Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

For Journal of Materials Chemistry A

Compact High Volumetric and Areal Capacity Lithium Sulfur Battery through Rock Salt induced Polymodally Distributed Sulfur Host

Matthew Li[a, ψ], Yining Zhang [a, ψ], Fathy Hassan[a], Wook Ahn[b], Xiaolei Wang[a], Wen Wen Liu[a], Gaopeng Jiang[a], Zhongwei Chen [a,]*

[a] Waterloo Institute for Nanotechnology, Department of Chemical Engineering, University of Waterloo, 200 University Ave. W., Waterloo, Ontario N2L 3G1, Canada

[b] Department of Energy Systems Engineering, Soonchunhyang University, 22 Soonchunhyang-ro, Shinchang-myeon, Asan-si, Chungcheongnam-do, 31538 Korea.

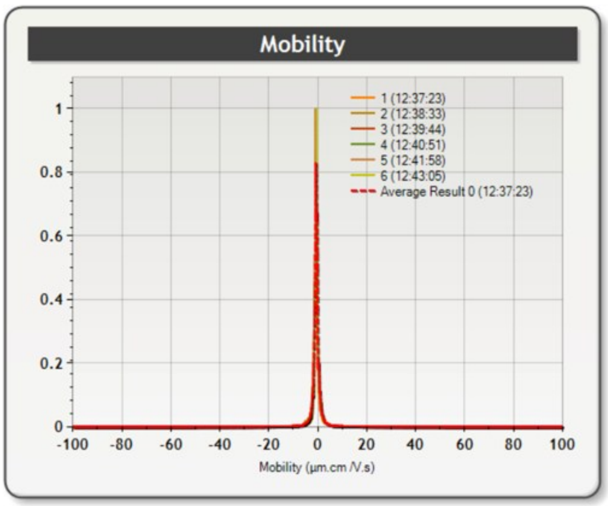
[ψ]Matthew Li and Yining Zhang contributed equally to this work.

*Corresponding Author
E-mail: zhwchen@uwaterloo.ca

Supporting Figures:

a)

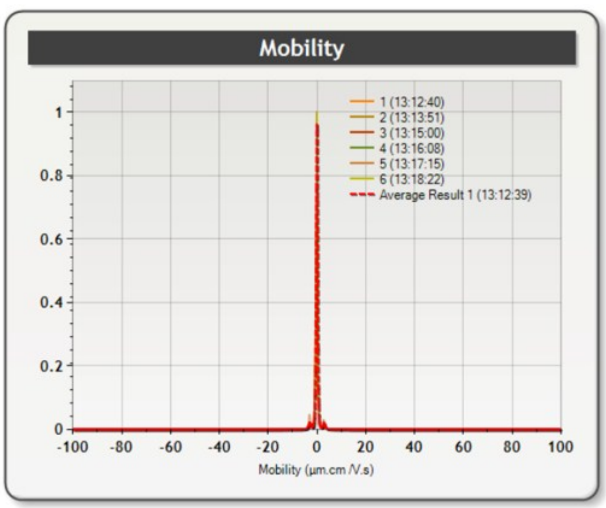
No NaCl



μ (μm.cm/V.s)	*ζ (mV)*
-0.77	-9.95
-0.85	-10.93
-0.98	-12.62
-0.85	-10.93
-0.65	-8.41
-0.85	-10.93

b)

With NaCl



μ (μm.cm/V.s)	*ζ (mV)*
-0.12	-1.49
-0.14	-1.79
-0.14	-1.79
-0.14	-1.79
-0.14	-1.79
-0.14	-1.79

Figure S 1: Zeta potential measurements displaying mobility plots with corresponding table of calculated Zeta potential of samples without (a) and with (b) NaCl. 6 runs were conducted for each sample to ensure repeatability.

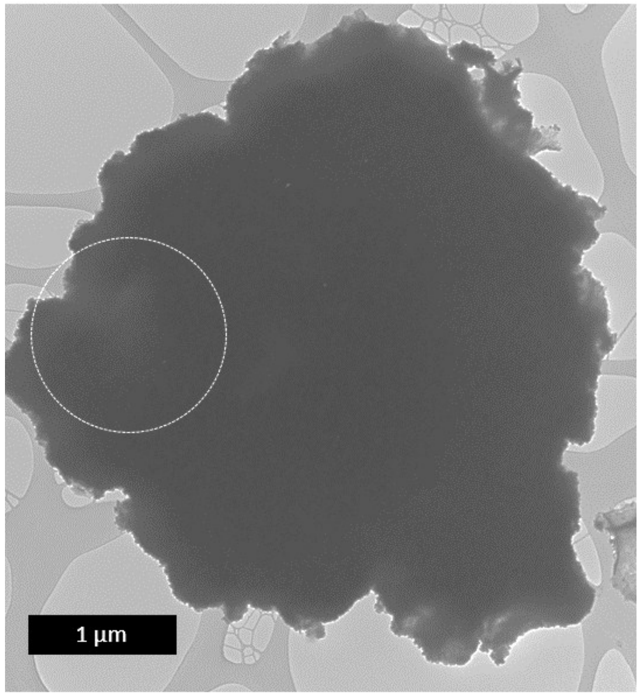


Figure S 2: TEM image of Poly-NPC prior to silica removal indicating lighter and darker spots throughout its structure. Dotted circle marks a lighter spot.

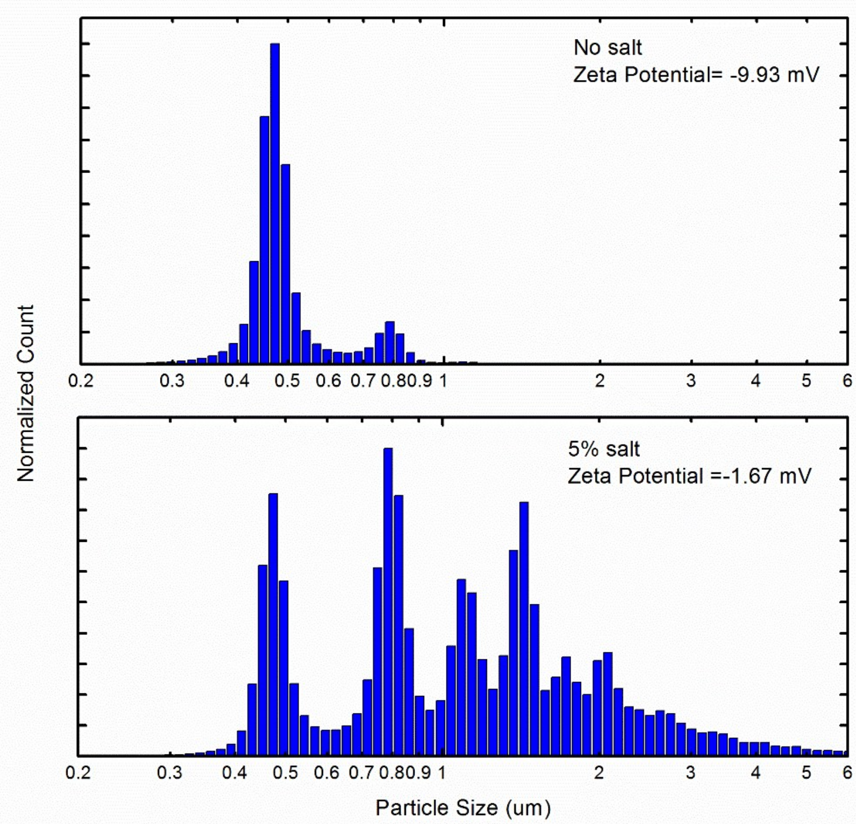


Figure S 3: Dynamic light scattering particle size distribution of sample with and without rock salt.

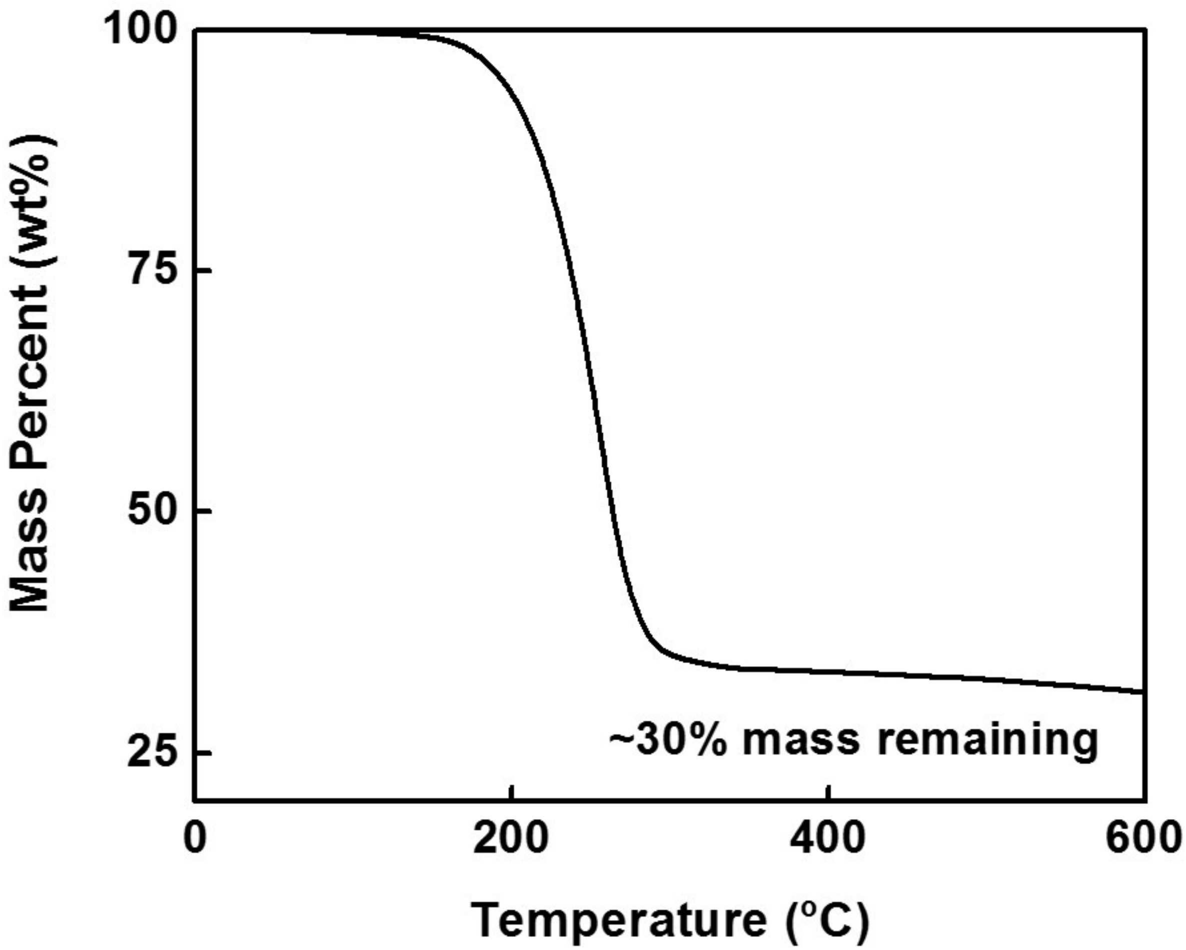


Figure S 4: Thermogravimetric analysis curve indicating 70% sulfur content in Poly-NPC /sulfur composite

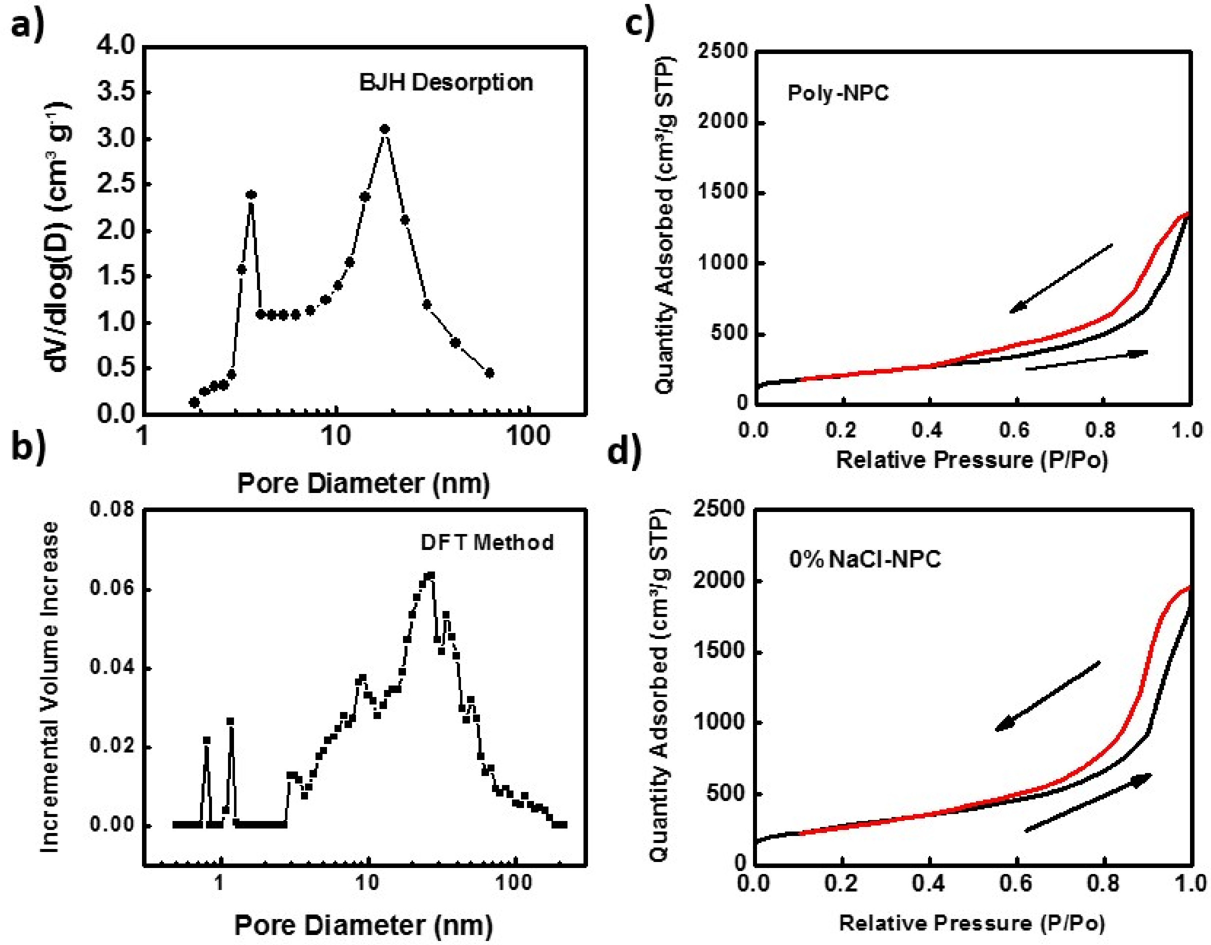


Figure S 5: Pore size distribution per: a) BJH desorption, b) DFT and adsorption and desorption curve of c) Poly-NPC and d) 0% NaCl-NPC.

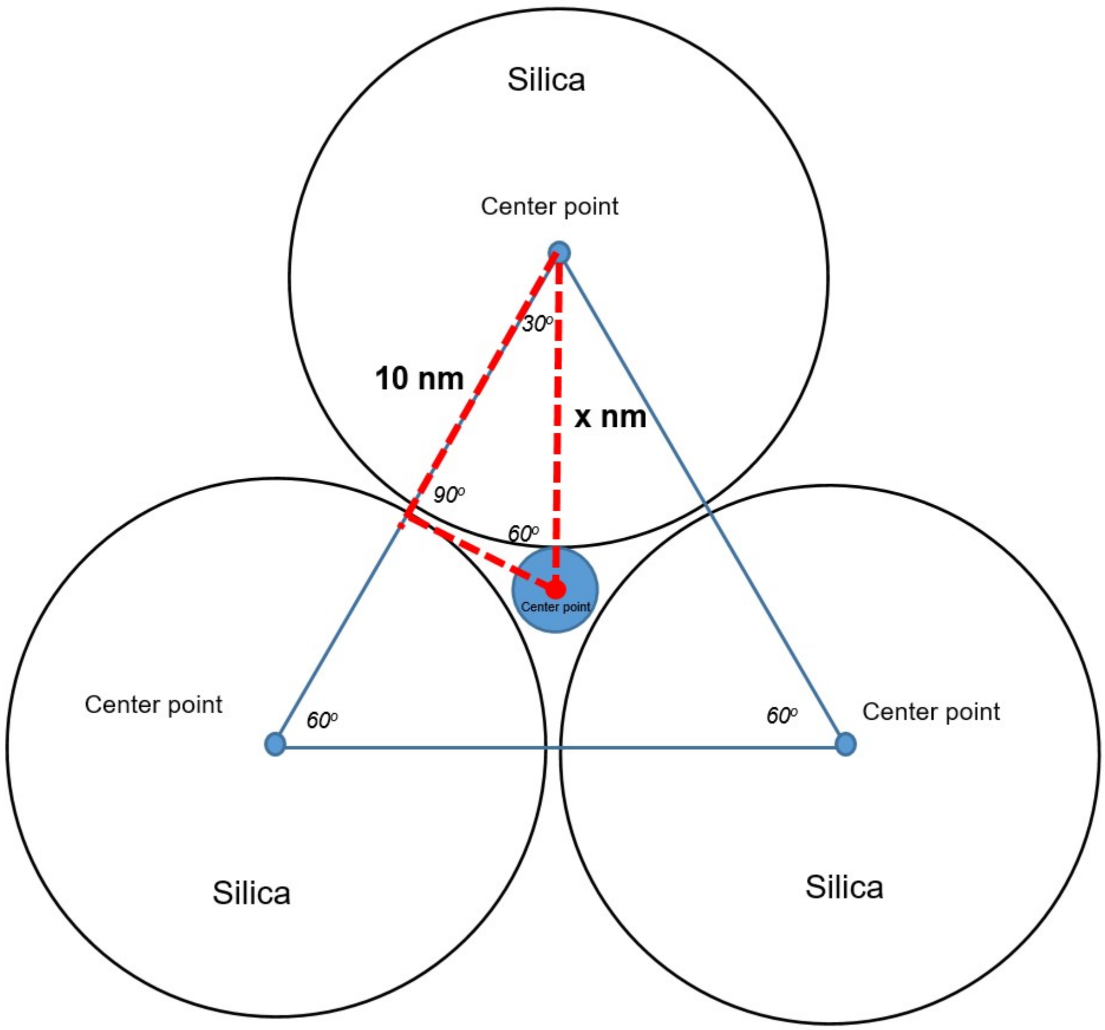


Figure S 6: Diagram used to deduce the inter-silica pore size, the circles represent silica nanoparticle of diameter ~20 nm. Whereas the small solid circle in the center of the diagram represents the inter-silica pore. The triangle is drawn from the center point of each silica particle. The dotted triangle is drawn from the center of the inter-silica pore to the center of the top silica particle (length=x nm) and to the bottom left edge of the top silica particle (length=10 nm), forming a right angle triangle with inner 60^0 angles. In other words, the dotted triangle has a height of 10 nm and an unknown hypotenuse of x nm. Since the length of one side and inner angles are known, from simple trigonometry of right angle triangles, the unknown x is calculated to be 11.54. Since x is actually the sum of the radius of the inter-silica pore and the radius of a silica particle (~10 nm). Then the radius of the inter-silica pores can be calculated to be ~1.5 nm which would yield a

diameter of ~3 nm , matching roughly the pore size distribution obtained from nitrogen sorption experiments.

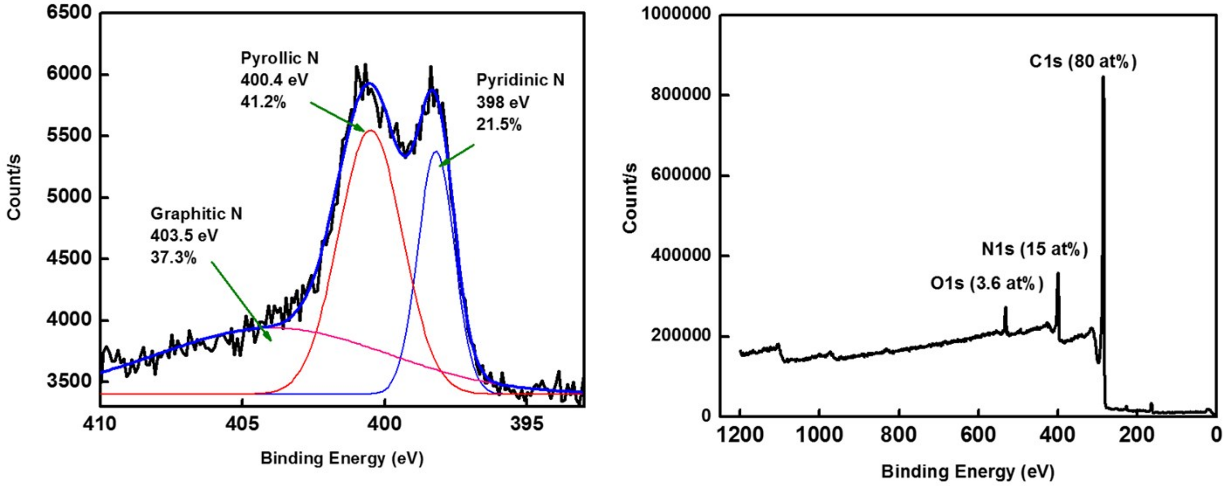


Figure S 7: a) XPS binding energy spectrum of Poly-NPC with 14.9 at% of nitrogen and b) the full XPS scan proving the proportion of nitrogen in carbon material.

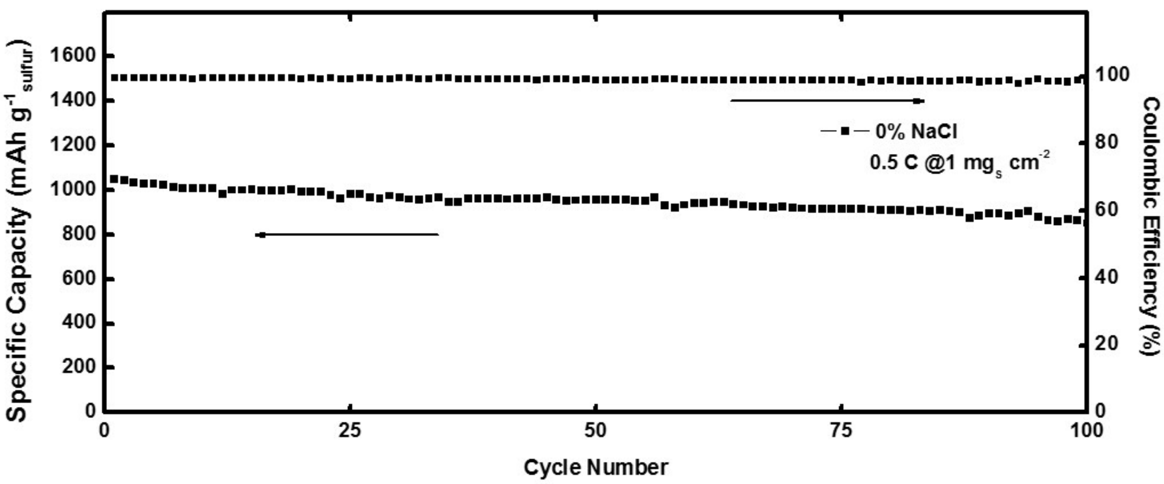


Figure S 8: Cycle performance at 0.5 C over 100 cycles of 0% NaCl sample with 70% S

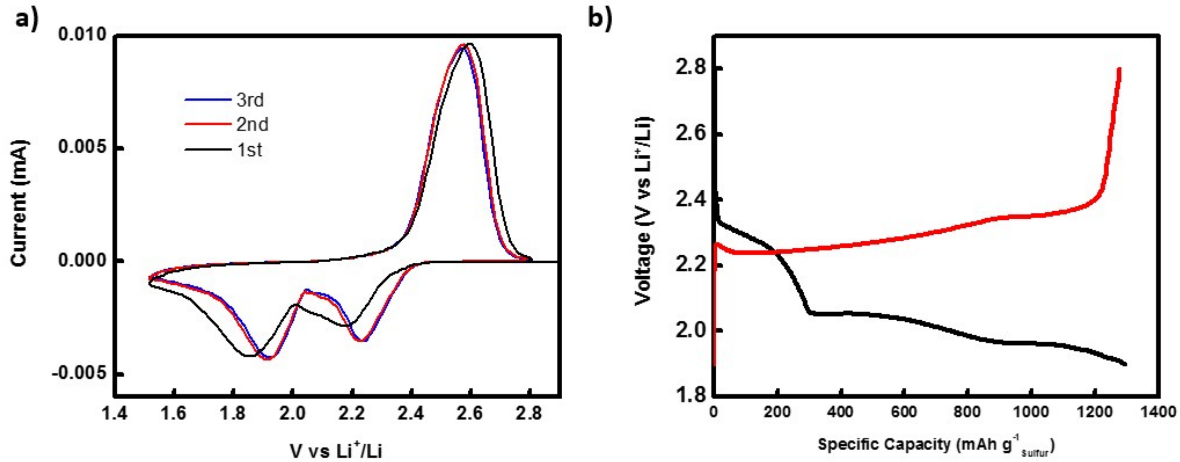


Figure S 9: a) Cyclic voltammetry of 4 mg cm^{-2} cell at 0.1 mV s^{-1} and b) corresponding charge/discharge voltage profile of 4 mg cm^{-2} cell.

Supporting Tables:

Table S 1: Performance summary of recent blade casted lithium sulfur electrodes

Title/Year	Traditional Battery Manufacturing?	Sulfur Loading (%wt of cathode coating)	Areal Capacity	Thickness	Electrode's Volumetric Capacity
High Energy Density Lithium-Sulfur Batteries: Challenges of Thick Sulfur Cathodes[1]/2015	Yes	3.5 mg cm^{-2} (64%)	3.5 mAh cm^{-2}	80 µm +23 µm (assumed current collector) =103 µm	339 mAh cm^{-3}
Long-Life and High-Areal-Capacity Li-S Batteries Enabled by a Light-Weight Polar Host with Intrinsic Polysulfide Adsorption[2]/2016	Yes	5 mg cm^{-2} (56.25%)	4.27 mAh cm^{-2}	150 µm	284 mAh cm^{-3}
A Comprehensive Approach toward Stable Lithium-Sulfur Batteries with High Volumetric Energy Density [3]/2016	Yes	5.1 mg cm^{-2} (65.45%)	5 mAh cm^{-2}	215 µm	239 mAh cm^{-3}
Investigation of non-woven carbon paper as a current collector for sulfur positive electrode—Understanding of the mechanism and potential applications for Li/S batteries[4]/2016	Yes	4.4 mg cm^{-2} (80%)	4.96 mAh cm^{-2}	270 µm	183 mAh cm^{-3}
Cathode materials based on carbon nanotubes for high-energy-density lithium–sulfur batteries[5]/2014	Yes	3.72 mg cm^{-2} (45%)	3.21 mAh cm^{-2}	215 µm	149 mAh cm^{-3}
This work	**Yes**	**4 mg cm^{-2}(60.9%)**	**5.4 mAh cm^{-2}**	**109 µm**	**495 mAh cm^{-3}**

Reference

1. D. Lv, J. Zheng, Q. Li, X. Xie, S. Ferrara, Z. Nie, L. B. Mehdi, N. D. Browning, J.-G. Zhang, G. L. Graff, J. Liu and J. Xiao, *Adv. Energy Mater.*, 2015, **5**, 1402290.
2. Q. Pang and L. F. Nazar, *ACS nano*, 2016, **10**, 4111-4118.
3. Q. Pang, X. Liang, C. Y. Kwok, J. Kulisch and L. F. Nazar, *Adv. Energy Mater.*, 2016, **7**, 1601630.
4. S. Waluś, C. Barchasz, R. Bouchet, J. F. Martin, J. C. Leprêtre and F. Alloin, *Electrochim. Acta*, 2016, **211**, 697-703.
5. L. Zhu, W. Zhu, X.-B. Cheng, J.-Q. Huang, H.-J. Peng, S.-H. Yang and Q. Zhang, *Carbon*, 2014, **75**, 161-168.