Supporting Information

Low-Cost Gel Polymer Electrolyte for High-Performance Aluminum Ion Batteries

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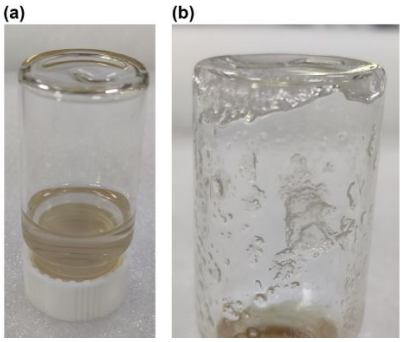

Figure S1. Digital photos of the $AlCl_3/Et_3NHCl$ (r=1.3) mixture: (a) liquid state and (b) transparent ice-like state.

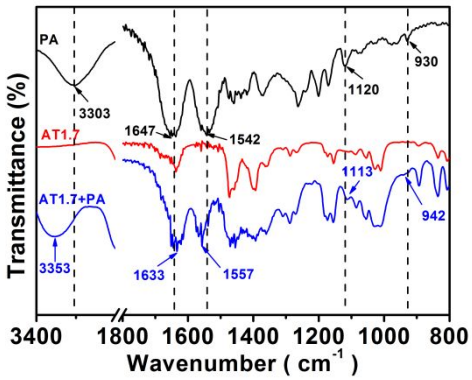

Figure S2. FTIR spectra of PA, $AlCl_3/Et_3NHCl$ (r=1.7) ionic liquid and the $AlCl_3/Et_3NHCl$ (r=1.7) gel polymer electrolyte

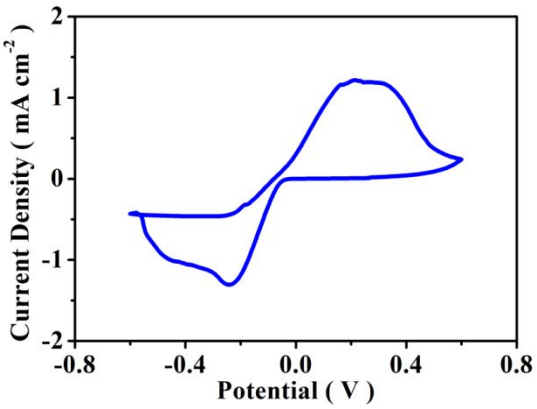

Figure S3. Reversible Al stripping/plating behavior of the $AlCl_3/Et_3NHCl$ (r=1.7) gel polymer electrolytes.

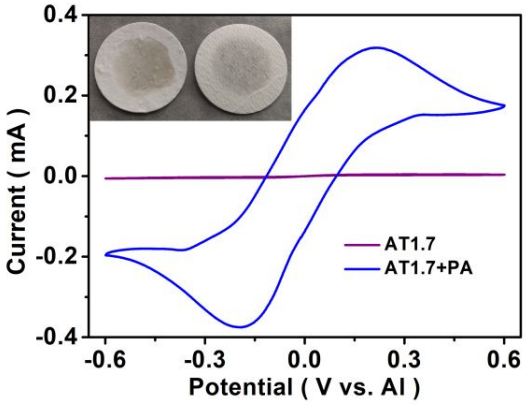

Figure S4. Comparison of cyclic voltammetry of the $AlCl_3/Et_3NHCl$ (r=1.7) gel polymer electrolyte and the $AlCl_3/Et_3NHCl$ (r=1.7) ionic liquid electrolyte after being exposed to the air for 10 min at a scan rate of 1 mV s^{-1}.

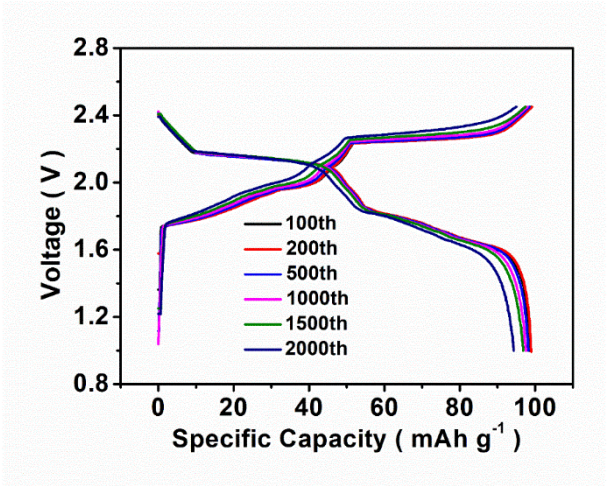

Figure S5. The charge/discharge curves of the Al//graphite batteries with the $AlCl_3/Et_3NHCl$ (r=1.7) gel polymer electrolyte at different cycles at room temperature.

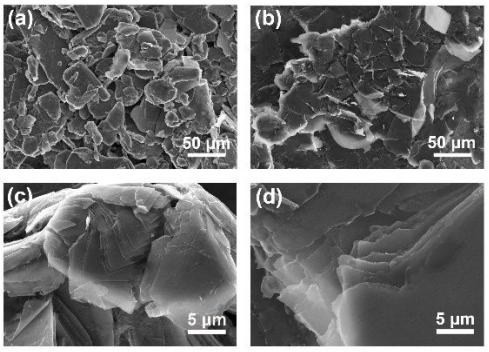

Figure S6. SEM images of the graphite cathode: (a), (c) before cycling and (b), (d) after cycling.

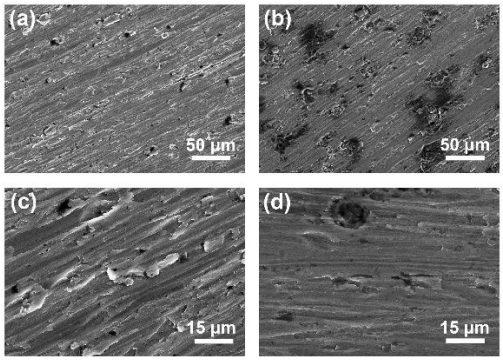

Figure S7. SEM images of the Al foil anode: (a), (c) before cycling and (b), (d) after cycling.

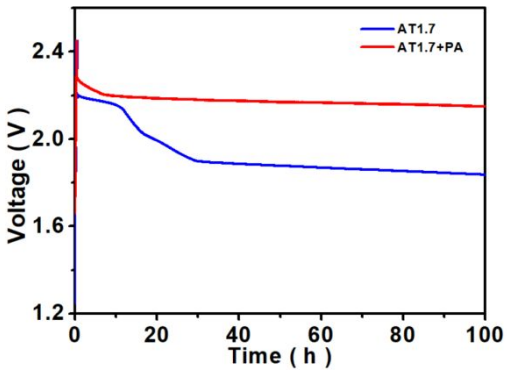

Figure S8. Self-discharge behaviors of the Al//GPE//Graphite and the Al//IL//Graphite batteries subjected to 100 h rest after charging to 2.45 V at a constant current density of 200 mA g^{-1}.

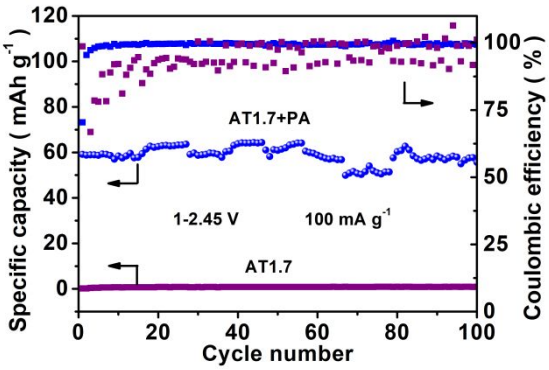

Figure S9. The electrochemical performance of the Al//graphite batteries with the GPE electrolyte and the ionic liquid electrolyte that are exposed to the air for 10 min.

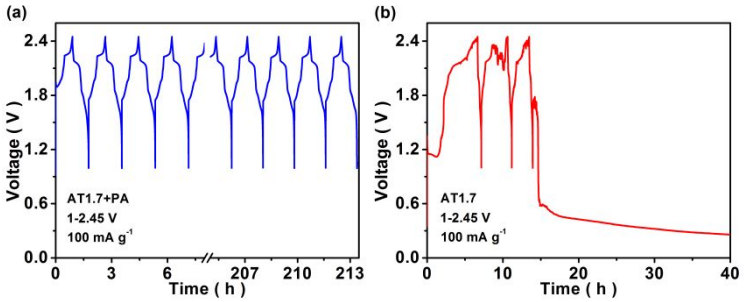

Figure S10. The charge-discharge profiles of the Al//graphite batteries with (a) the GPE electrolyte and (b) the ionic liquid electrolyte in coin cell assembly.

Figure S11. Digital photos of the disassembled coin cell shells of the Al//GPE//Graphite battery and the Al//IL//graphite battery after cycling.

Table S1. The price comparison of different reagents from different brands.

brand / reagent	Aladdin	Sigma-Aldrich	Macklin
$AlCl_3$ (99.99%, 100 g)	￥3,699.00	￥1,128.58	￥2,920.00
EMIC (98%, 25 g)	￥181	￥1,023.89	￥180
Et_3NHCl (99%)	￥49 (250g)	￥467.59 (250g)	￥91 (500g)

Table S2. The ionic conductivities of the $AlCl_3/Et_3NHCl$ (r=1.7) gel polymer electrolyte at different temperature.

Temperature (^oC)	80	70	60	50	40	30	25
Ionic conductivity (mS cm^{-1})	8.50	7.47	7.21	6.76	5.66	4.51	3.86

Table S3. The performance comparison with previous reports.

Electrolytes	Positive electrode	Current density (mA g^{-1})	Capacity (mAh g^{-1})	Cycles	Working time (h)
$AlCl_3$/EMIC (r=1.3)[10]	Natural graphite	660	60	6000	~1091
$AlCl_3$/Urea (r=1.3)[18]	Graphite	100	73	200	~292
$AlCl_3$/Et_3NHCl (r=1.7)[19]	Graphite	1000	64	1000	~128
$AlCl_3$/Urea (r=1.3)[20]	Natural graphite	600	50	1000	~167
$AlCl_3$-NaCl-LiCl-KCl[25]	Graphite	200	83.4-114.9	1500	~1350-1800
$AlCl_3$/Et_3NHCl (r=1.5)[27]	Graphene	5000	112	30000	~1344
EMIC-GPE[29]	Graphite	60	109-120	100	~400
Et_3NHCl-GPE[30]	Graphite	1000	90	800	~108
$AlCl_3$/EMIC (r=1.3)[38]	GF-HC	100000	120	250000	~600
$AlCl_3$/EMIC (r=1.3)[39]	Few-layer graphene:CoB	1000	≈70	4250	~595
$AlCl_3$/EMIC (r=1.3)[40]	Carbon nanoscrolls	50000	≈101	55000	~222
$AlCl_3$/EMIC (r=1.3)[41]	Graphene aerogel	5000	100	25000	~1000
Our work	Graphite	200	94.6	2000	~1892