Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

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

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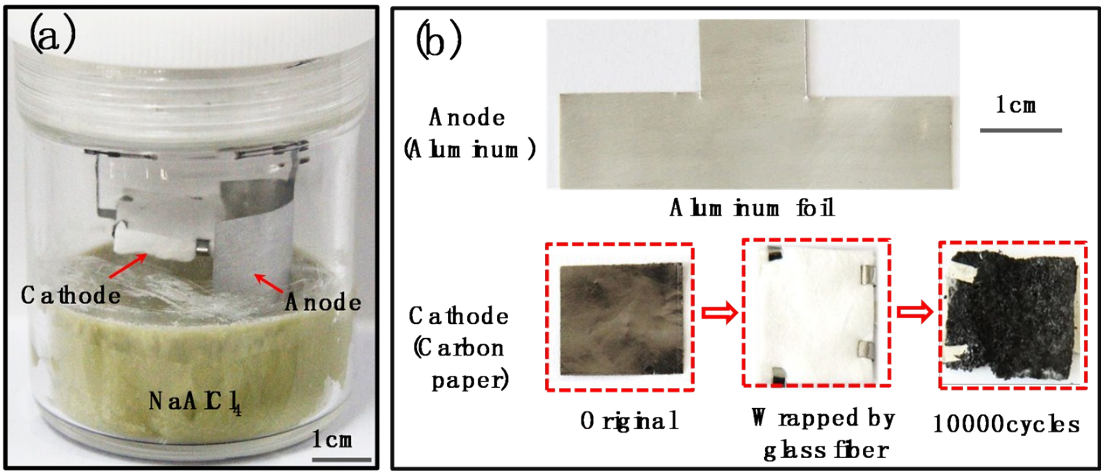


Fig.S1(a)*The photograph of a assembled Al/graphite cell;* ***(b)*** *The photographs of the aluminum foil (upper), and the graphitic carbon cathode (bottom): original graphitic carbon paper (left), wrapped by glass fiber (middle), the one after10000 cycles (right).*

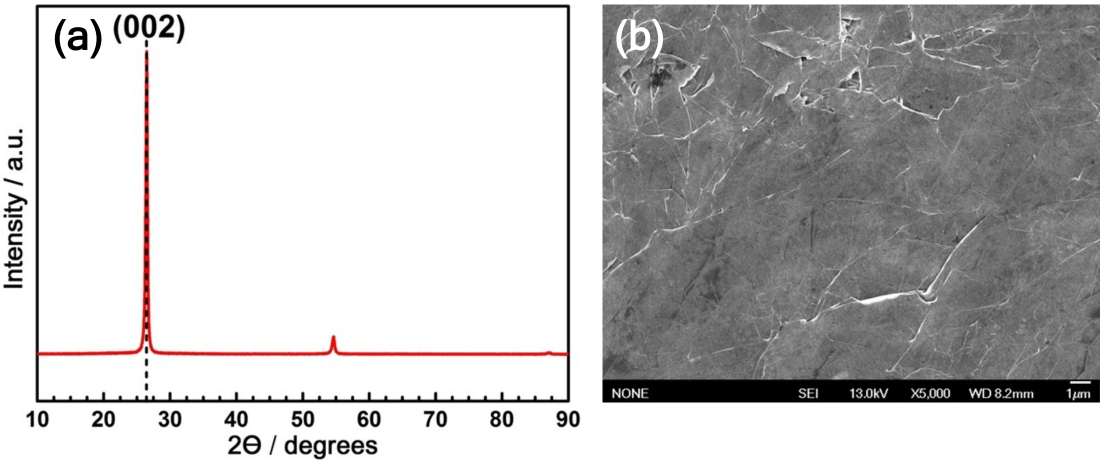


Fig.S2*The XRD(a) pattern and SEM image(b) of the pristine graphitic carbon paper before test*

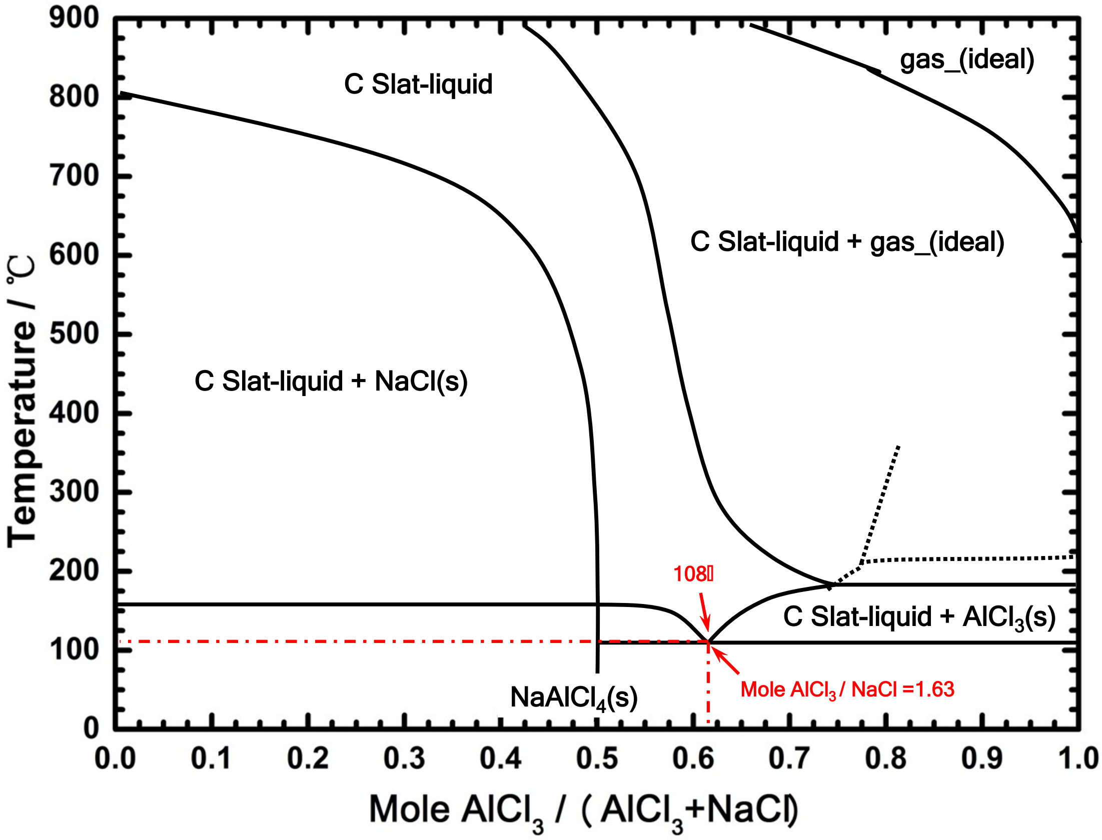


Fig.S3 *Phase equilibrium diagram of AlCl3-NaCl mixture.*[1-3]

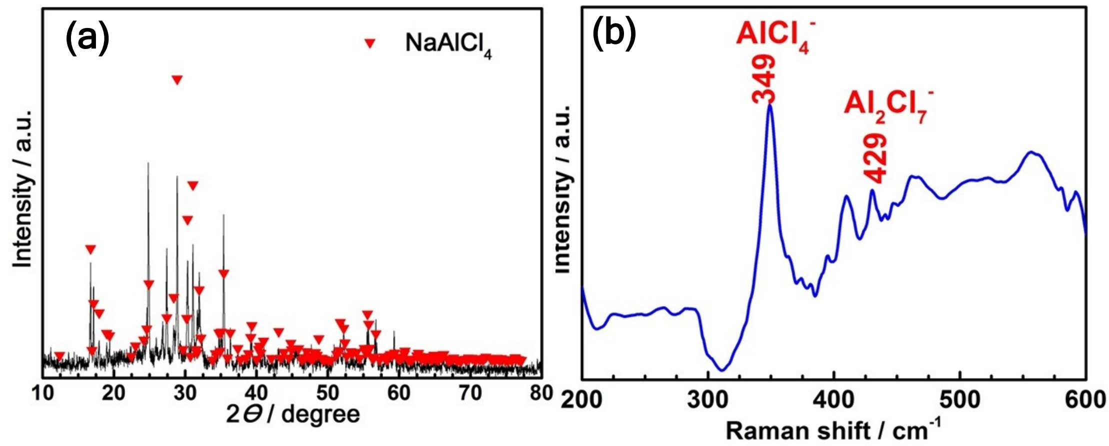


Fig. S4(a)*X-ray diffraction pattern of the inorganic molten salt electrolyte with a mole ratio of $AlCl_3/NaCl$ ~1.63. (****b)****Raman spectrum of the inorganic molten salt electrolyte with a mole ratio of $AlCl_3/NaCl$ ~ 1.63.*

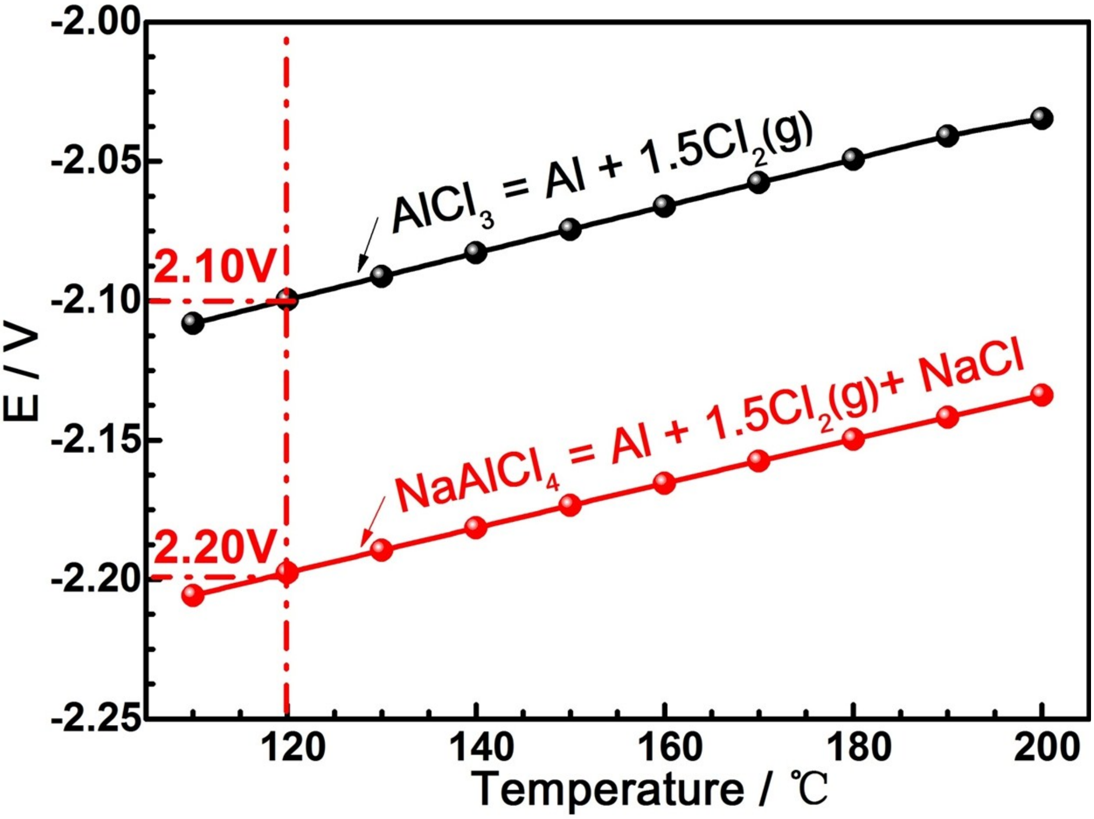


Fig.S5*Theoretical decomposition potentials of theindicated reactions at different temperatures.*

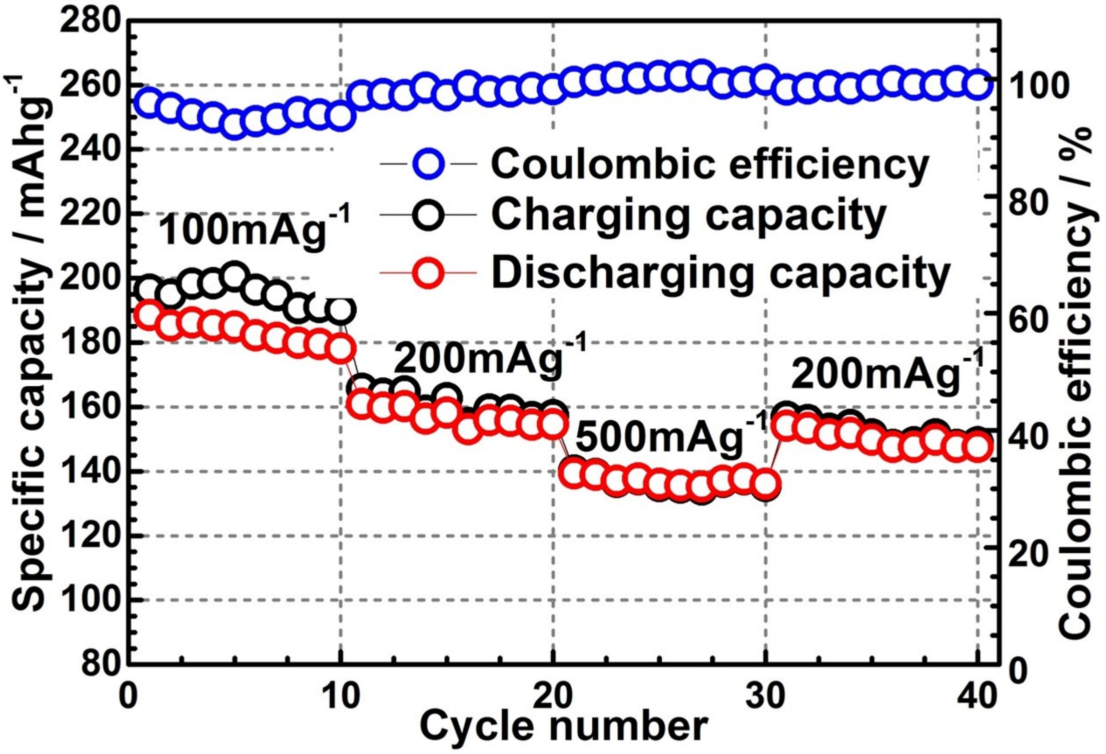


Fig.S6*Coulombic efficiencyand capacityretention of an Al/Graphite batteryat various current densities(100 ~ 500mAg^{-1}).*

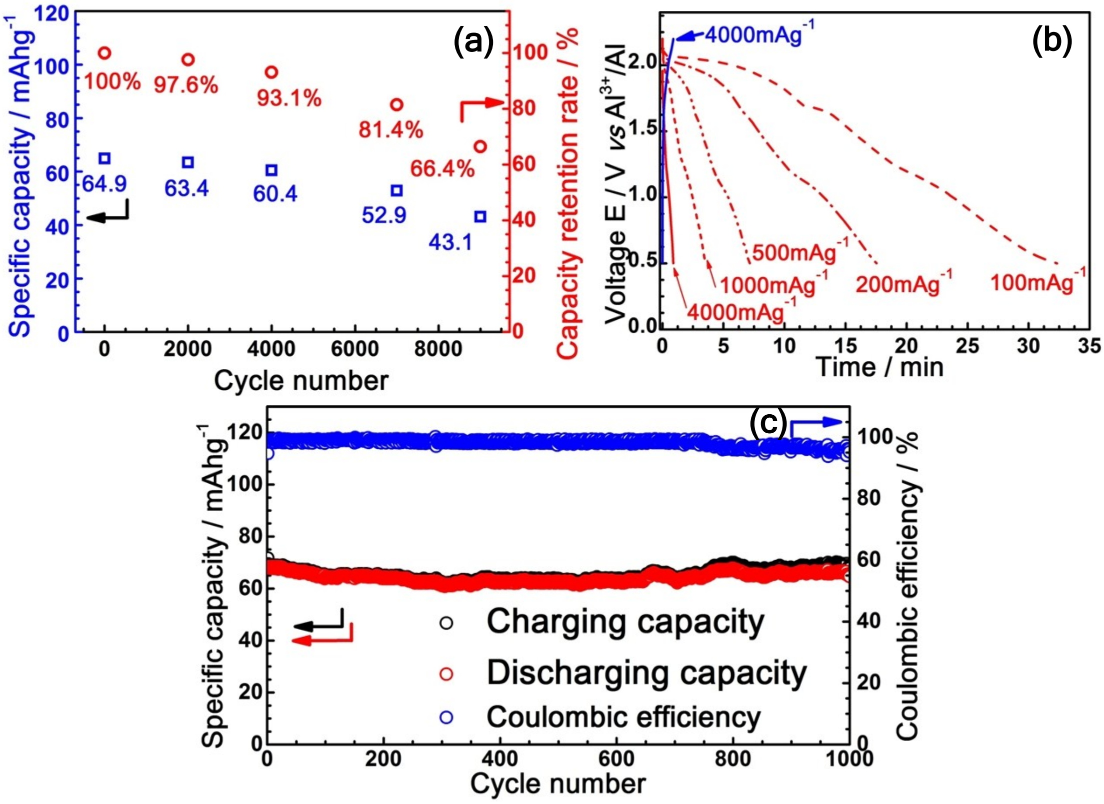
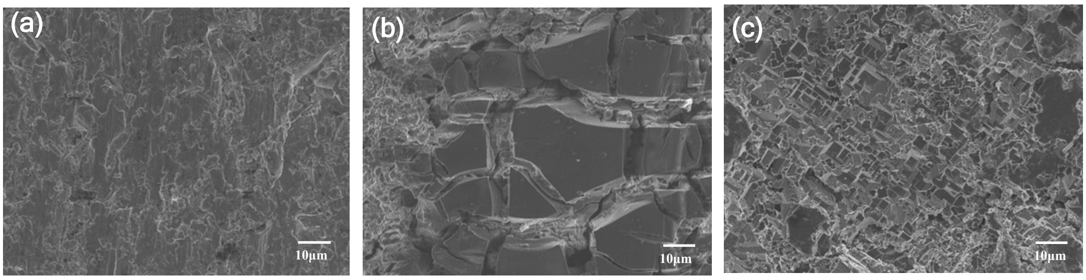


***Fig. S7 (a)** The discharge capacity and the corresponding retention rate of the Al/Graphite battery; **(b)**Galvanostatic charge and discharge curves of Al/Graphite battery charging at 4000mAg^{-1} and discharging at various current densities ranging from 100 to 4000 mAg^{-1}.**(c)**The cycling performance and coulombic efficiency at a charging current density of 3000mAg^{-1} and a discharging current density of 200mAg^{-1}*



Fig, S8*Surface analysis of the Al anodes, (****a-c****)SEM images of the Al anodes obtained from threeAl/Graphite battery after 20(****a****), 100 (****b****) 10000 (****c****) cycles,respectively, indicating no dendrite formation over these cycles.*

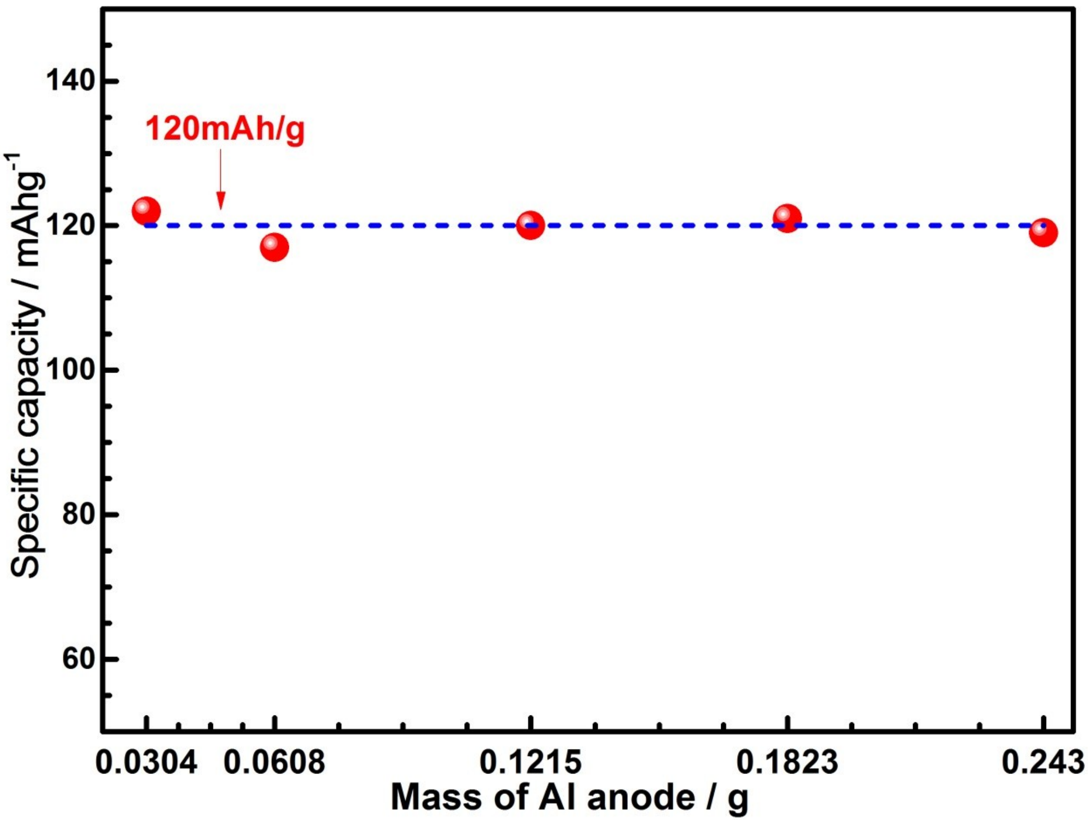


Fig. S9 The discharge capacities of the cells with different aluminum anodes (from 0.0304 to 0.243g) at a current density of 500 mAg^{-1}

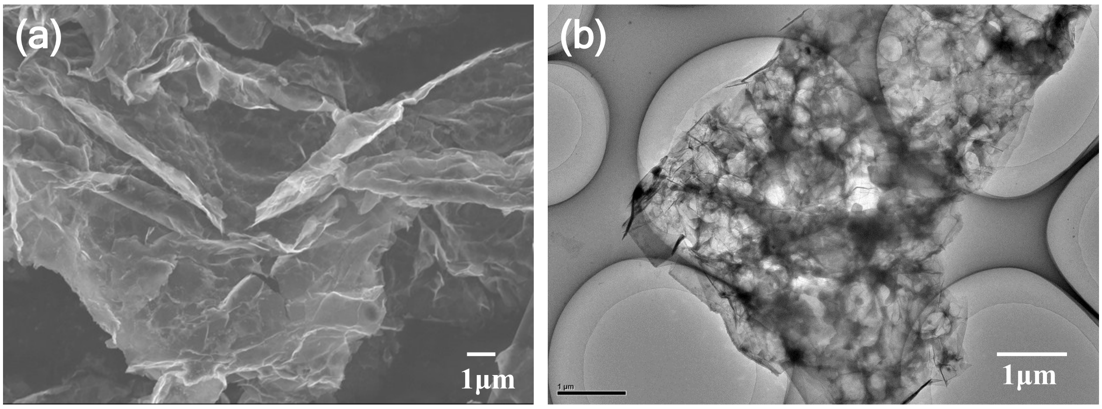


Fig. S10 *SEM image (**A**) and (**B**) TEM image of the graphitic carbon papersafter 10000 cycles.*

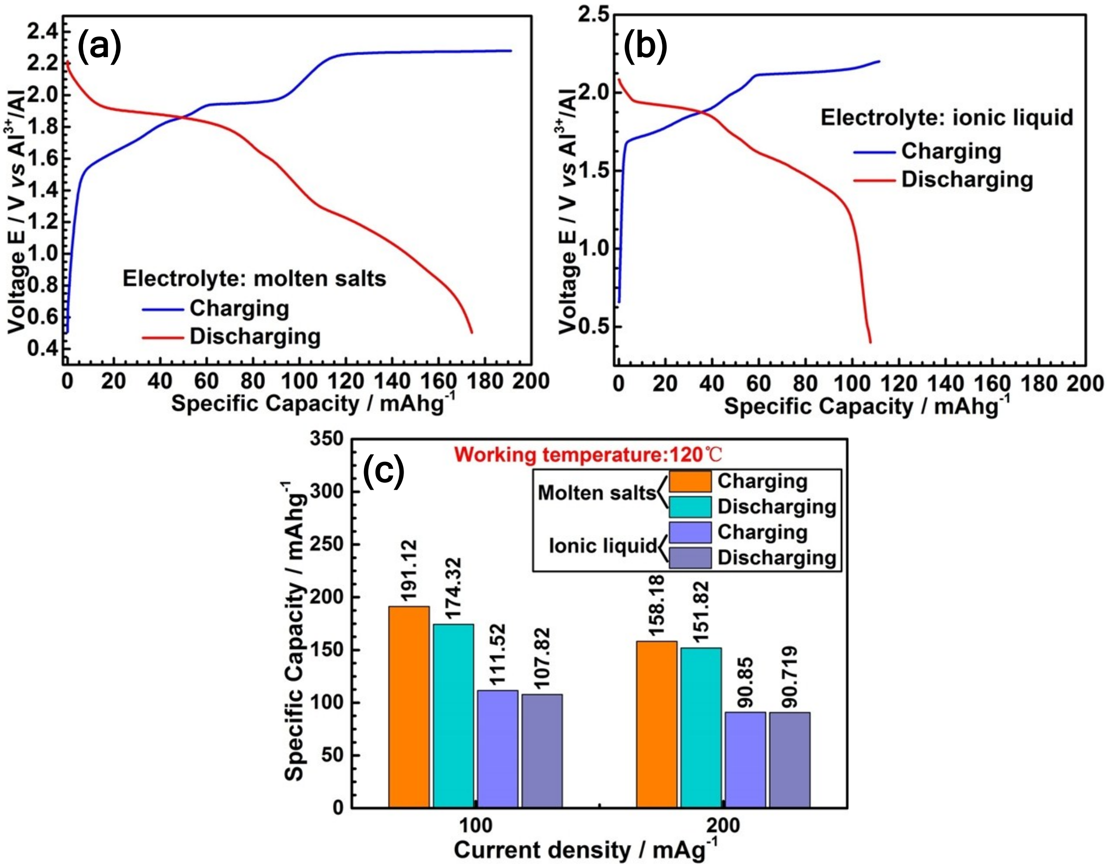


Fig.S11 ***(a)*** *The charge–discharge curves at 100mAg*$^{-1}$ *with a electrolyte of molten salts at 120℃;* ***(b)*** *The charge–discharge curves at 100mAg*$^{-1}$ *with a electrolyte of ionic liquid at 120℃;* ***(c)*** *Specific capacity of different electrolyte at different current density,when the temperature is 120℃*

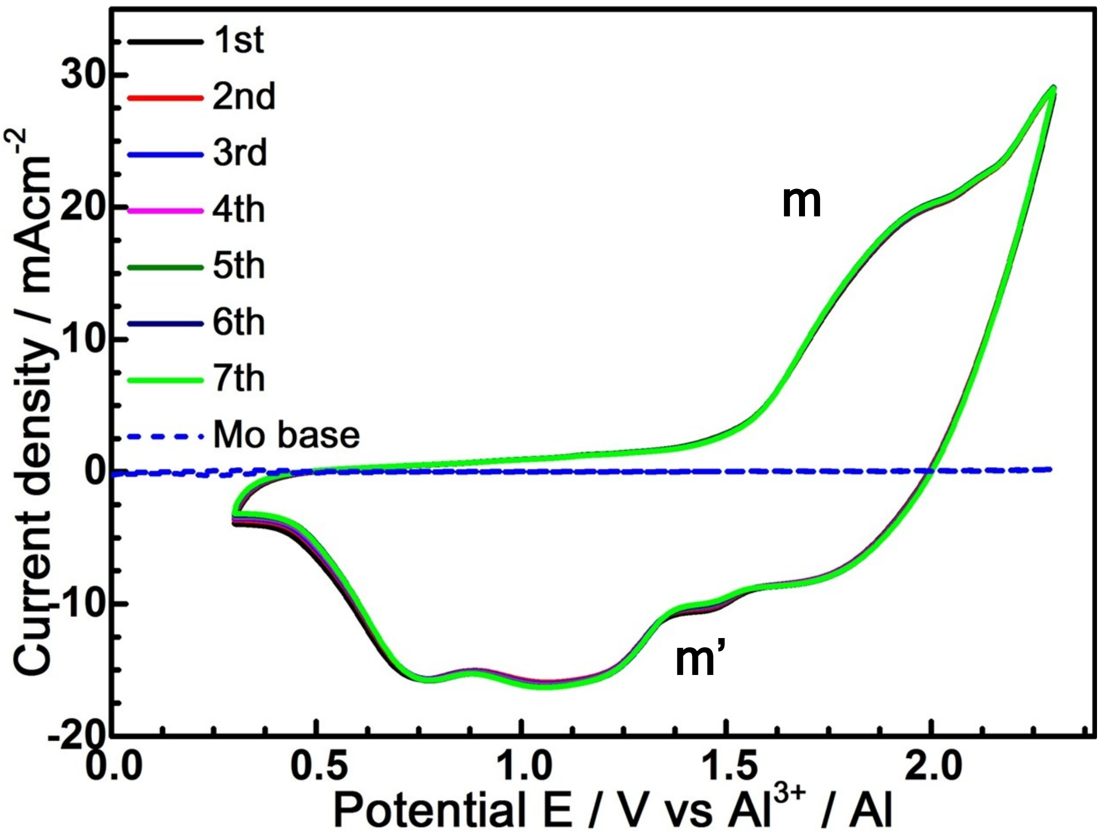


Fig. S12*The cyclic voltammogram curve of an Al-ion batteryat a scan rate of 10 mVs*$^{-1}$

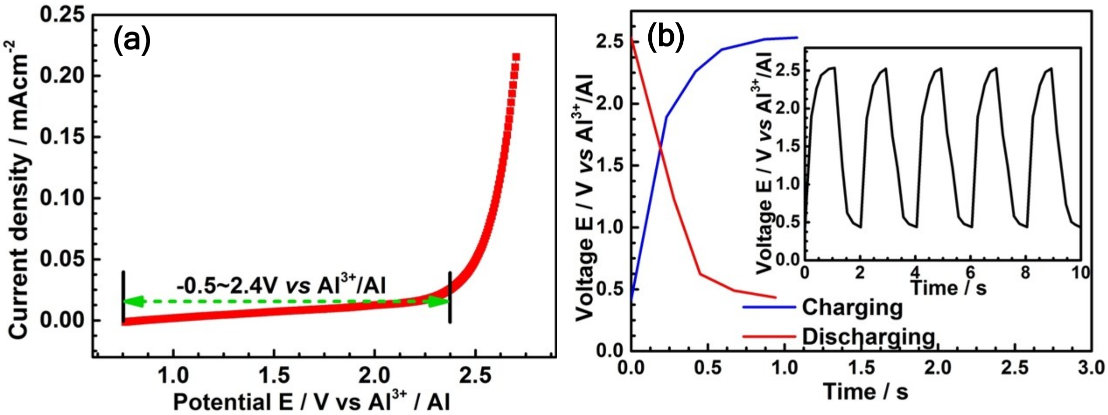


Fig. S13 (*a) Polarization curve of the molybdenum sheet in $NaAlCl_4$ electrolyte; (b)Charge–discharge curves of Mosheet at 500mAg-1. Theinset shows the charge and discharge cycles.*

Table S1 | The voltage drop (ΔE) under different the cut-off voltages

Charge cut-off voltage/V	1.80	1.98	2.14
The voltage drop, ΔE/V	0.352	0.081	0.051

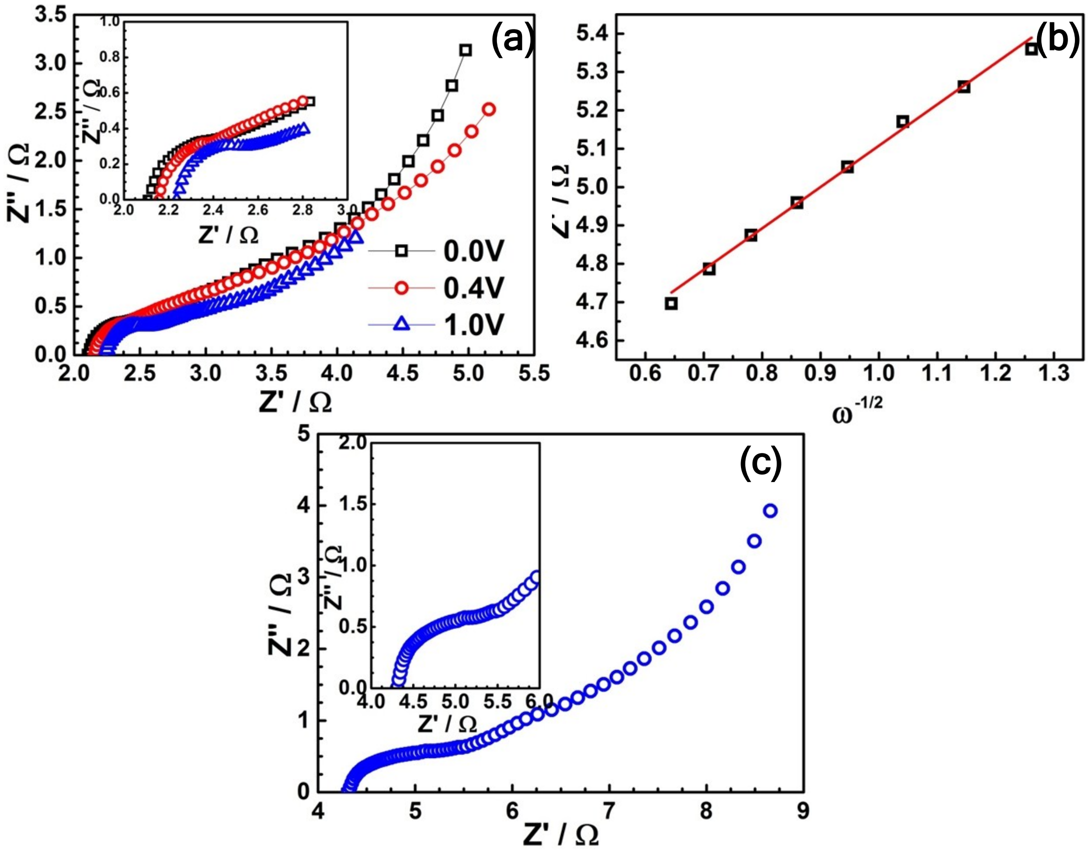


Fig. S14.(a)*The Nyquist plots of the Al-ion full battery at different bias from 0.0 V to 1.0 V. (****b****) The linear fits of the Z' vs. $\omega^{1/2}$ in the low-frequency region. (****c****)The Nyquist plots of the Al-ion full battery at the 10000th cycle*

Reference

*1 J. Kendall, E. D. Crittenden and H. K. Miller, J. Am. Chem. Soc., 1923, **45**, 963.*

*2 R. Midorikawa, J. Electrochem. Soc. Japan., 1955, **23**, 72.*

*3 E. Dewing, Metall. Mater. Trans. B, 1981, **12**, 705.*