Supplementary Materials

A stable porous aluminum electrode with high capacity for rechargeable lithium-ion batteries

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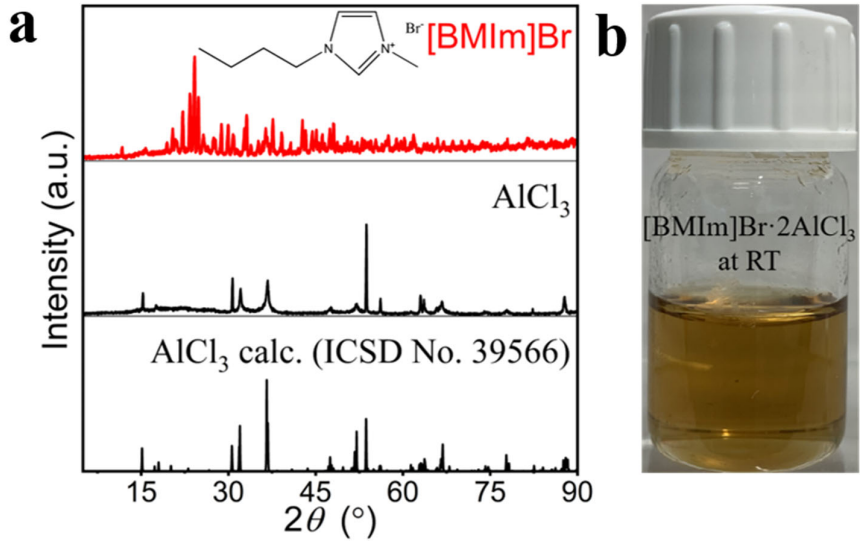

Figure S1. (a) The comparison of the [BMIm]Br and $AlCl_3$ used in this paper with the standard XRD patterns (the insertion is the molecular structure of [BMIm]Br). **(b)** Photograph of the IL [BMIm]Br·2$AlCl_3$ at room temperature.

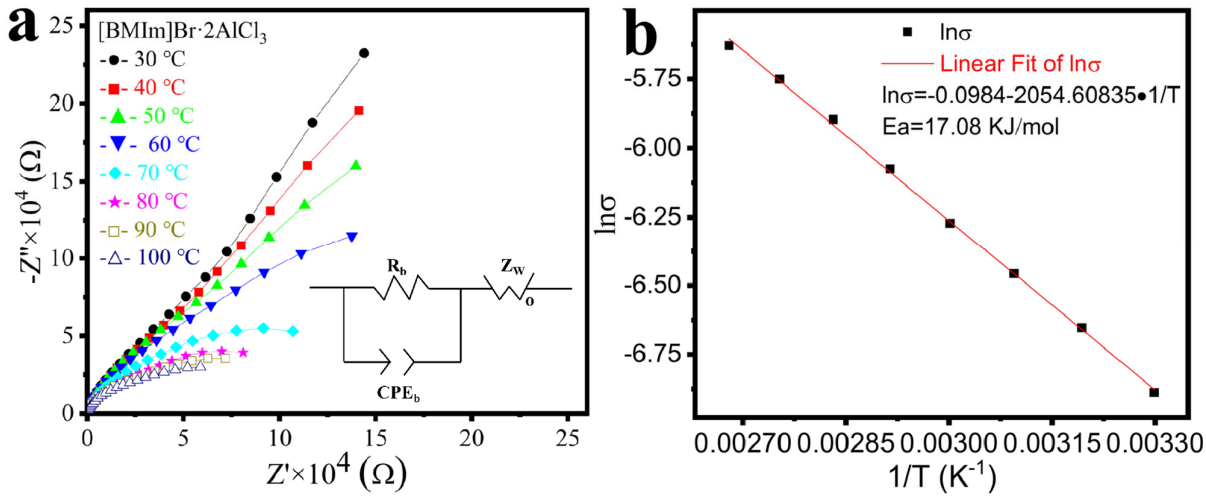

Figure S2. (a) EIS of the IL [BMIm]Br·2$AlCl_3$ (inset: the equivalent circuit for the simulation). **(b)** The linear fitting curve of activation energy.

Table S1. Measured data and corresponding calculated values of ionic conductivity of the IL [BMIm]Br·2AlCl$_3$.

Temperature/°C	Thickness/mm	Impedance/Ω	Area/cm^2	Ionic Conductivity/(S cm^{-1})
30	3.03	95.03	3.14	$1.02\cdot10^{-3}$
40	3.03	74.59	3.14	$1.29\cdot10^{-3}$
50	3.03	61.38	3.14	$1.57\cdot10^{-3}$
60	3.03	51.05	3.14	$1.89\cdot10^{-3}$
70	3.03	41.98	3.14	$2.30\cdot10^{-3}$
80	3.03	35.16	3.14	$2.75\cdot10^{-3}$
90	3.03	30.33	3.14	$3.18\cdot10^{-3}$
100	3.03	26.94	3.14	$3.59\cdot10^{-3}$

Equations for the temperature dependence of the ionic conductivity:

$$\sigma(T) = A \cdot \exp(\frac{-Ea}{R \cdot T}) \quad \text{(S1)}$$

$$\ln\big(\sigma(T)\big) = \ln(A) - \frac{Ea}{R \cdot T} \quad \text{(S2)}$$

$$\ln\big(\sigma(T)\big) = \ln(A) - \frac{Ea}{R} \cdot \frac{1}{T} \quad \text{(S3)}$$

where σ is the ionic conductivity, T is the absolute temperature, E_a is the activation energy, and A is a pre-exponential factor.

Table S2. Based on the calculated ionic conductivity (σ) of the IL [BMIm]Br·2AlCl$_3$, the relevant parameters used to fit the activation energy E_a are calculated according to the Equations S1–S3.

T / °C	σ / (S cm^{-1})	ln σ	T^{-1} / (10^{-3} K^{-1})
30	$1.02\cdot10^{-3}$	–6.89	3.30
40	$1.29\cdot10^{-3}$	–6.65	3.19
50	$1.57\cdot10^{-3}$	–6.46	3.09
60	$1.89\cdot10^{-3}$	–6.27	3.00
70	$2.30\cdot10^{-3}$	–6.07	2.91
80	$2.75\cdot10^{-3}$	–5.90	2.83
90	$3.18\cdot10^{-3}$	–5.75	2.75
100	$3.59\cdot10^{-3}$	–5.63	2.68

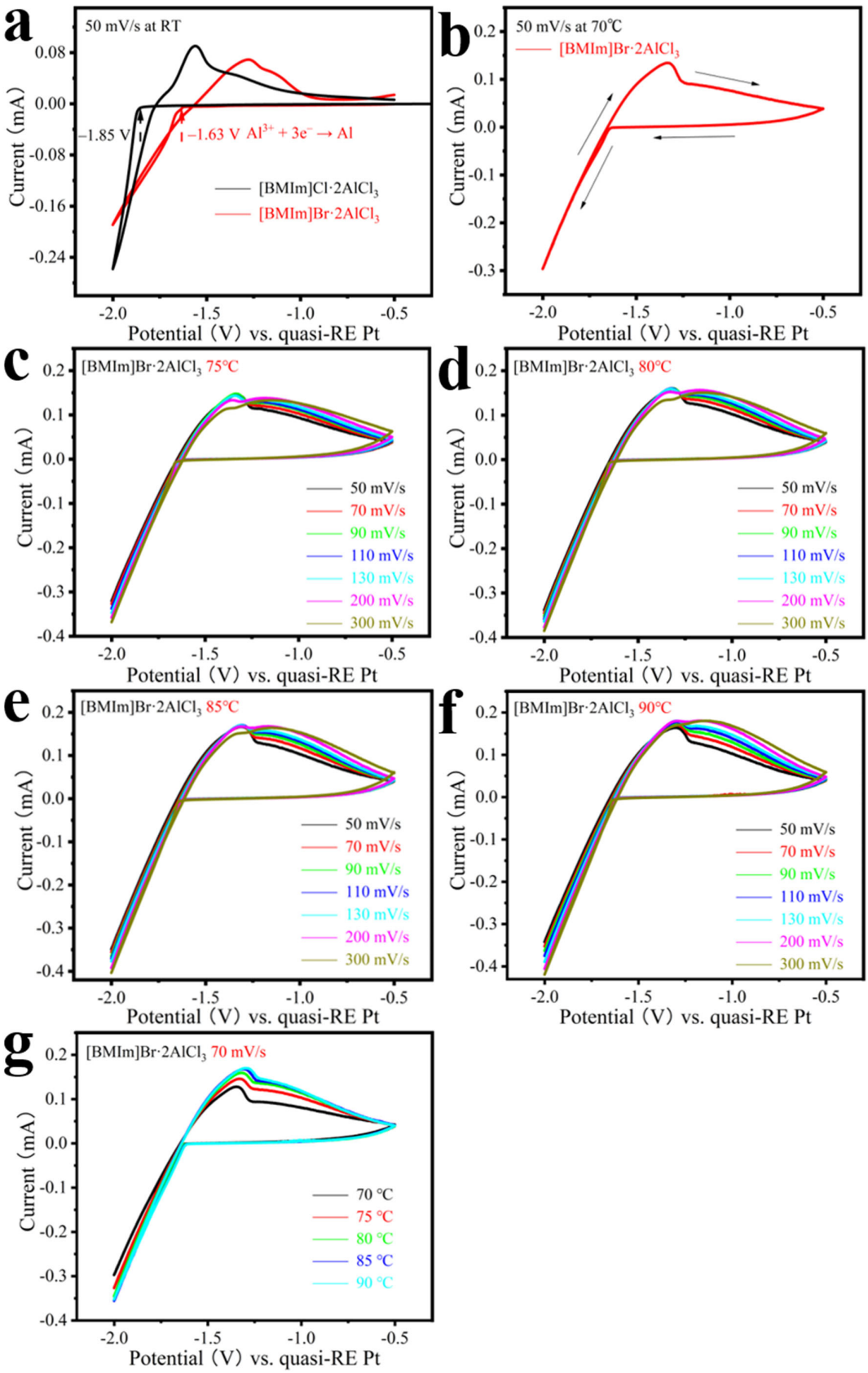

Figure S3. Synopsis of the CVs of [BMIm]Br·2AlCl$_3$ and [BMIm]Cl·2AlCl$_3$ at different scan rates and temperatures.

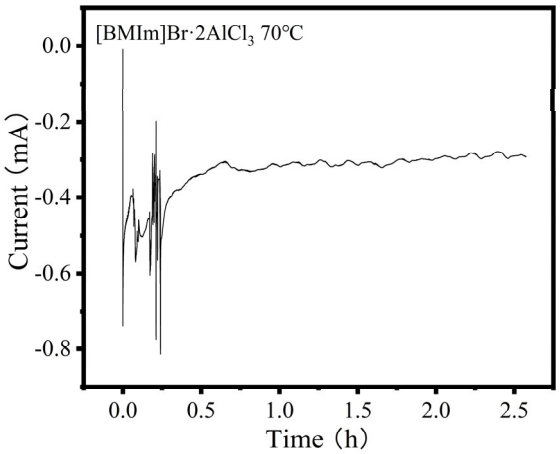

Figure S4. Time–current curve via potentiostatic electrolysis for electrodeposited Al at –1.70 V and 70 °C after about 2.5 h.

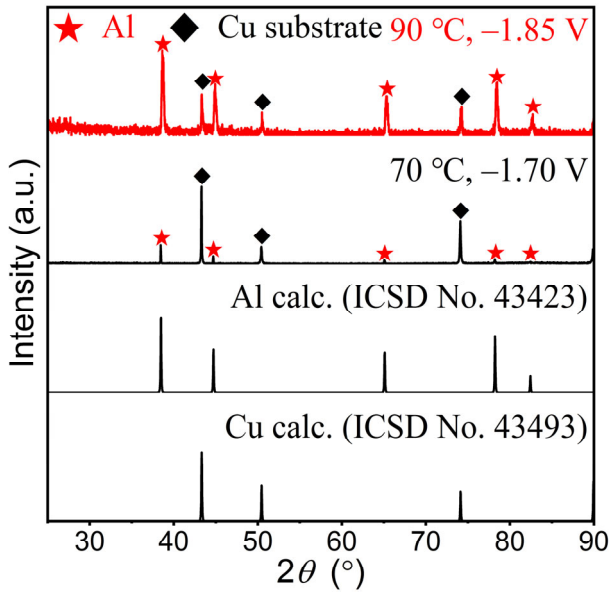

Figure S5. PXRD pattern of Al electrodeposited on Cu foil from of the IL [BMIm]Br·2AlCl$_3$ at chosen conditions.

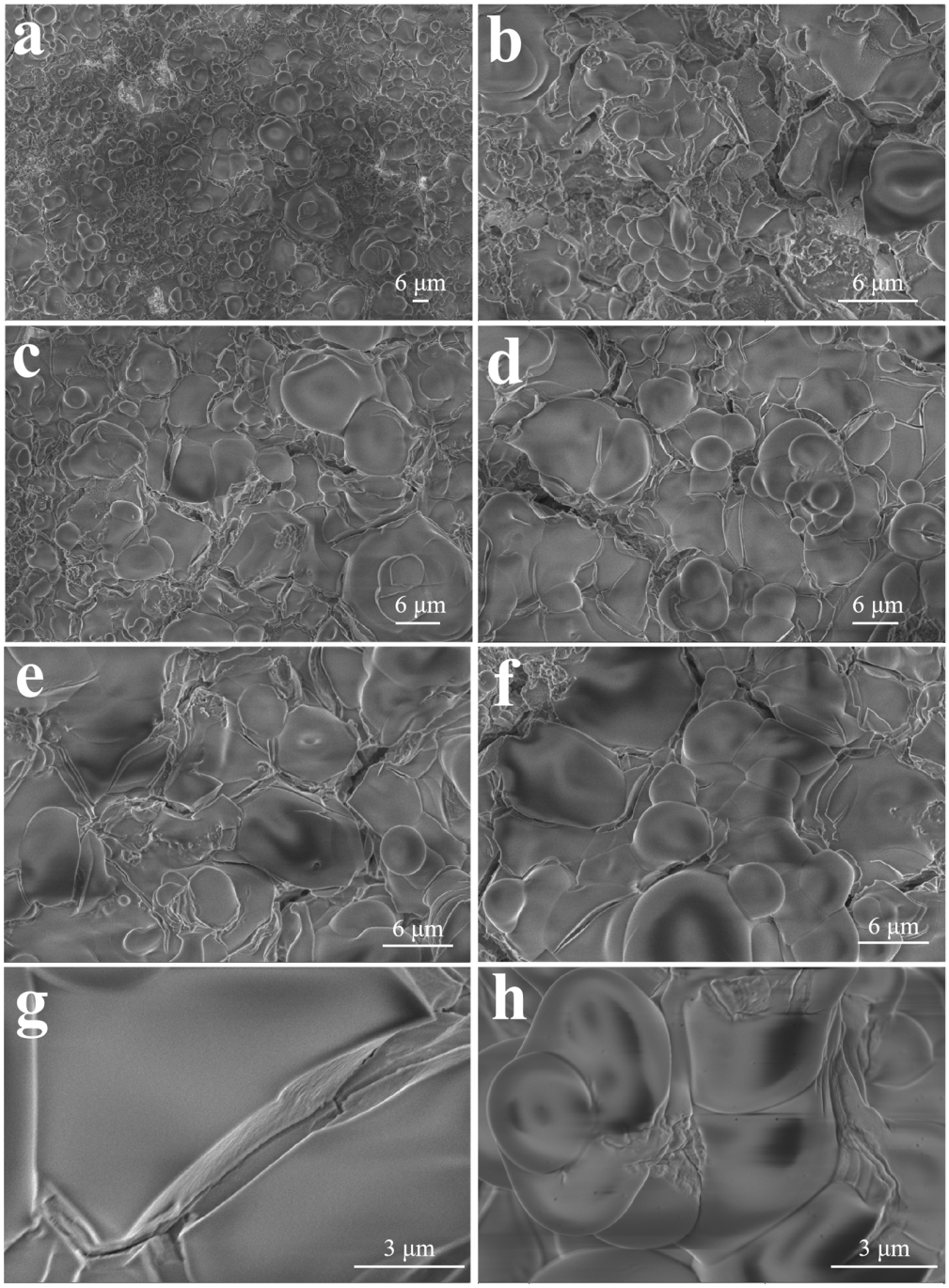

Figure S6. (a–h) SEM images (increasing magnification) of electrodeposited Al on Cu foil substrate at –1.70 V and 70 °C after about 2.5 h.

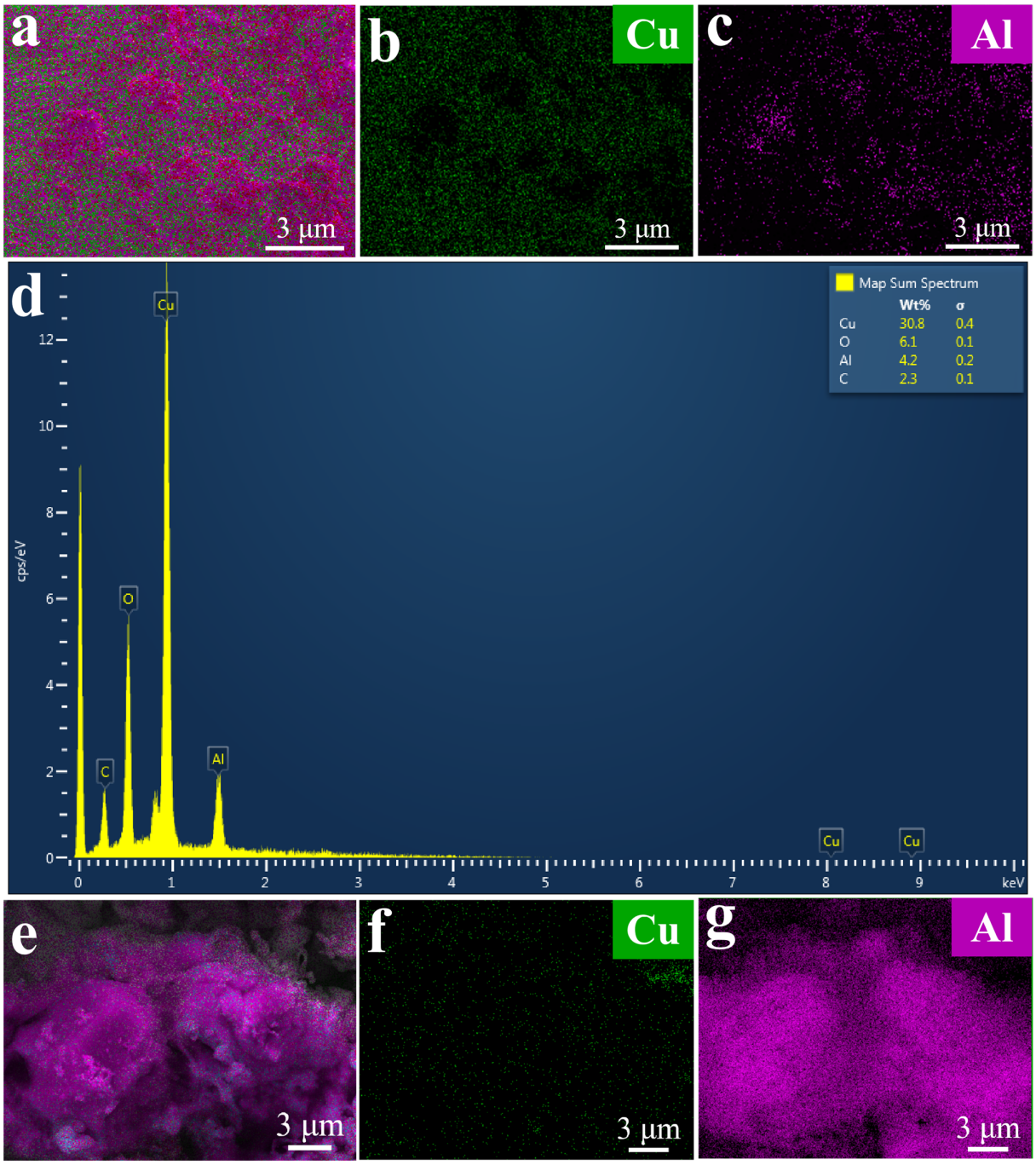

Figure S7. EDX mappings and signals of all elements of the Cu and Al distribution of the Al layer electrodeposited at –1.70 V **(a-d)** or –1.85 V **(e-g)** at 70 °C.

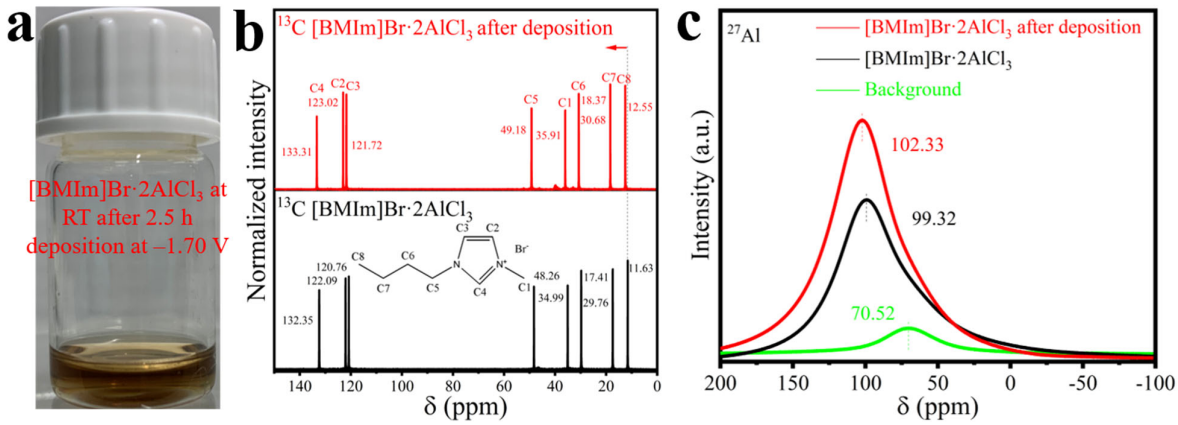

Figure S8. (a) Photograph of the [BMIm]Br·2AlCl$_3$ solution at room temperature after about 2.5 h of Al electrodeposition at –1.70 V and 70 °C. Comparison of pristine [BMIm]Br·2AlCl$_3$ (black line) and the ILs after about 2.5 h of Al electrodeposition at –1.70 V and 70 °C (red line). **(b)** Corresponding ^{13}C NMR spectra (the insertion is the labeling of different carbon atoms of [BMIm]Br). **(c)** ^{27}Al NMR spectra.

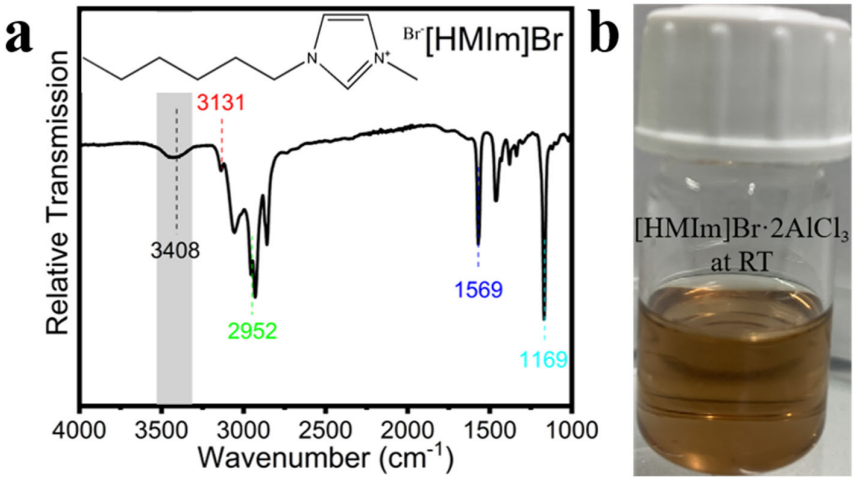

Figure S9. (a) FT-IR spectrum in the range of 1000 cm^{-1} ≤ $\tilde{\upsilon}$ ≤ 4000 cm^{-1} of [HMIm]Br used in this paper (the insertion is the molecular structure of [HMIm]Br). **(b)** Photograph of [HMIm]Br·2AlCl$_3$ ILs solution at room temperature.

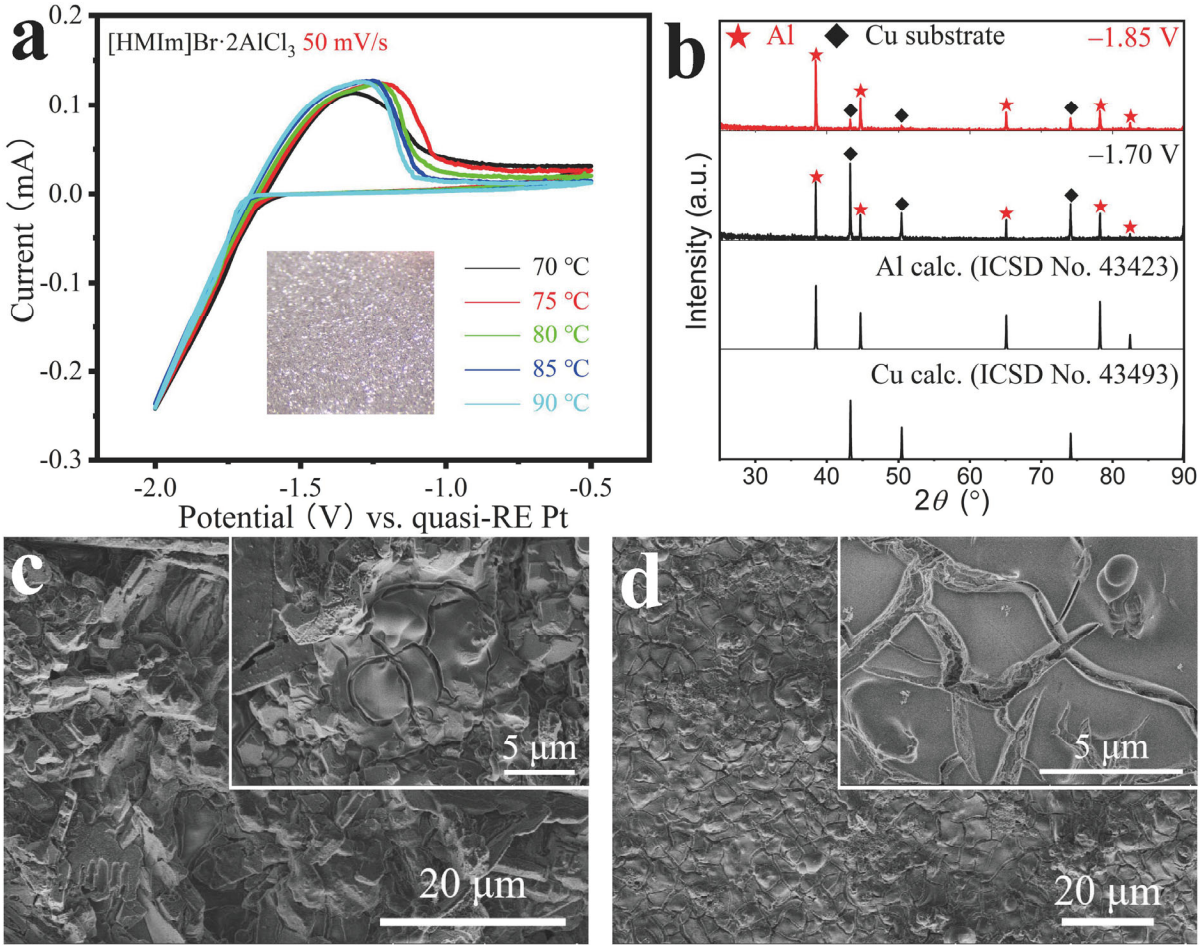

Figure S10. (a) CV of [HMIm]Br·2AlCl$_3$ at a scan rate of 50 mV s^{-1} and different temperatures; inset: photograph of the Cu foil substrate after 7 h of Al electrodeposition at –1.70 V and 90 °C. **(b)** Comparison of the PXRD pattern of the coated electrode. SEM images of the Al layers with enlarged details (inset) that were electrodeposited at **(c)** –1.70 V or **(d)** –1.85 V at 90 °C within 7 h.

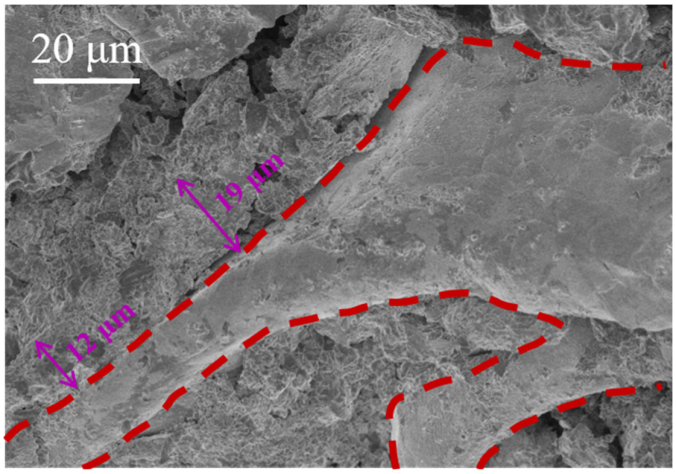

Figure S11. Cross-sectional SEM image of the Al layer electrodeposited at –1.85 V and 90 °C (skeleton structure of ^{3D}Cu indicated with red dotted lines, the thickness of Al layer is about 12–19 µm).

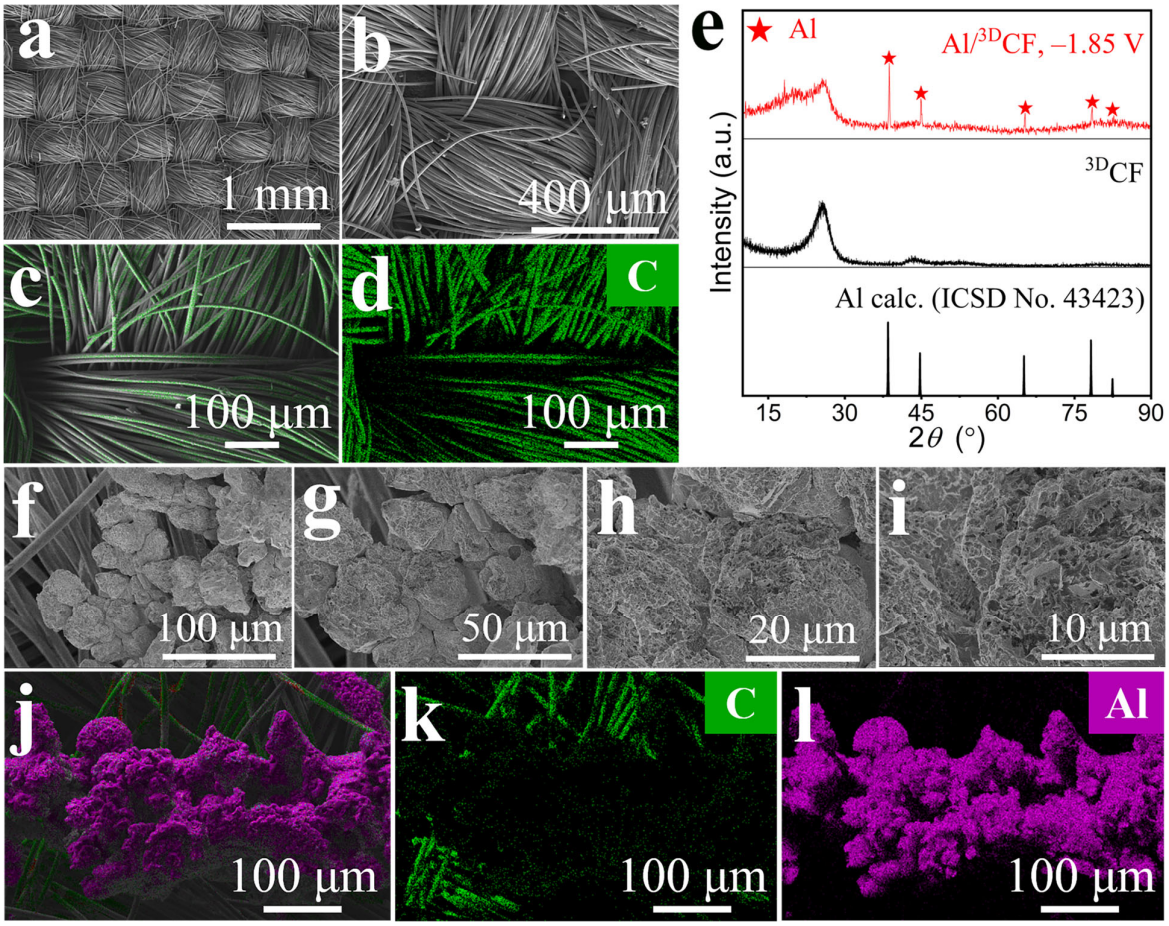

Figure S12. (a-b) SEM images and **(c-d)** EDX mappings of all elements of the C distribution of ^{3D}CF. **(e)** PXRD pattern comparison. **(f-i)** SEM images and **(j-l)** EDX mappings of all elements of the C and Al distribution of the loaded Al/^{3D}CF electrode electrodeposited at –1.85 V at 90 °C.

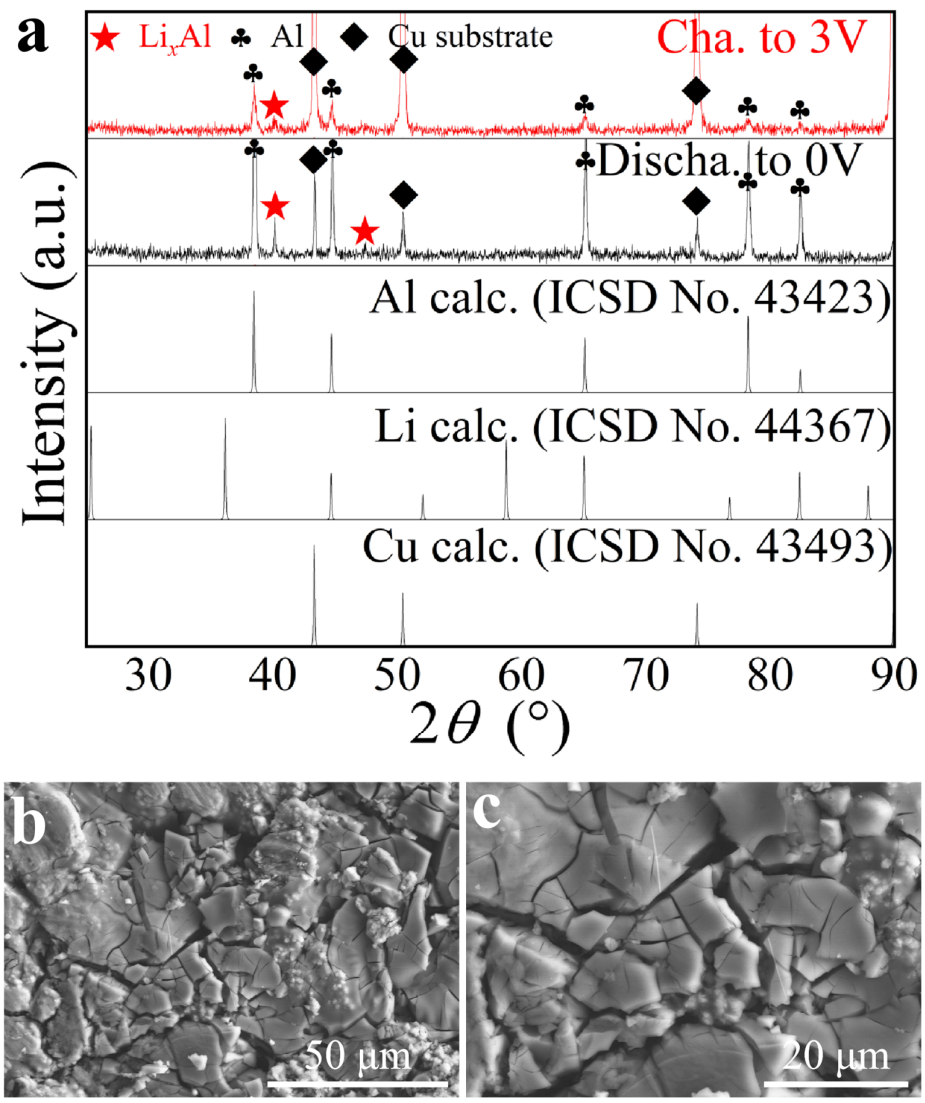

Figure S13. (a) PXRD pattern comparison of discharged to 0 V at 4.2 mA g^{-1} and charged to 3 V electrode at 21 mA g^{-1}. **(b-c)** SEM images (increasing magnification) of an Al/^{3D}Cu electrode charged to 3 V at 21 mA g^{-1}.