Electronic Supplementary Material (ESI) for RSC Advances.

Supporting information

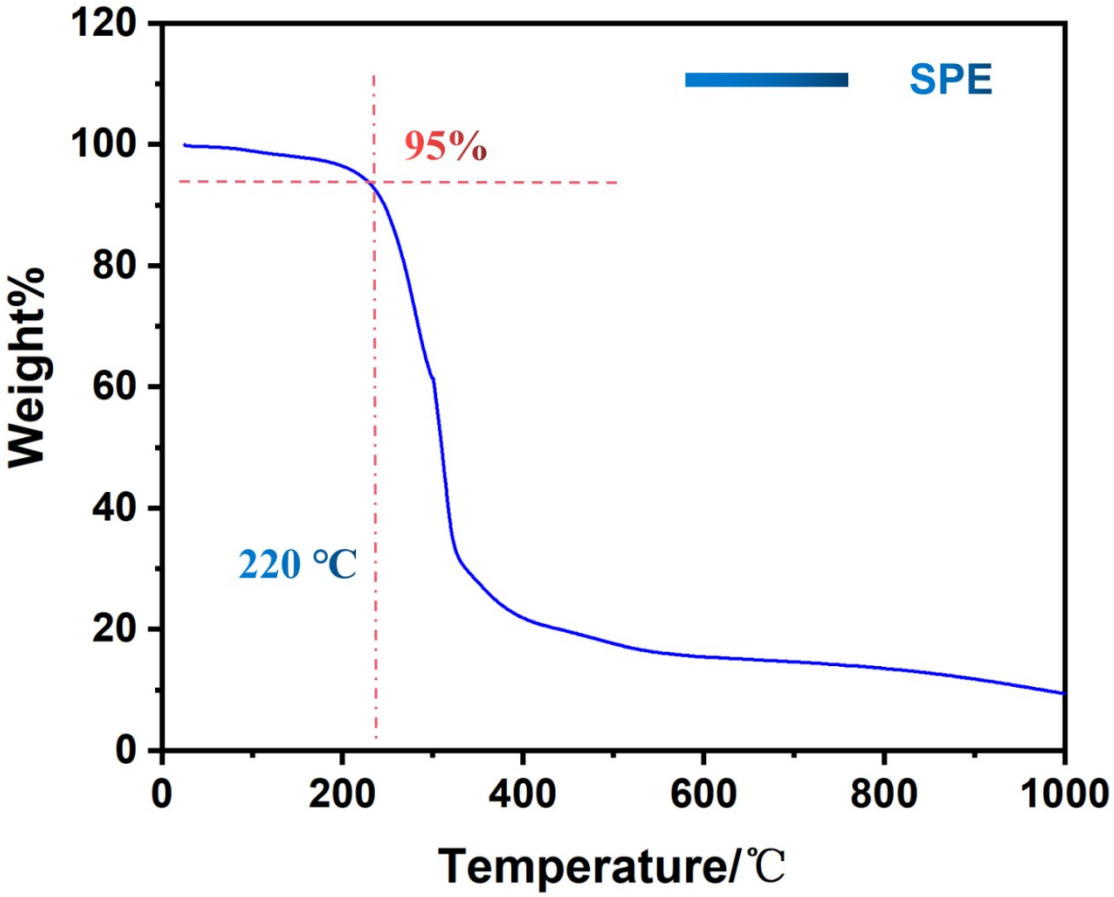

Figure S1.TGA curve of the PLAP membrane

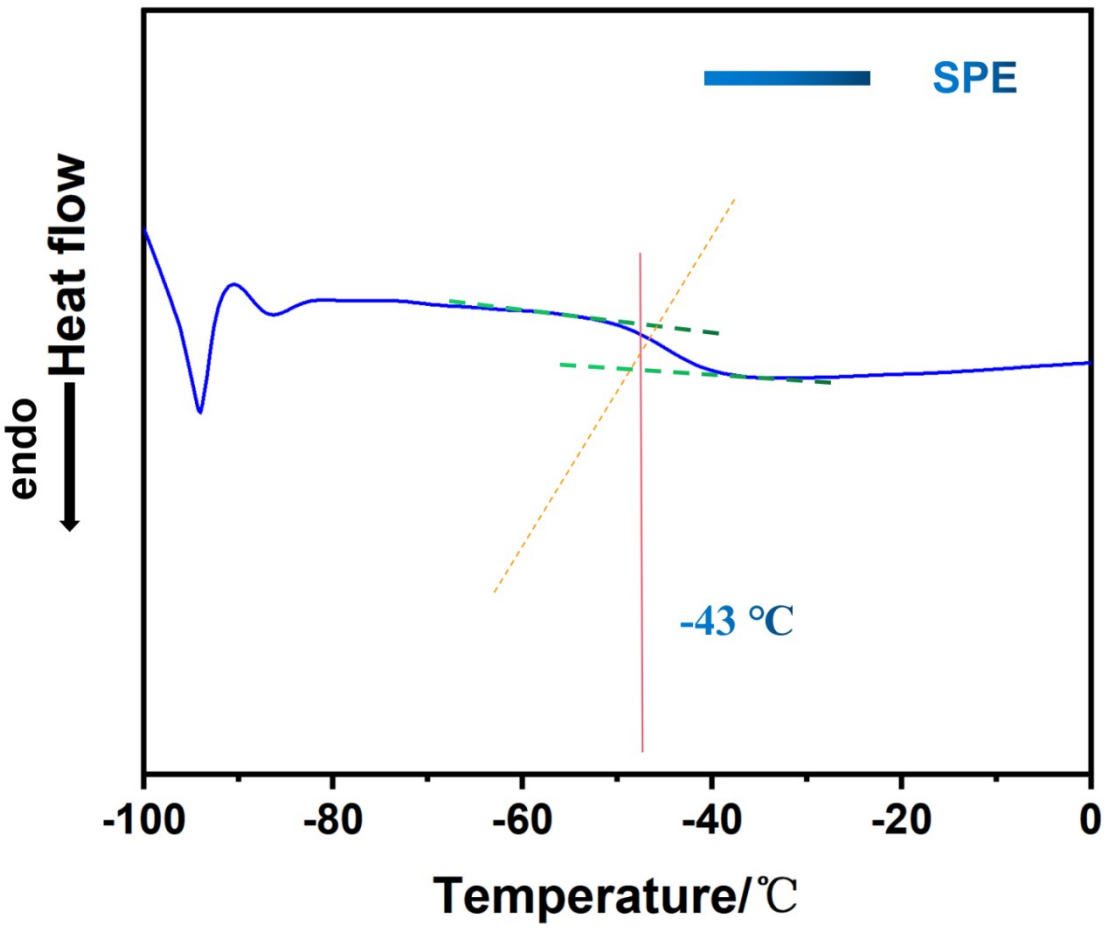

Figure S2. DSC curve of the PLAP membrane.

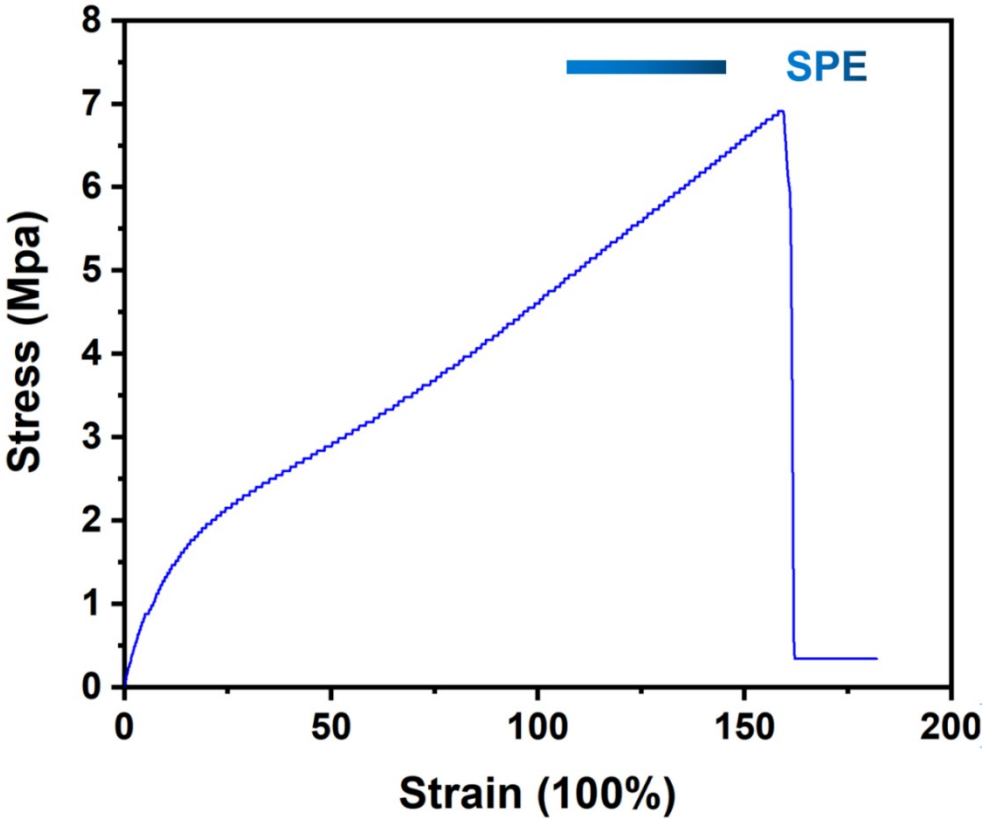

Figure S3. The stress-strain curve of as-prepared PLAP.

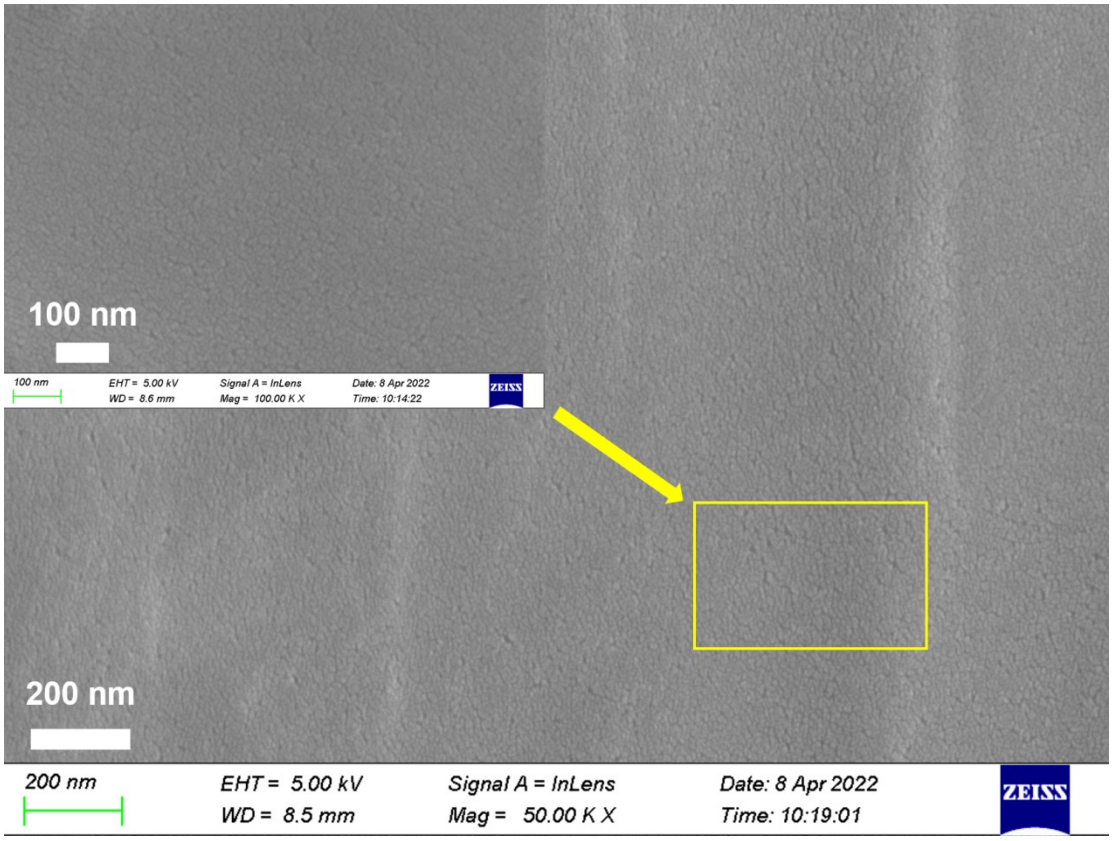

Figure S4. The surface morphology SEM image of PLAP.

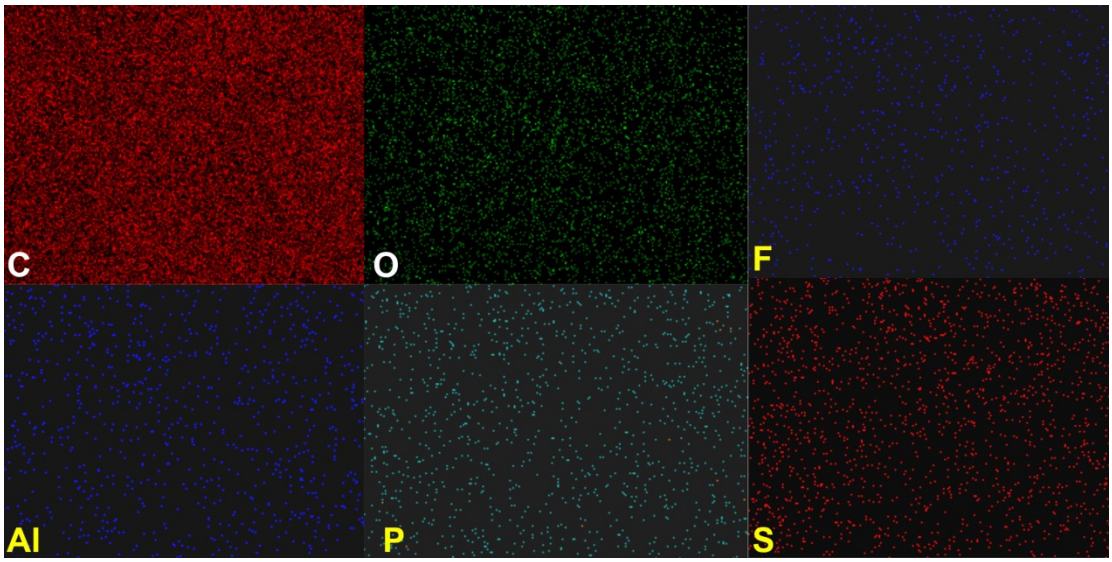

Figure S5. The elements mapping of PLAP.

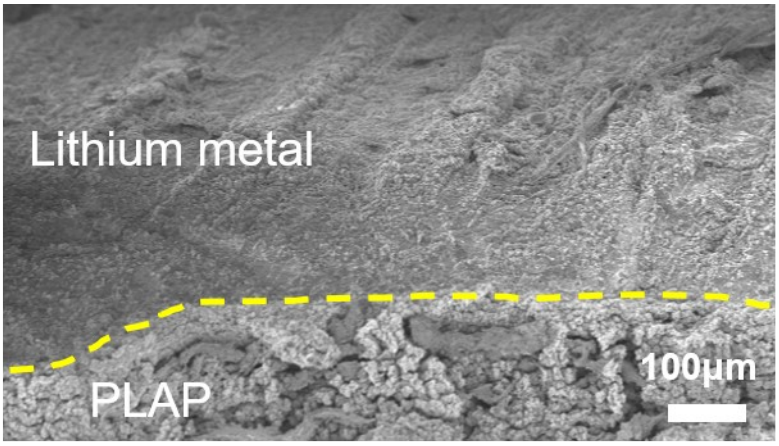

Figure S6. Cross-section SEM image of the interface between Lithium metal and PLAP.

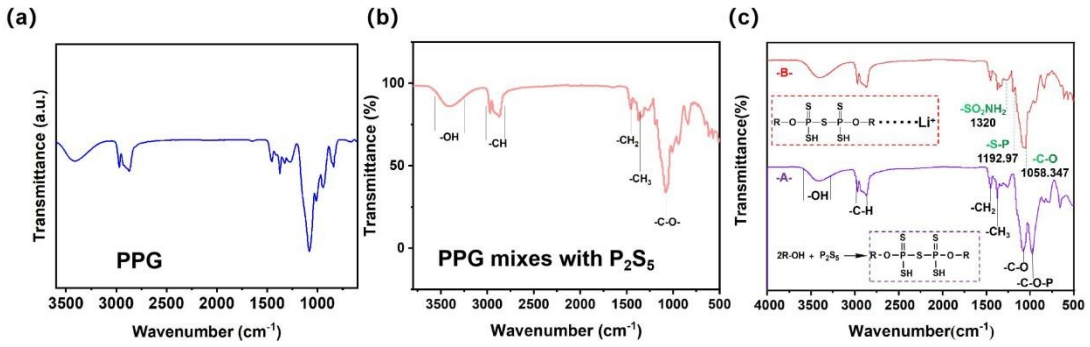

Figure S7. Infrared spectrum of (a) PPG ;(b) mixed with P_2S_5 before reaction and (c) after the reaction of PPG and P_2S_5.

Table S1 Ionic conductivity of PU/LiTFSI–Al_2O_3–xP_2S_5 (x =0.1, 0.4, 0.8, 1.0, 1.5, 2.0) system

Samples	PPG_{mol}:P_2S_5 $_{mol}$	L [a] (thickness, um)	R [b] (Ω)	S [c]=πr^2 (r=0.05 cm)	Conductivity (S cm^{-1})
1	2:0.1	300	1274	π/4	3.0×10^{-5}
2	2:0.4	300	273	π/4	1.4×10^{-4}
3	2:0.8	300	106	π/4	3.6×10^{-4}
4	2:1.0	300	50	π/4	7.4×10^{-4}
5	2:1.5	300	50	π/4	7.4×10^{-4}
6	2:2.0	300	50	π/4	7.4×10^{-4}

[a] The samples thickness. [b] Electrolyte impedance value. [c] Electrolyte area.

Table S2. Comparison of PU-based batteries

Polymer matrix	Lithium salt	Ionic conductivity	Mechanical strength	Thermalstability	Battery performance	Ref
This work (PLAP)	LiTFSI	7.4×10^{-4} (25 ℃) 4.3×10^{-3} (80 ℃)	7 Mpa	220	LiFePO4/Li ：168 (0.2 C) (25℃) 143 (5 C) (25℃)	
PEUU	$LiClO_4$	~10 - ^{8}	NA	NA	NA	[1]
PDXL-PU	$LiClO_4$ (O/Li = 12)	2 x 10 -^{5}	NA	NA	NA	[2]
PE-BCPE	LiTFSI	~5.7 x 10-^{4}	~0.9 MPa (stress)	NA	$LiFePO_4$/Li (1C, 133 mAh g^{-1})	[3]
LPU	$LiClO_4$	2.7 x 10^{-7} (RT)	NA	NA	NA	[4]
HPU	$LiClO_4$	1.51 x 10^{-5}	NA	NA	NA	[4]
NWPU	$LiClO_4$ (15 wt%)	5.44 x 10^{-6}	NA	176	$LiFePO_4$/Li (0.02C, 134 mAh g^{-1})	[5]
WPU	LiTFSI (20 wt%)	7.3 x 10-^{4} (60。C) 2.2 x 10^{-3}	0.5 MPa (stress)	~250	$LiFePO_4$/Li (0.1C, 151 mAh gT) (2.2-4 V 60 °C)	[6]
PCPU	LiTFSI (20 wt%)	1.12 x 10-^{4}	6 MPa	306	$LiFePO_4$/Li (1C, 134 mAh g^{-1})	[7]
PDMS-WPU	LiTFSI (20 wt%)	1.05 x 10^{-5}	NA	260	NA	[8]
SLICPs	NA	8.91 x 10^{-7}	NA	288	NA	[9]
SIPU	NA	9.8 x 10-^{8}	NA	200	NA	[10]
CL-PUA	$LiClO_4$	~10 - ^{8}	> 0.7 MPa (neat PU	> 400	NA	[11]
In-situ PUA	$LiClO_4$ (60 wt%)	3.72 x 10^{-3}	NA	NA	NA	[12]
PUA	$LiPF_6$	4.5 x 10-^{3} (20°C)	NA	NA	$LICoO_2$/graphite (0.2C, 147 mAh g^{-1}) (2.7-4.2 V 20 °C)	[13]
GPE-SN-IM	LiTFSI	1.63 x 10^{-3}	6.5 Mpa	NA	$LICoO_2$/Li	[14]
TPU-A	$LiClO_4$	~3 x 10-^{4}	NA	NA	NA	[15]
Cellulose/PU	LiTFSI	4.8 x 10 —^{4}	NA	NA	$LiFePO_4$/Li	[16]
EPE-25	LiTFSI	>10-^{4}	~1.3 MPa	295	NMC622/Li	[17]

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Table S3. All the orbital comparisons of the elements

	Binding energy (eV) (**before/ after**)	Full width high maximum (eV)	Area (cps, eV)	Content(%) (**before/ after**)
C 1s				
C-C	**284.8 / 284.8**	1.25	34169.29	**34.75 /37.6**
C-O	**286.42 / 286.4**	1.30	55410.43	**62.35/60.6**
O-C=O	**289.01 / 289.4**	1.06	1874.94	**2.9 / 1.8**

O 1s				
C-O	**530.95 / 531.0**	1.53	5714.34	**7.58 / 5.7**
C=O/-OH	**532.64 / 532.6**	1.53	85145.10	**92.42 / 94.3**
S 2p				
-S- 2p3/2	**161.5 / 162.1**	1.34	1393.28	**31.5 / 30.3**
-S- 2p1/2	**162.76 / 163.2**	1.34	709.57	**15.4 / 15.5**
S=P 2p3/2	**163.53 / 163.6**	1.20	1004.46	**21.5 / 21.8**
S=P 2p1/2	**164.83 / 164.7**	1.20	512.93	**11.31 / 11.2**
O=S=O 2p3/2	**168.23 / 168.7**	1.17	651.91	**14.01 / 14.2**
O=S=O 2p1/2	**169.3 / 169.8**	1.17	327.05	**6.93 / 7.0**
P 2p				
P 2p3/2	**133.22 / 133.7**	1.65	1693.01	**56.01 / 56.5**
P 2p1/2	**134.21 / 134.4**	1.79	1307.81	**43.32 / 43.5**
Li 1s				
Li-S	**55.4 / 55.4**	2.19	126.73	**100 / 100**