Supplementary Information

Propanesultone-based polymer electrolyte for high-energy solid-state lithium battery with lithium-rich layered oxides

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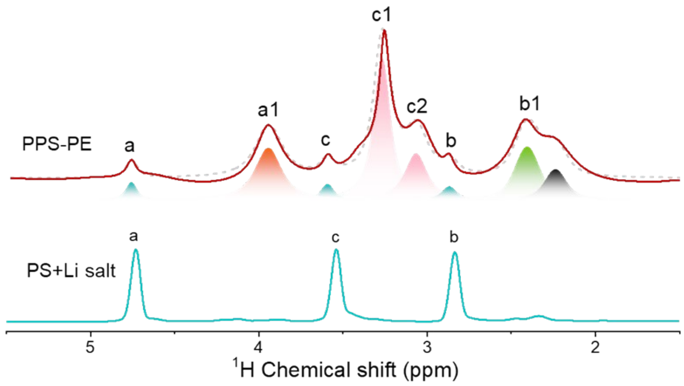

Fig. S1 The ^{1}H spectra and simulations for percent conversion of PPS-PE from PS monomer. The weak peaks in the range of 2.2~2.5 ppm can be indexed to the impurities.

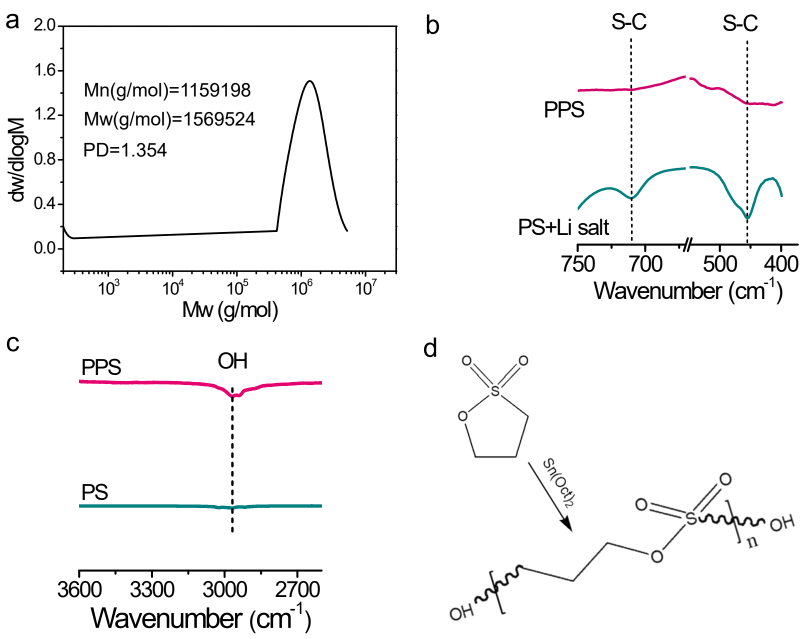

Fig. S2 a, The GPC test of PPS-PE. b, c, The S-C and -OH bonds in FT-IR spectra of PS+Li salt precursor and PPS-PE. d, The chain-like structure of PPS-PE form PS monomer by $Sn(Oct)_2$ catalyzation.

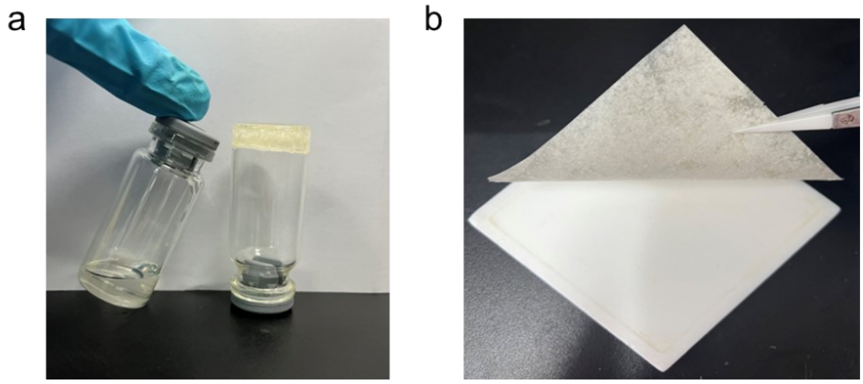

Fig. S3 a, The photos of PPS-PE before and after polymerization. b, The flexible PPS-PE film.

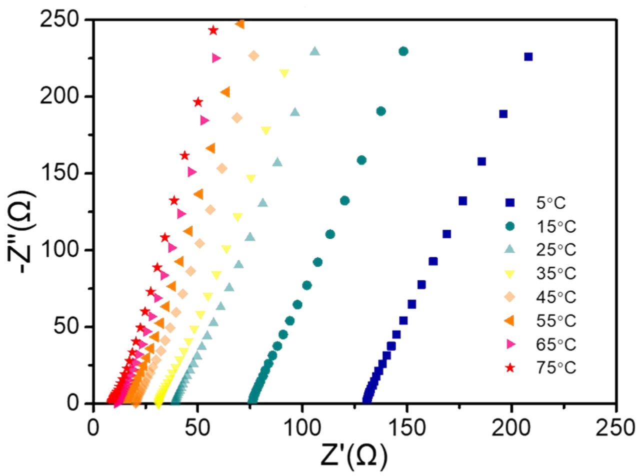

Fig. S4 The EIS of SS/PPS-PE/SS symmetric cell at different temperatures.

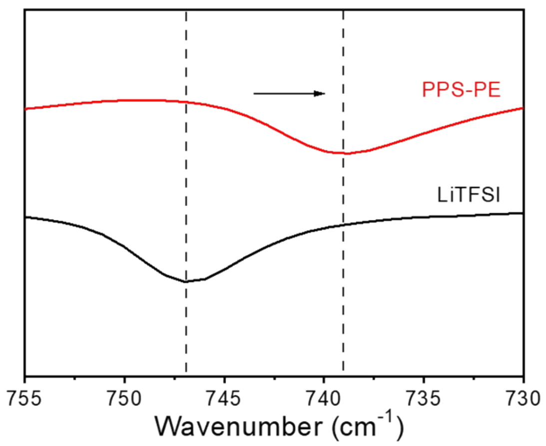

Fig. S5 The FT-IR spectra of Li salt and PPS-PE.

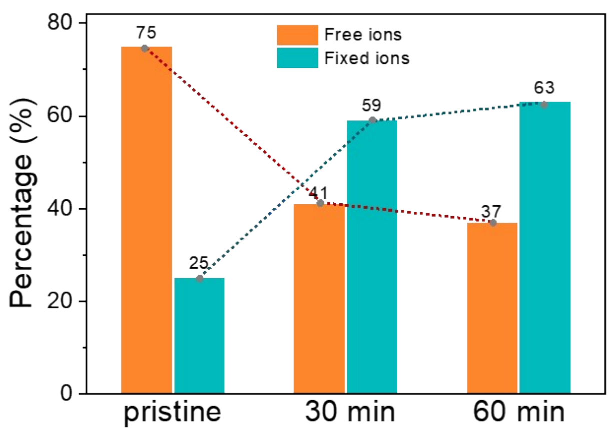

Fig. S6 The changes of area ratios of free and fixed ions at different states.

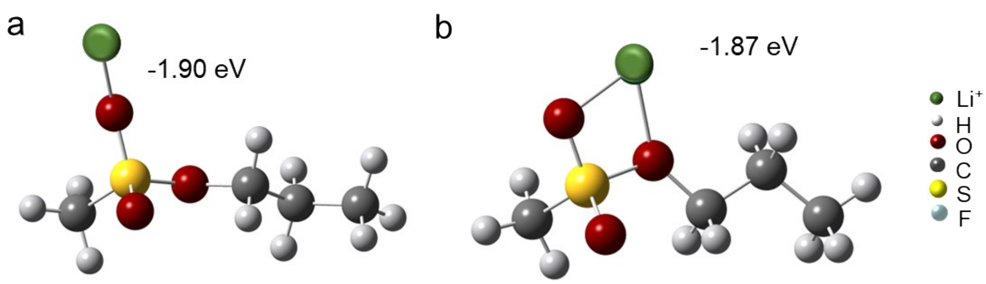

Fig. S7 The configurations and binding energies between the free Li ion and a, the O atom on S=O group, b, the O atoms on S=O and S-O groups.

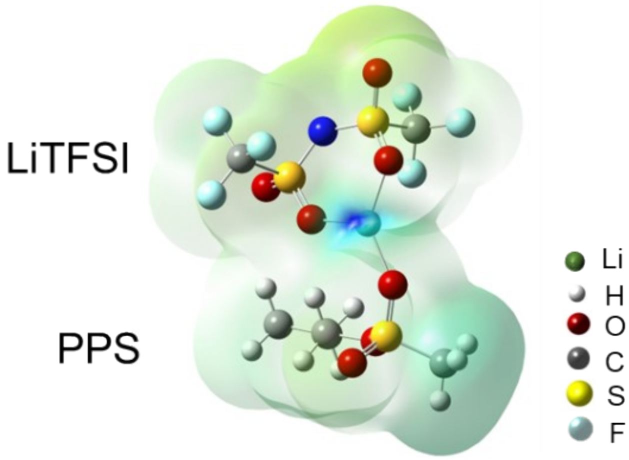

Fig. S8 The electrostatic potentials with the interaction between LiTFSI and PPS.

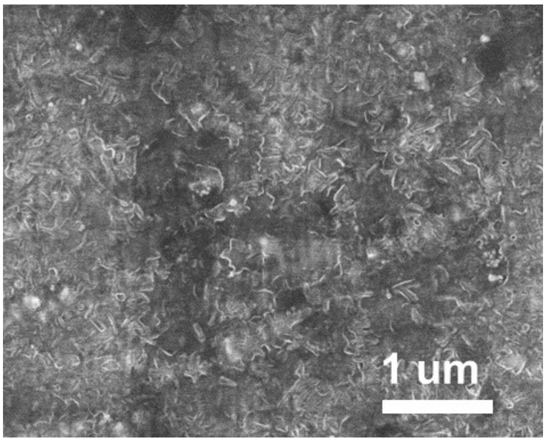

Fig. S9 The SEM image of Li anode surface after test of battery with PPS-PE.

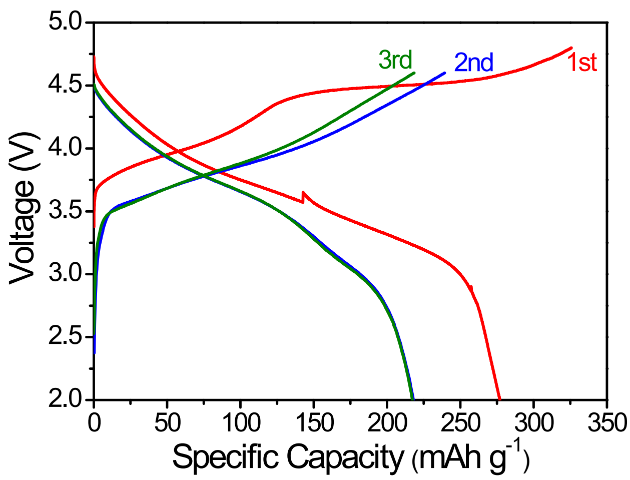

Fig. S10 The initial charge/discharge curves of liquid electrolyte based battery with LLOs cathode material.

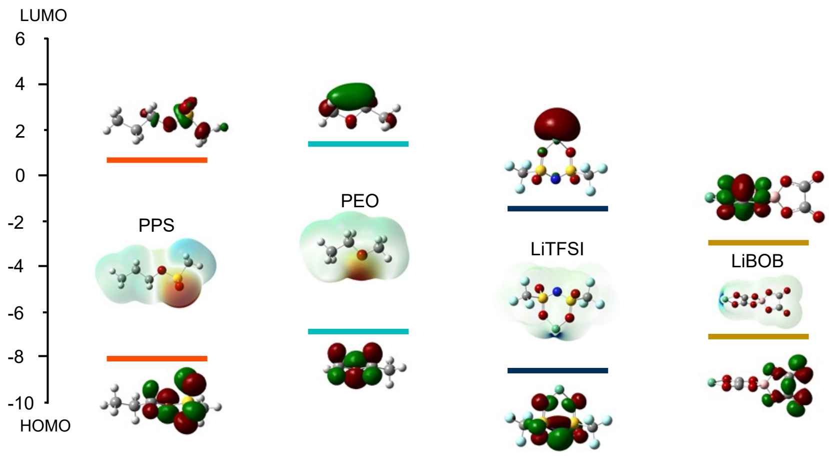

Fig. S11 The HOMO and LUMO energy levels of PPS, PEO, LiTFSI, LiBOB and the interactions.

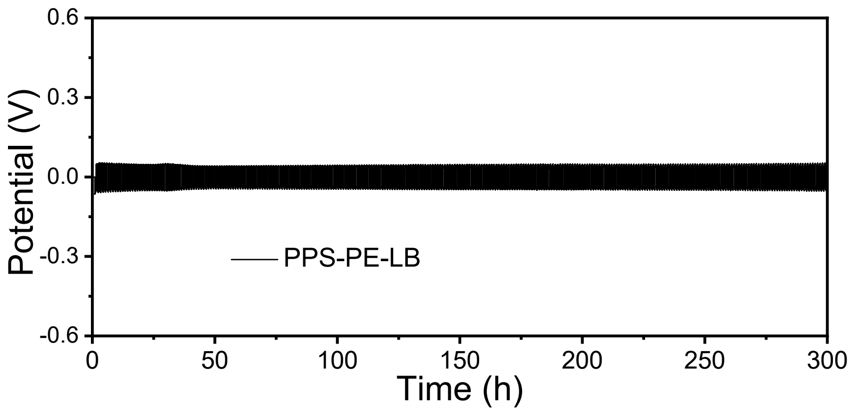

Fig. S12 The potential profiles of Li plating/striping in Li/PPS-PE-LB/Li symmetric battery with current density of 0.1 mA cm^{-2}.

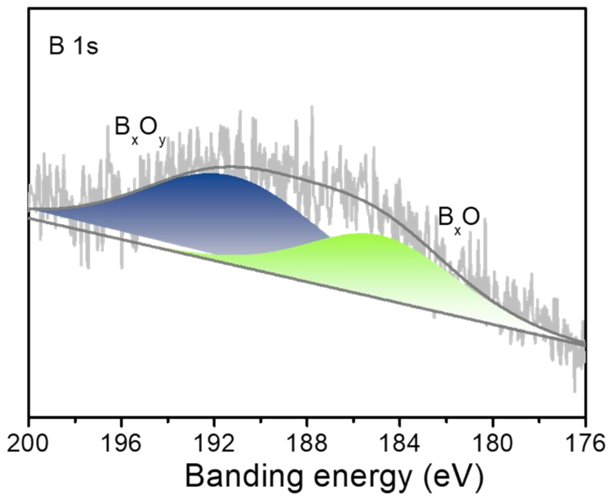

Fig. S13 The XPS spectra of B element on the cathode side after the cycling of LLOs/PPS-PE/Li battery.

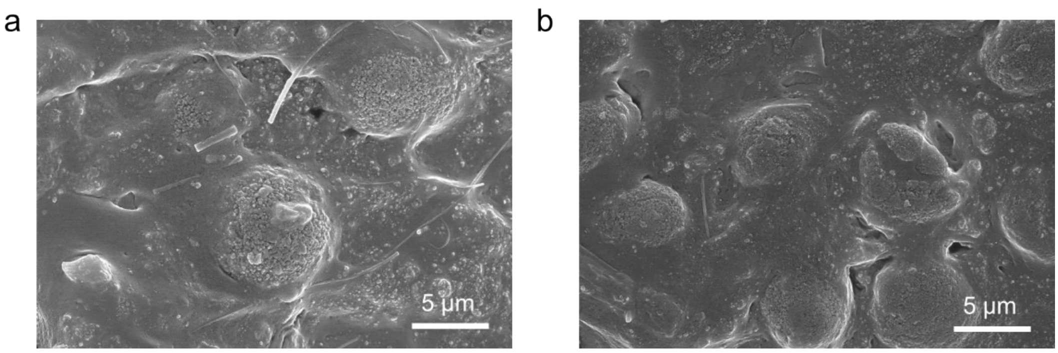

Fig. S14 The SEM images of composite cathodes in (a) LLOs/PPS-PE/Li and (b) LLOs/PPS-PE-LB/Li batteries after cycling.

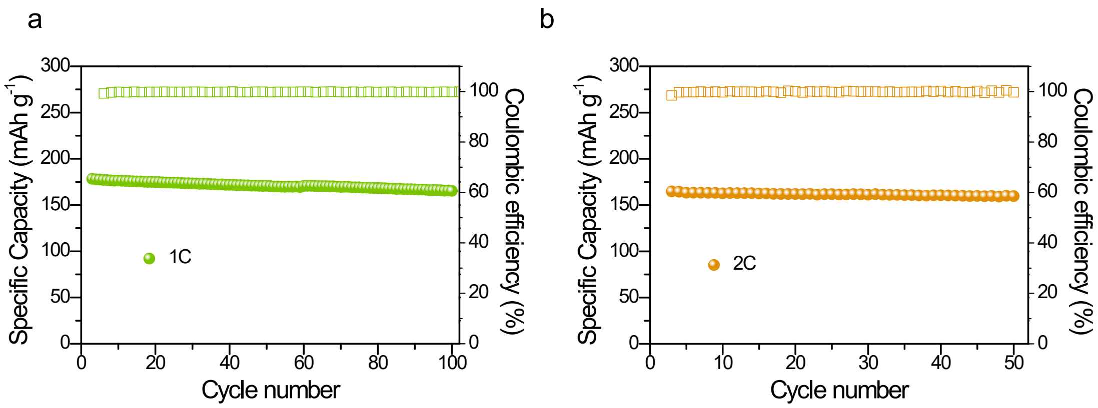

Fig. S15 The cycling stabilities of LLOs/PPS-PE-LB/Li batteries at current density of (a) 1C and (b) 2C.

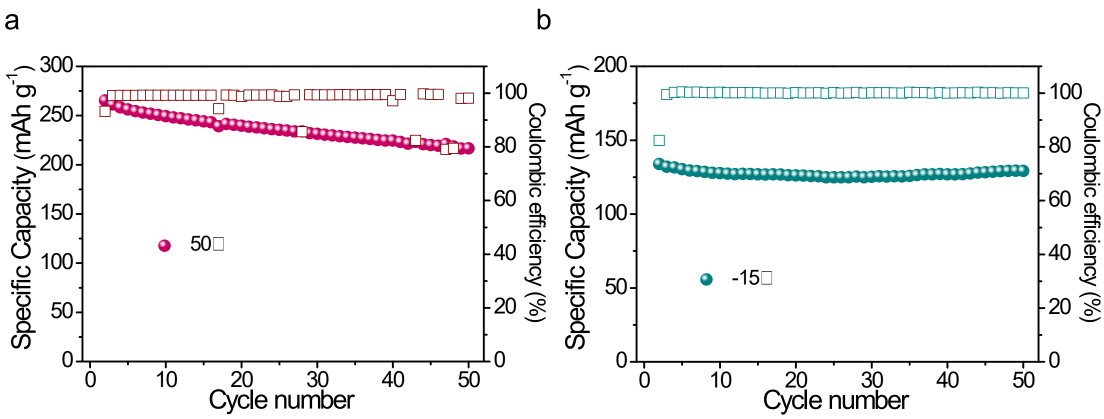

Fig. S16 The cycling stabilities of LLOs/PPS-PE-LB/Li batteries at (a) 50 ^{o}C and (b) -15 ^{o}C.

Fig. S17 The optical photographs for the LLOs/PPS-PE-LB/Li soft package battery that lit up a logo at a, normal, b, wrinkled and c, cutting states.

Table S1 The relative area for each peak of PS monomer and PPS-PE from **Fig. S1**.

Type of peak	PS monomer			PPS-PE				Impurity
	a	c	b	a1	c1	c2	b1	
Integral area (e9)	2.36	2.36	2.35	16.69	28.71	12.61	14.20	7.55
Percent conversion	（72.21/86.83）/（1-7.55/86.83）=91.08%							

Table S2 The comparisons of charge voltages of cathode materials in the solid-state batteries, and the ions transference number of polymer electrolytes, which including the $LiNi_xCo_yMn_{1-x-y}O_2$, $LiCoO_2$, $LiNi_{0.5}Mn_{1.5}O_4$ and Li-rich cathode materials.

Composition	Anode/ Cathode	The Li^+ transference number	Current density	Voltage Range (V)	Initial discharge capacity (mAh/g)	Cycles	Final discharge capacity (mAh/g)	Ref.
PEGDA+BA+SN/LiTFSI	$Li/LiNi_{0.83}Mn_{0.06}Co_{0.11}O_2$	0.75	1.1C	2.7-4.5V	~170	100	140	23
PEGDME/LiTFSI+LiFSI	$Li/LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$	-	0.2C	2.5-4.5V	167	100	97	24
VEC+TFEMA/LiTFSI	$Li/LiNi_{0.83}Co_{0.11}Mn_{0.06}O_2$	0.44	0.1C (1C=275 mA g^{-1})	3.0-4.5V	218	300	~153	25
PME+LiPVFM+NMP/ LiTFSI+SN	$Li/LiCoO_2$	0.62	0.5C	2.8-4.5V	196.3	50	180.4	26
VEC/LiTFSI	$Li/LiCoO_2$	0.4	0.5C (1C=160 mA g^{-1})	3.0-4.5V	154.6	100	104.9	27
Uio-66-NH-MET+PEGDA+PETMP/ LiTFSI	$Li/LiCoO_2$	0.44	0.5C (1C=148 mA g^{-1})	3.0-4.5V	136	100	108.8	28
PEGDA+NML+UPyMA/ LiTFSI	$Li/LiCoO_2$	0.66	0.5C (1 C =180 mA g^{-1})	3.0-4.6V	188.5	1000	150.8	29
CUMA/SN+LiTFSI +LiDFOB	$Li/LiCoO_2$	0.62	0.5C	3.0-4.6V	~220	100	~181	30
FEC/LiDFOB	$Li/LiNi_{0.5}Mn_{1.5}O_4$	-	0.2C (1C=148 mA g^{-1})	3.0-4.9V	~110	20	~90	31
PMHS+PEO+DMAA+ PS+THF/LiTFSI/Speiers	$Li/LiNi_{0.5}Mn_{1.5}O_4$	0.25	0.1C (1C=170 mA g^{-1})	3.5-4.9V	131.5	50	126.3	32
PEGDA+NML+UPyMA/ LiTFSI	$Li/Li_{1.2}Ni_{0.13}Co_{0.13}Mn_{0.54}O_2$	0.66	0.2 C	2.1-4.9V	225	60	~220	29
PS/LiTFSI	**$Li/Li_{1.13}Mn_{0.517}Ni_{0.256}Co_{0.097}O_2$**	**0.78**	**0.1C 0.5C (1C=200 mA g^{-1})**	**2.0-4.8V 2.0-4.6V**	**270 208**	**100**	**192**	**This work**