Supporting Information

A long-life rechargeable Al ion battery based on molten salts

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Fig. S1(a) The photograph of an assembled Al/graphite cell; (b) The photographs of the aluminum foil (upper), and the graphitic carbon cathode (bottom): original graphitic carbon paper (left), wrapped by glass fiber (middle), the one after 10,000 cycles (right).
**Fig.S2** The XRD(a) pattern and SEM image(b) of the pristine graphitic carbon paper before test.
Fig. S3 Phase equilibrium diagram of AlCl₃-NaCl mixture.¹ ³
Fig. S4(a) X-ray diffraction pattern of the inorganic molten salt electrolyte with a mole ratio of \( \text{AlCl}_3/\text{NaCl} \sim 1.63 \). (b) Raman spectrum of the inorganic molten salt electrolyte with a mole ratio of \( \text{AlCl}_3/\text{NaCl} \sim 1.63 \).
Fig. S5 Theoretical decomposition potentials of the indicated reactions at different temperatures.
Fig. S6: Coulombic efficiency and capacity retention of an Al/Graphite battery at various current densities (100 – 500 mAg⁻¹).
Fig. S7 (a) The discharge capacity and the corresponding retention rate of the Al/Graphite battery; (b) Galvanostatic charge and discharge curves of Al/Graphite battery charging at 4000\,mAg$^{-1}$ and discharging at various current densities ranging from 100 to 4000 \,mAg$^{-1}$; (c) The cycling performance and coulombic efficiency at a charging current density of 3000\,mAg$^{-1}$ and a discharging current density of 200\,mAg$^{-1}$. 
Fig. S8 Surface analysis of the Al anodes. (a-c) SEM images of the Al anodes obtained from three Al/Graphite battery after 20(a), 100 (b) 10000 (c) cycles, respectively, indicating no dendrite formation over these cycles.
Fig. S9 The discharge capacities of the cells with different aluminum anodes (from 0.0304 to 0.243g) at a current density of 500 mA g⁻¹
Fig. S10 SEM image (A) and (B) TEM image of the graphitic carbon papers after 10000 cycles.
**Fig.S11** (a) The charge–discharge curves at 100mAg⁻¹ with a electrolyte of molten salts at 120 °C; (b) The charge–discharge curves at 100mAg⁻¹ with a electrolyte of ionic liquid at 120 °C; (c) Specific capacity of different electrolyte at different current density, when the temperature is 120 °C.
Fig. S12: The cyclic voltammogram curve of an Al-ion battery at a scan rate of 10 mVs$^{-1}$.
Fig. S13 (a) Polarization curve of the molybdenum sheet in NaAlCl$_4$ electrolyte; (b) Charge–discharge curves of Mosheet at 500mAg$^{-1}$. The inset shows the charge and discharge cycles.
<table>
<thead>
<tr>
<th>Charge cut-off voltage/V</th>
<th>1.80</th>
<th>1.98</th>
<th>2.14</th>
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<tbody>
<tr>
<td>The voltage drop, ΔE/V</td>
<td>0.352</td>
<td>0.081</td>
<td>0.051</td>
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</table>
Fig. S14. (a) The Nyquist plots of the Al-ion full battery at different bias from 0.0 V to 1.0 V. (b) The linear fits of the $Z'$ vs. $\omega^{1/2}$ in the low-frequency region. (c) The Nyquist plots of the Al-ion full battery at the 10000th cycle.
Reference