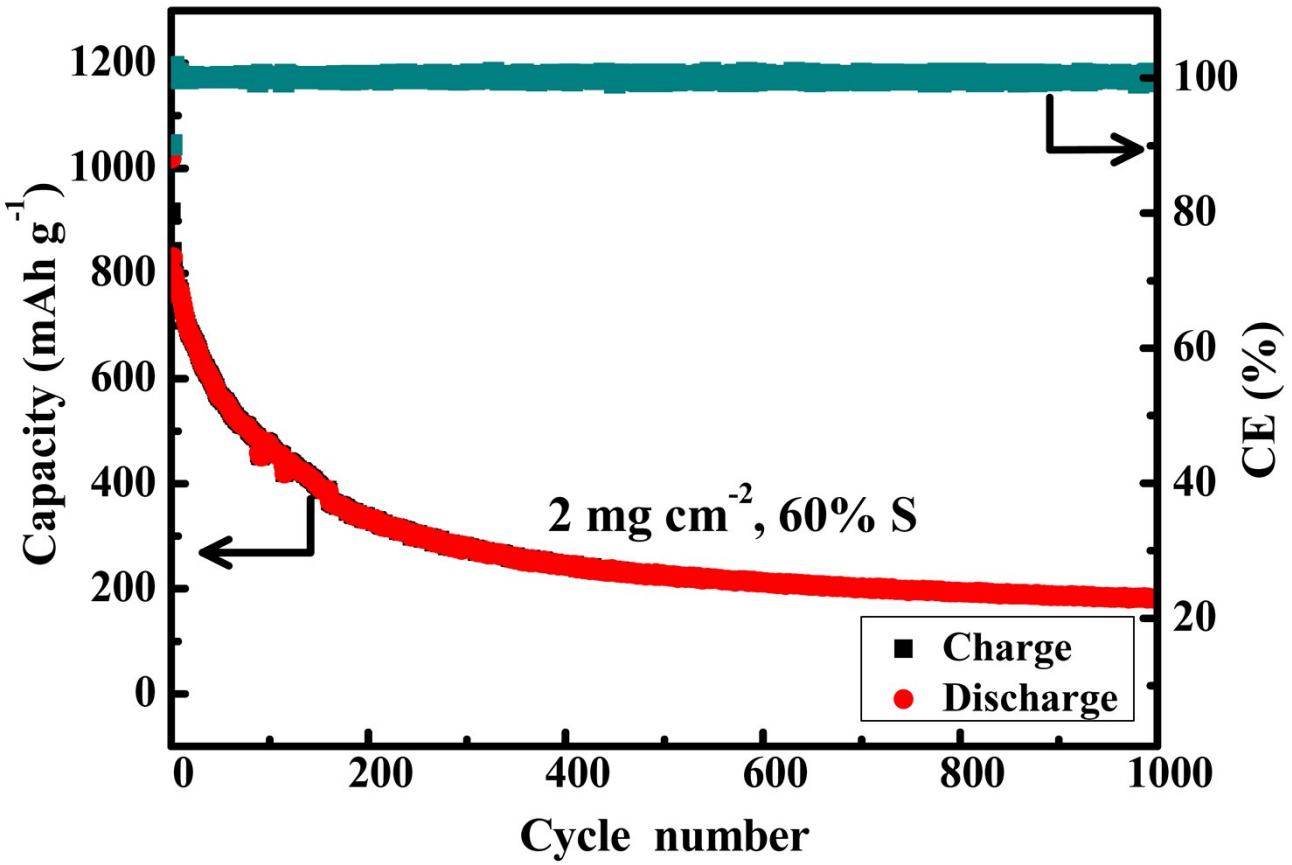

Figure S5. Cycling performance of S/KB composite with sulfur content of 60 wt% at 0.5 C.

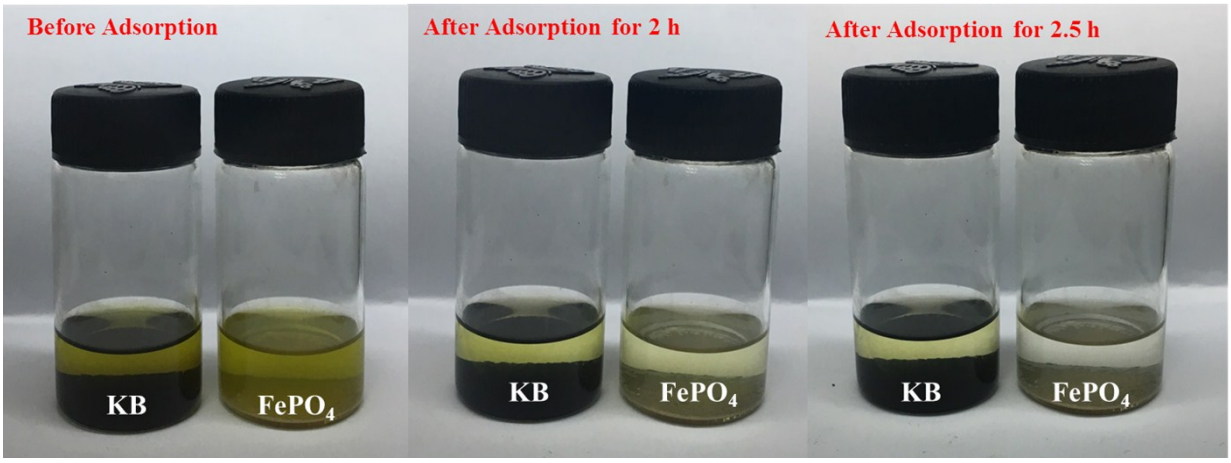

Figure S6. Photograph of sealed vials of a Li_2S_6/DME solution before and after soaking with $FePO_4$ or KB**.** The adsorption test was performed by adding 20 mg KB or $FePO_4$ to 0.002M Li_2S_6 solution. Li_2S_6 solution was prepared by adding Li_2S and sulfur at a molar ratio of 1:5 in DME.

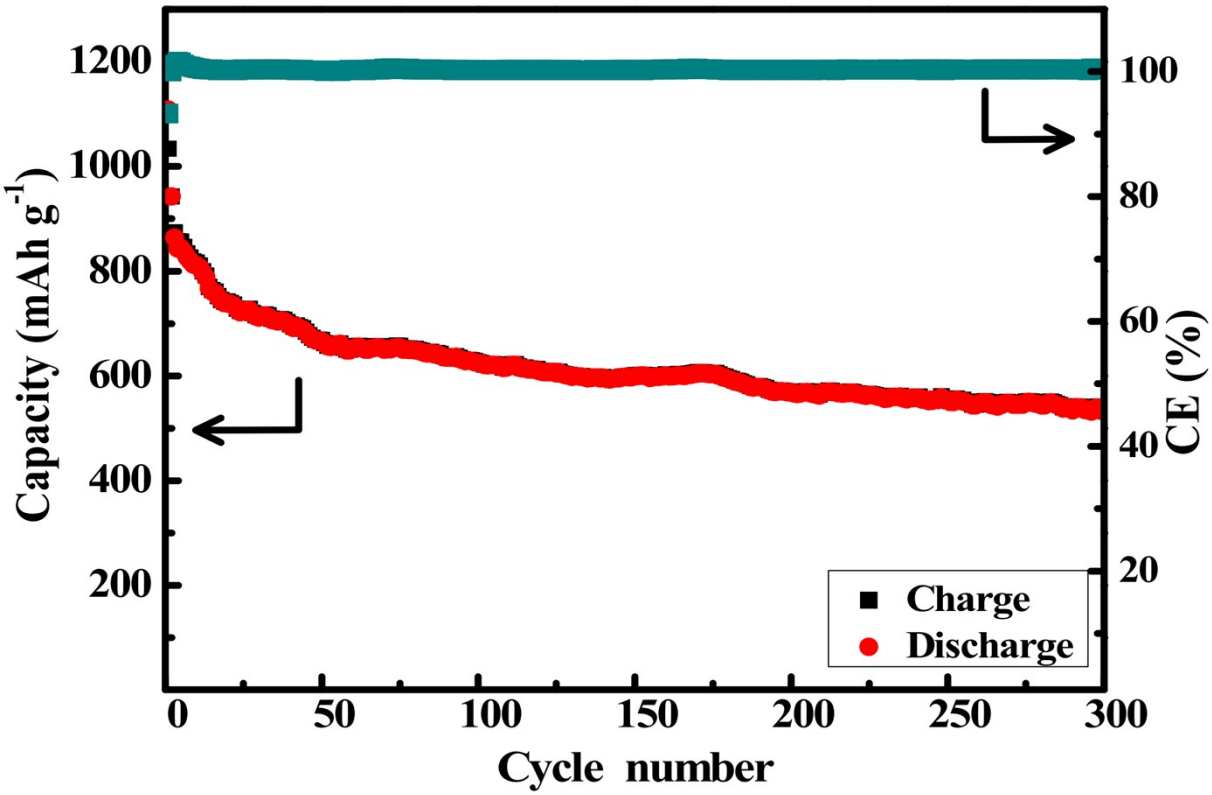

Figure S7. Cycling performance of S/$FePO_4$/C-64 wt% at 0.2 C.

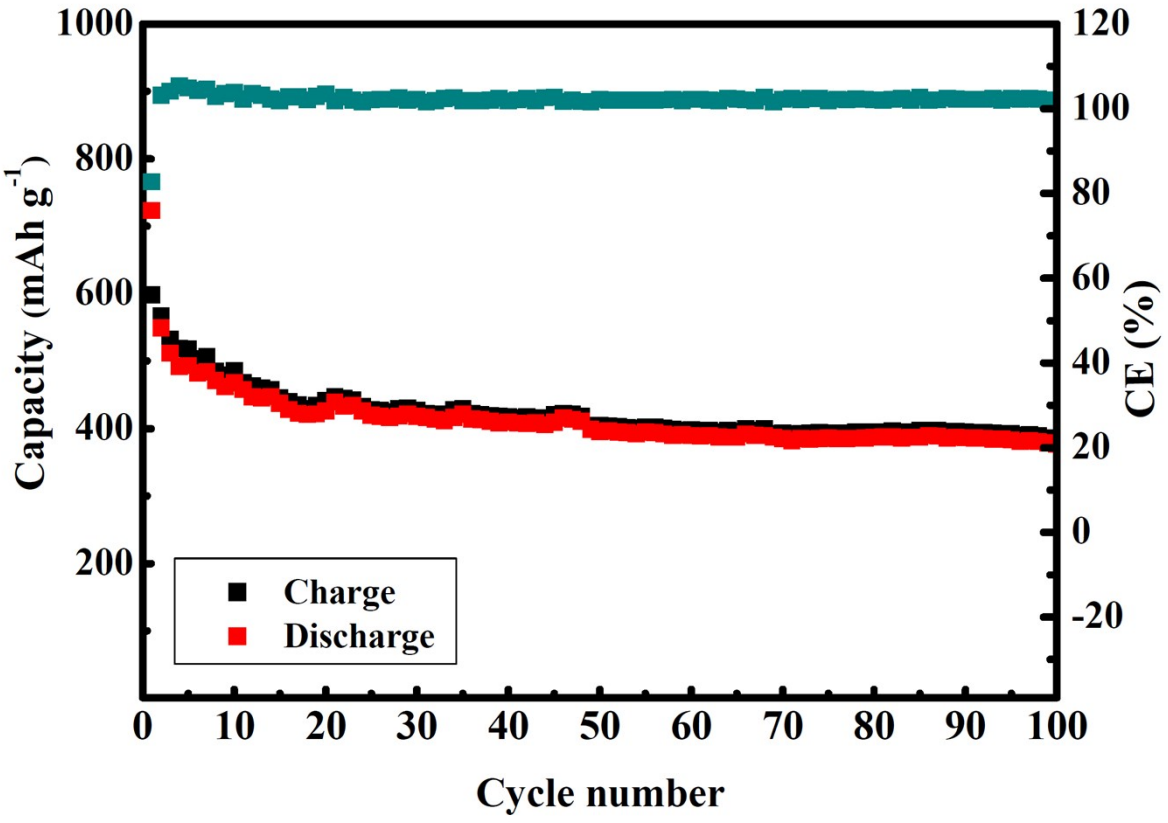

Figure S8. Electrochemical performance of S/$FePO_4$/C-64 wt% with a total mass loading of 6 mg cm^{-2} on the electrode at 0.5 C.

Table S1 Electrochemical performance of Li-S batteries basing on different cathodes

Sample	S content in the cathode (%)	Mass loading (mg cm^{-2})	Achieved cycle number	Ref.
S/spherical carbon	61.4	0.78	100	12
S/CNT@MPC	40	1	200	15
S/carbon spheres	42	3	100	18
S/ N-Doped Carbon	80	1	50	19
3D coral-like Carbon/S	54	0.8	250	S1
S@ZrO_2/RGO	65	1	100	S2
RGO/C–Co/S	59	1	300	S3
C Nanocapsules /Graphene /S	59.4	0.6-0.8	100	S4
S/$FePO_4$/C	64	2	500	This work
S/$FePO_4$/C	64	4	500	This work
S/$FePO_4$/C	77	2	500	This work

Table S2 Initial areal capacity of this work compared to other reported literatures

Mass loading of the electrode [mg cm^{-2}]	S Content in the composite[%]	S mass loading [mg cm^{-2}]	Initial Areal Capacity[mAh cm^{-2}]	Ref.
1.2	75	0.7	0.84	S5
1.3	72	0.65	0.71	S6
2	64.2	1	0.62	S7
1	59	0.5	0.47	S8
0.8	59.4	0.33	0.27	S9
2	61	0.85	0.79	S10
1.4	67.9	0.7	0.72	S11
1.1	73	0.64	0.68	S12
0.8	62	0.35	0.36	S13
2	64	0.9	0.86	This Work
2	77	1.1	0.9	This Work
4	64	1.8	1.2	This Work

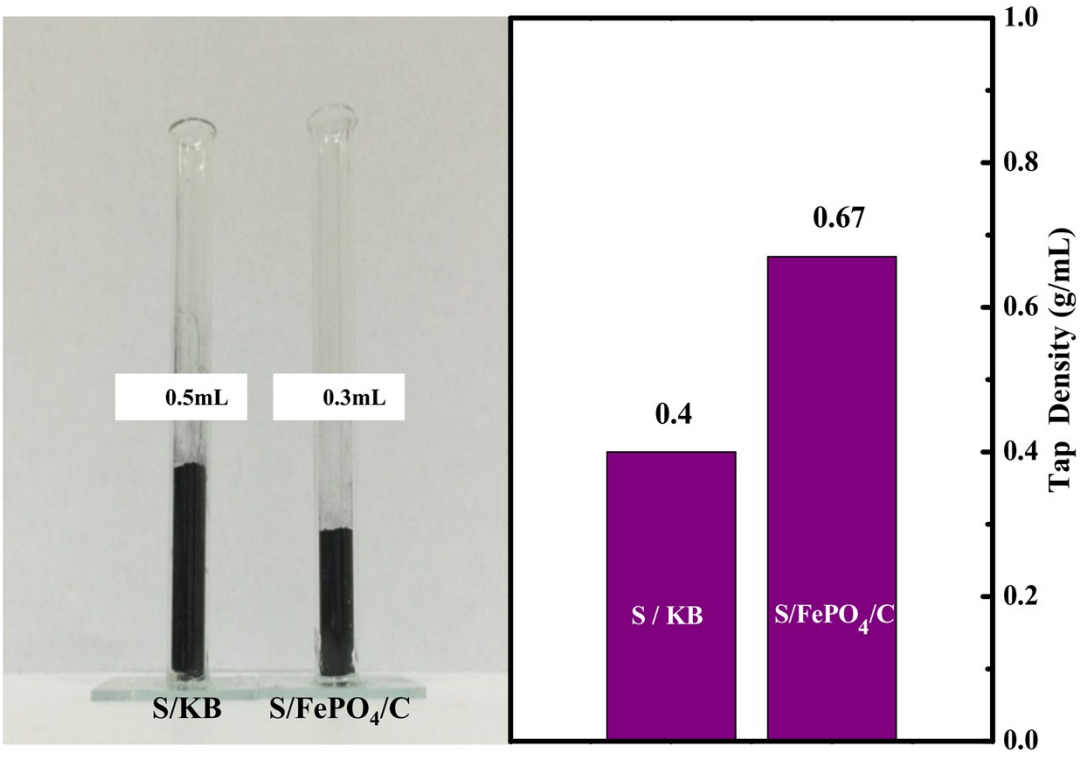

Figure S9. Comparison of tap densities of S/KB with 60 wt% S and S/$FePO_4$/C with 64 wt% S for the same weight of 0.2 g, the tap densities is 0.4 and 0.67 g/mL respectively.

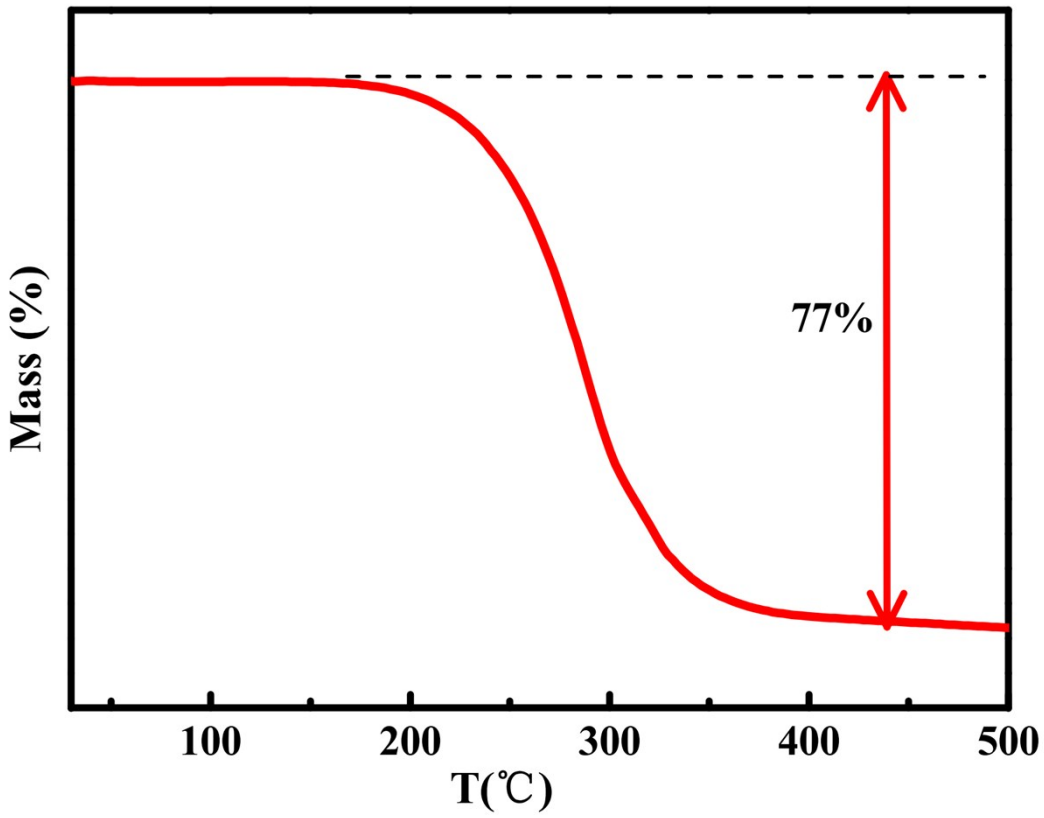

Figure S10. Thermo-gravimetric (TG) analysis of S/$FePO_4$/C nanocomposite with sulfur contents of 77 wt%.

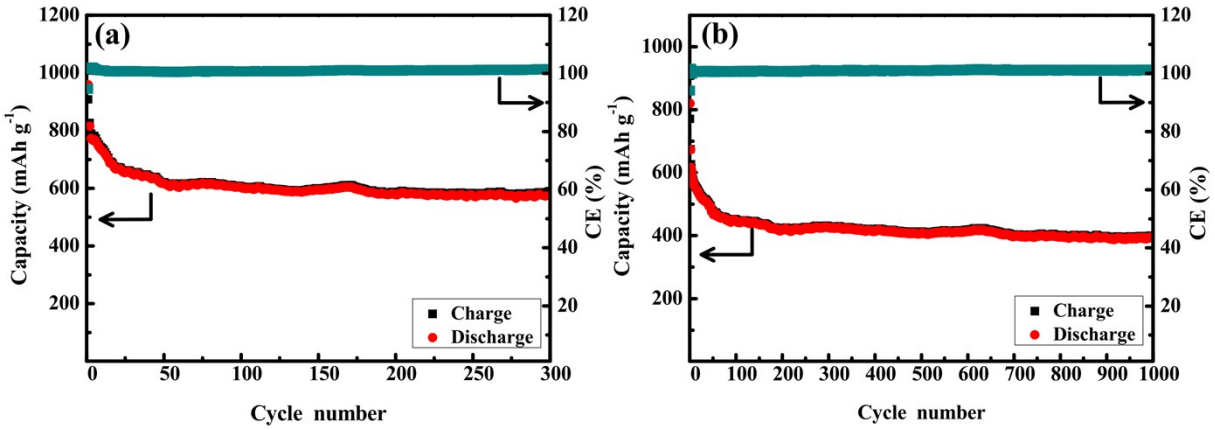

Figure S11. (a) Cycling performance of S/$FePO_4$/C-77 wt% S at 0.2 C and (b) 0.5 C.

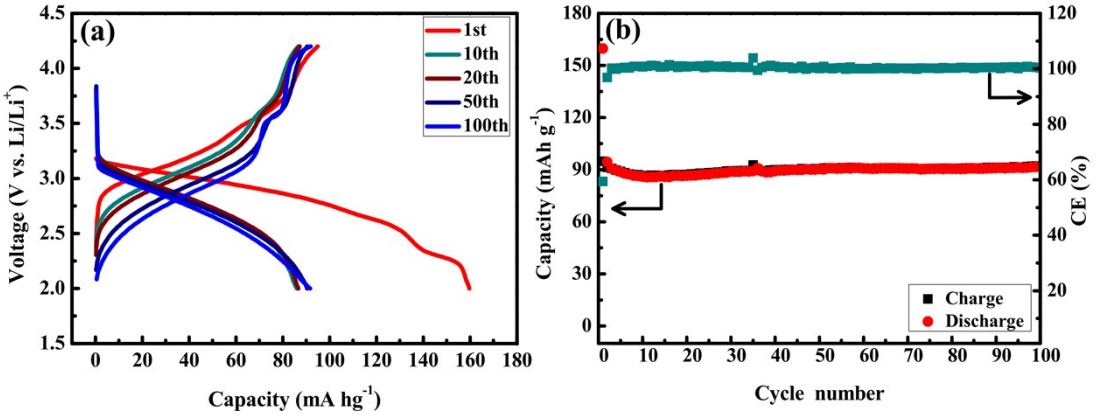

Figure S12. (a) Charge/discharge profiles of pure $FePO_4$ nanospheres cycled in DOL/DME /LTFSI/$LiNO_3$ electrolyte and (b) their corresponding cycling performance at 0.5 C.

Table S3 OCV self-discharge results of this work compared to other reported literatures

	Rest time	Initial voltage (V)	Voltage after rested (V)	Ref.
GO membrane	24 h	2.68	2.38	29
MoS_2/Celgard separator	14 h	2.45	2.38	S14
Cellulose interlayer	25 h	2.5	2.39	S15
PAN/GO separators	5 Days	2.67	2.73	S16
PP13-TFSI electrolyte	7 Days	2.78	2.5	S17
B-rGO/Celgard separator	7 Days	2.96	2.4	S18
S/$FePO_4$/C Cathode	7 Days	2.93	2.9	This work
S/$FePO_4$/C Cathode	15 Days	3.18	2.95	This work
S/$FePO_4$/C Cathode	30 Days	3.18	2.7	This work

[S1] F. Wu, J. Li, Y. Tian, Y. Su, J. Wang, W. Yang, N. Li, S. Chen and L. Bao, *Sci. Rep.*, 2015, **5**, 13340.

[S2] C. Wan, W. Wu, C. Wu, J. Xu and L. Guan, *RSC Adv.*, 2015, **5**, 5102-5106.

[S3] Z. Li, C. Li, X. Ge, J. Ma, Z. Zhang, Q. Li, C. Wang and L. Yin, *Nano Energy*, 2016, **23**, 15-26.

[S4] S.-K. Park, J. Lee, T. Hwang and Y. Piao, *J. Mater. Chem. A*, 2017, **5**, 975-981.

[S5] X. Liang, C. Hart, Q. Pang, A. Garsuch, T. Weiss and L. F. Nazar, Nat. Commun. 2015, 6, 5682.

[S6]Y. Li, Q. Cai, L. Wang, Q. Li, X. Peng, B. Gao, K. Huo and P. K. Chu, ACS Appl. Mater. Interfaces 2016, 8, 23784.

[S7] X. Tao, J. Wang, Z. Ying, Q. Cai, G. Zheng, Y. Gan, H. Huang, Y.Xia, C. Liang, W. Zhang, Nano Lett. 2014, 14, 5288.

[S8] Z. Li, C. Li, X. Ge, J. Ma, Z. Zhang, Q. Li, C. Wang and L. Yin, Nano Energy 2016, 23,15.

[S9] S.-K. Park, J. Lee, T. Hwang and Y. Piao, J. Mater. Chem. A 2017, 5, 975.

[S10] L. Ni, Z. Wu, G. Zhao, C. Sun, C. Zhou, X. Gong and G. Diao, Small 2017, 13.

[S11] S. Rehman, T. Tang, Z. Ali, X. Huang and Y. Hou, Small 2017, 13.

[S12] D. Su, M. Cortie and G. Wang, Adv. Energy Mater. 2017, 7, 1602014.

[S13] M. Zhang, C. Yu, J.Yang, C. Zhao, Z. Ling and J. Qiu, J. Mater. Chem. A 2017, 5,10380.

[S14] Z. A. Ghazi, X. He, A. M. Khattak, N. A. Khan, B. Liang, A. Iqbal, J. Wang, H. Sin, L. Li and Z.Tang, *Adv. Mater*., 2017, **29**, 1606817.

[S15] S. Li, G. Ren, M. N. F. Hoque, Z. Dong, J. Warzywoda and Z. Fan, *Appl. Surf .Sci.* 2017, **396**, 637-643.

[S16] J. Zhu, C. Chen, Y. Lu, J. Zang, M. Jiang, D. Kim and X. Zhang, *Carbon*, 2016, **101**, 272-280.

[S17] L. Wang and H. R. Byon, *J. Power Sources*, 2013, **236**, 207-214.

[S18] F. Wu, J. Qian, R. Chen, Y. Ye, Z. Sun, Y. Xing and L. Li, *J. Mater. Chem. A*, 2016, **4**, 17033-17041.