Supporting Information

Enhanced cyclic stability of Li-sulfur battery composites by low pressure penetration of PEDOT:PSS coating

Qiang Huang[1], Guojun Zha[2*], Zhaoyu Hu[1], Hangzhong Liu[1], Seema Agarwal[3], Haoqing Hou[1*]

[1]*College of Chemistry and Chemical Engineering, Jiangxi Normal University, Nanchang, China.*

[2]*School of new energy science and engineering, Xinyu University, Xinyu, China.*

[3]*Macromolecular Chemistry and Bavarian Centre for Battery Technology, University of Bayreuth, Universitätsstrasse 30, 95440 Bayreuth, Germany.*

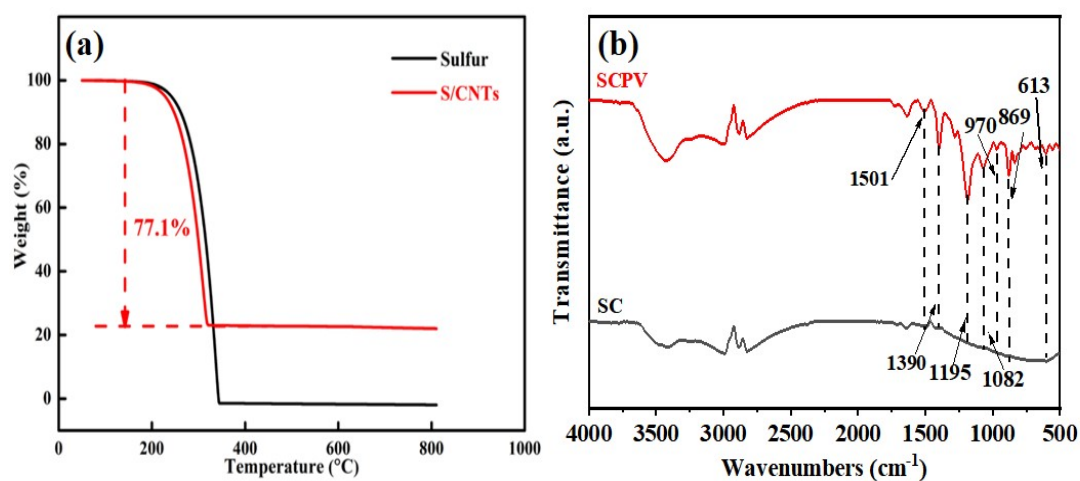**Email:zhaguojun_8@163.com *Email: haoqing@jxnu.edu.cn*

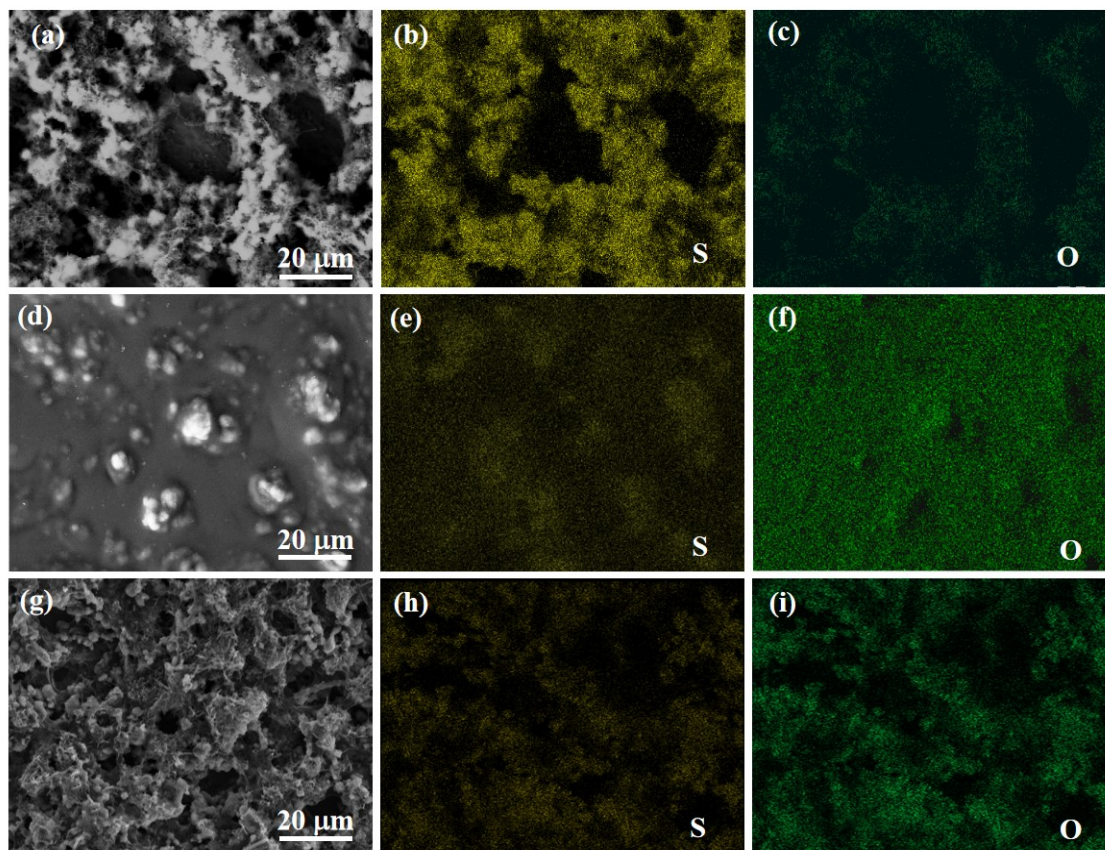Fig.S1. (a)TGA curves of S and S/CNTs and (b)FTIR Spectrum of SC and SCPV

Fig.S2. SEM image of the SC (a) electrode and the EDS mapping of S (b) and O (c) elements on the (a) electrode surface, SEM image of the SCP (d) electrode and the EDS mapping of S (e) and O (f) elements on the (d) electrode surface, SEM image of the SCPV (g) electrode and the EDS mapping of S (h) and O (i) elements on the (g) electrode surface.
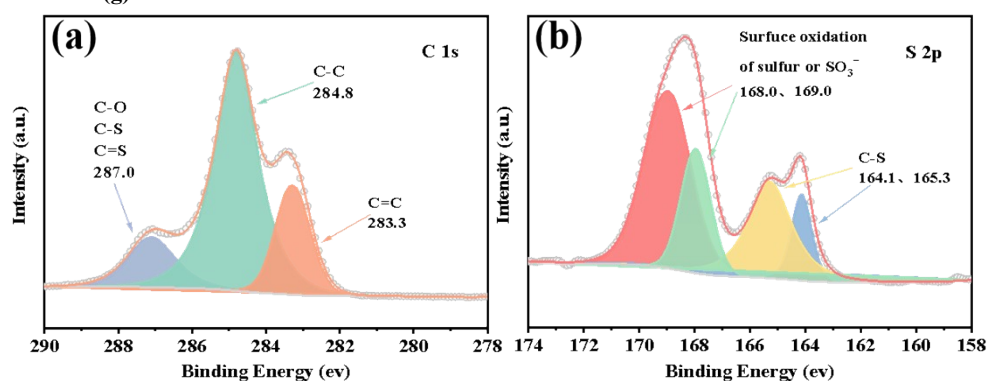

Fig.S3. XPS spectra of (a) C1s, (b) S2p for PEDOT:PSS.

One of the parameters affecting the rate performance of lithium-sulfur battery electrode materials is the Li^+ diffusion coefficient. The GITT method was used to determine the Li^+ diffusion coefficient of SC, SCP and SCPV. The formula of Li^+ diffusion coefficient is as follows (eq 1) [1,2].

$$D_{Li^+} = \frac{4}{\pi}\left(\frac{m_B V_M}{M_B S}\right)^2\left\{\frac{\Delta E_S}{\tau(dE_\tau/d\sqrt{\tau})}\right\}^2 \left(\tau \ll \frac{L^2}{D_{Li^+}}\right) \qquad \text{(Seq 1)}$$

V_M (cm^3 mol^{-1}) represents the molar volume of the sample. M_B (g mol^{-1}) represents the molar mass of the cathode material and m_B (g) represents the mass of the cathode material. S (cm^2)

represents the area of the pole piece.　The eq 2 can be further simplified as follows [1,2] in the area where the curve conforms to the linear relationship between the square root of time ($\tau^{1/2}$) and potential (E):

$$D_{Li^+} = \frac{4}{\pi\tau}\left(\frac{m_B V_M}{M_B S}\right)^2\left(\frac{\Delta E_S}{\Delta E_\tau}\right)^2 \tag{Seq 2}$$

According to the $M_B = V_M \rho_B$, eq 3 can be further simplified as follows:

$$D_{Li^+} = \frac{4}{\pi\tau}\left(\frac{m_B}{\rho_B S}\right)^2\left(\frac{\Delta E_S}{\Delta E_\tau}\right)^2 \tag{Seq3}$$
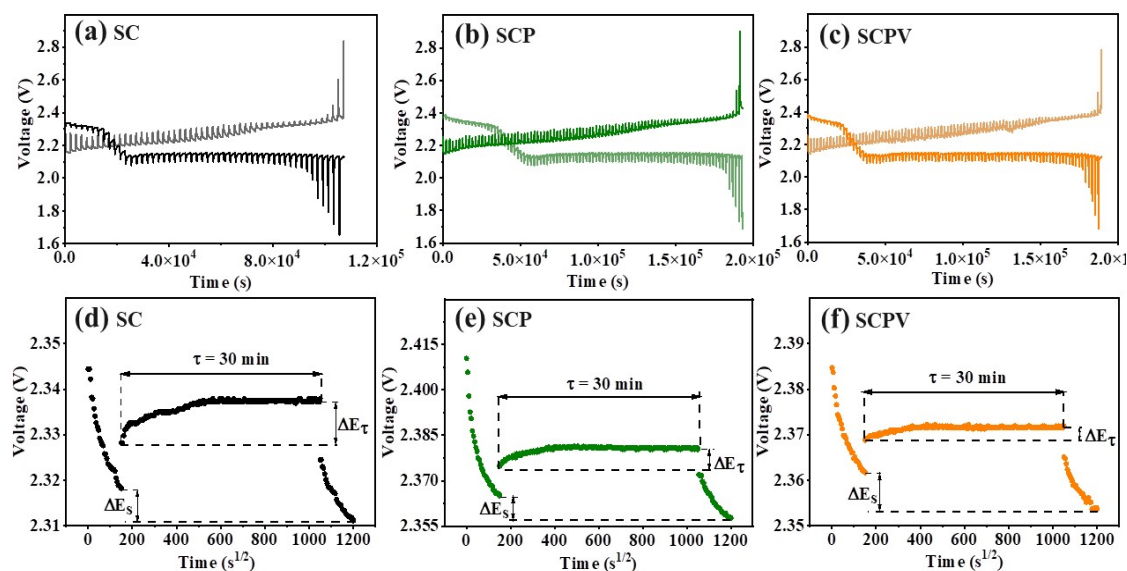

Fig.S4. GITT curves of (a) SC, (b) SCP and (c) SCPV electrodes at second discharging-charging process. The single titration presents linear correlation both the square root of time and the potential for (d) SC, (e) SCP, (f) SCPV samples.

Tab.S1. Comparison of the electrochemical performance of PEDOT: PSS modified Lithium-sulfur battery in this work with other literatures reported in the literature.

| Materials	Measurement Conditions			Electrochemical Performance			Ref.
	Voltage Range (V)	T(K)	Current Density (mA g^{-1})	Initial Capacity (mAh g^{-1})	Cycle Number	Retention Rate	
PEDOT:PSS modified LSB	1.7-2.7 vs. Li/Li$^+$	298	0.5C (1C=1675)	996.8	200	91.87%	This Work
					500	62.42%	
			0.1C	1320.0	/	/	
PVDF-HFP modified LSB	1.7-2.7 vs. Li/Li$^+$	298	0.5C	813.0	100	90.7%	[3]
	2.8-4.3 vs. Li/Li$^+$		2C	408	/	/	
PEDOT:PSSCNT inter layer modified LSB	1.7-3.0 vs. Li/Li$^+$	303	0.5C	921	200	70.9%	[4]
PEDOT:PSS modified LSB	1.5-3.0 vs. Li/Li$^+$	303	0.2 C	1051	100	79%	[5]
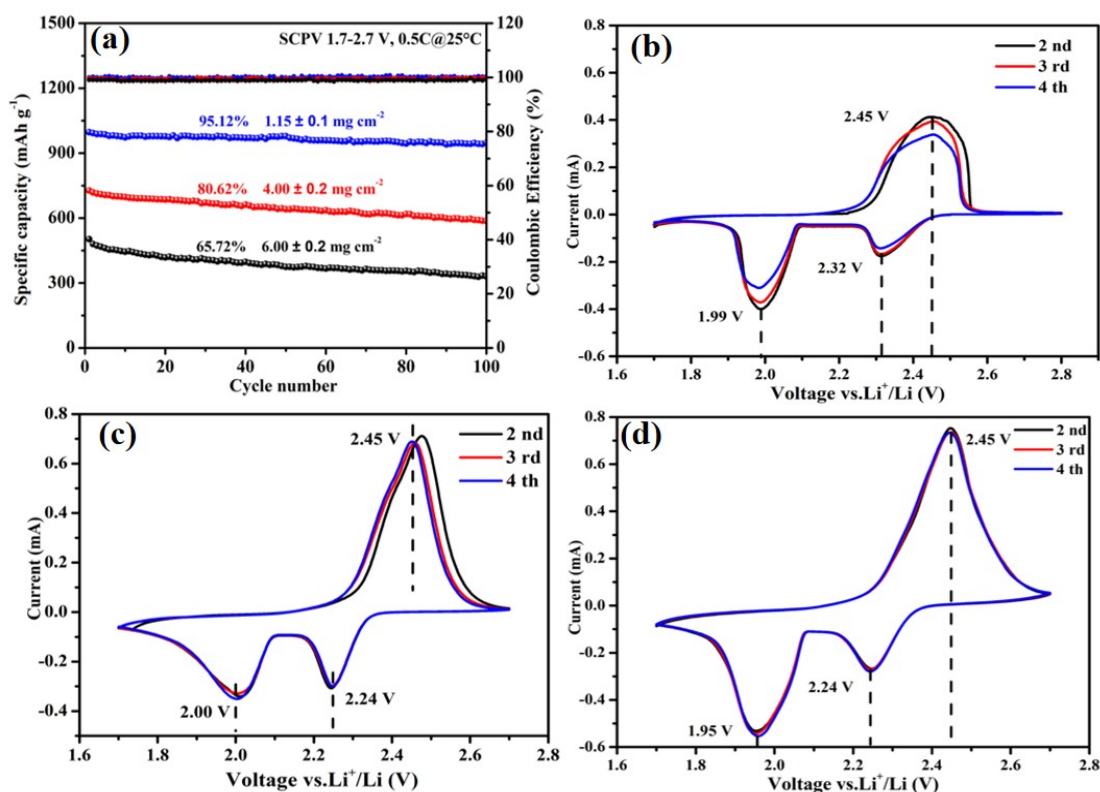
Fig.S5. (a)cycling performance under different loads of sulfur. CV curves of (b) SC, (c) SCP and (d) SCPV at a scan rate of 0.1 mV s⁻¹.
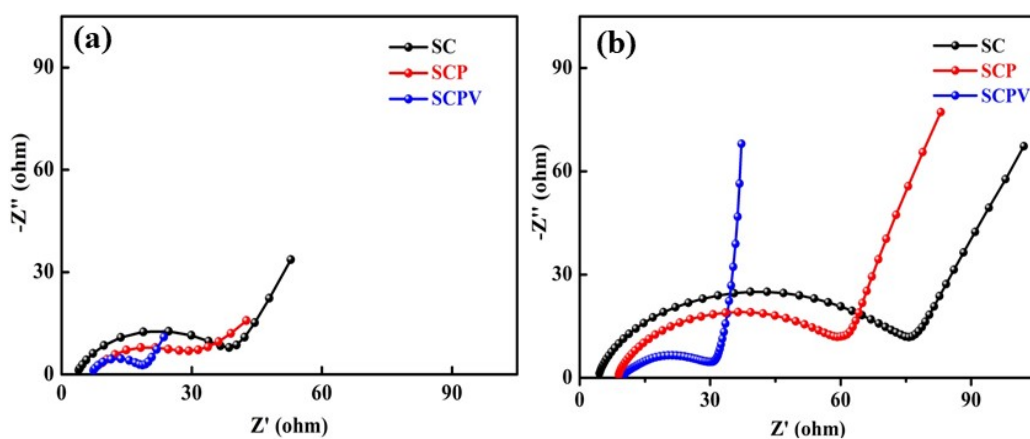

Fig.S6. EIS spectra of SC, SCP, and SCPV electrodes (a) before (b) after cycle.
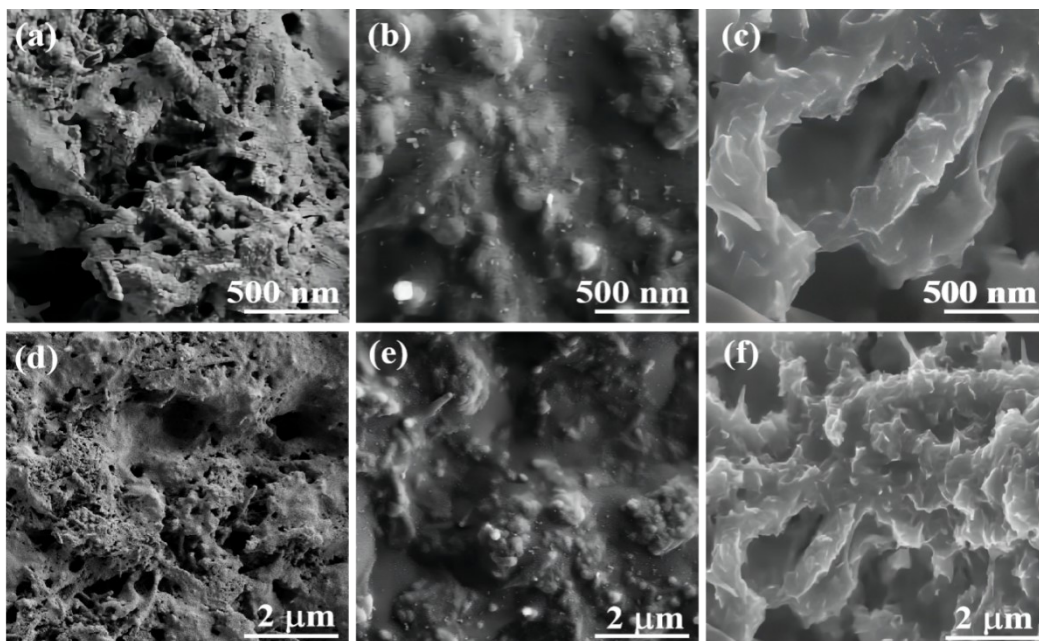
Fig.S7. SEM image of (a, d) SC, (b, e) SCP and (c, f) SCPV electrodes after 200 cycles at 0.5 C.

References

[1] G. Zha, Y. Luo, N. Hu, C. Ouyang, H. Hou, Surface modification of the $LiNi_{0.8}Co_{0.1}Mn_{0.1}O_2$ cathode material by coating with $FePO_4$ with a yolk-shell structure for improved electrochemical performance, *ACS Appl. Mater. Inter.* 12 (2020), 36046-36053.

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