Supporting Information

Rod-shaped Cu_{1.81}Te as a Novel Cathode Material for Aluminum Ion Batteries

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Figure S1. (a) SEM image of $Cu_{1.81}$ Te power and corresponding EDS mapping images of (b) Cu and

(c) Te elements.



Figure S2. (a \sim c) LSV results of different current collectors at 5 mV s⁻¹ with Al foil as both the counter

electrode and reference electrode in a three-electrode system.



Figure S3. (a) Cyclic voltammograms of Mo foil at 1 mV s⁻¹. (b) Cyclic performance of Mo foil at a current density of 100 mA g⁻¹.



Figure S4. (a) Cyclic performance with coulombic efficiency at a current density of 100 mA g^{-1} . (b) Cyclic performance after activation with coulombic efficiency at a current density of 100 mA g^{-1} .



Figure S5. Contents of Al in $Cu_{1.81}$ Te electrode in first cycle.



Figure S6. XRD pattern of Mo current collector.



Figure S7. XPS spectra of Te: (a) original $Cu_{1.81}$ Te power, (b) fully charged $Cu_{1.81}$ Te electrode.



Figure S8. (a \sim b) SEM of the cathode electrode after the initial cycle.



Figure S9. (a) Galvanostatic intermittent titration technique (GITT) curve at 50 mA g^{-1} . (b) Calculated aluminum ion diffusion coefficients from GITT curve.

The galvanostatic intermittent titration technique (GITT) technology is used to measure the diffusion kinetics of aluminum ions. First, the battery was discharged and charged at a current density of 50 mA g⁻¹ for two cycles, and then the battery was discharged at the same current density for 10 mins followed by 2 hours of open circuit test, and reciprocated. These steps were repeated many times. Figure S9a expresses the GITT curve in the discharge process. The calculation of the diffusion coefficient of aluminum ions is based on the following formula¹⁻³:

$$D_{Al} = \frac{4}{\pi\tau} \left(\frac{mV_m}{zMA}\right)^2 \left(\frac{\Delta E_s}{\Delta E_\tau}\right)^2 \quad \left(\tau \ll \frac{L^2}{D_{Al}}\right) \tag{1}$$

where m and M are active material mass and molecular weight, V_m is the molar volume of $Cu_{1.81}Te$, z is the charge number, A is the surface area of electrode, L is the thickness of electrode, ΔE_s is the steady-state voltage charge and ΔE_τ is the voltage charge during the constant current pulse. The result of the calculation is revealed in the Figure S9b. D_{Al} of $Cu_{1.81}Te$ range from 3.48 × 10⁻¹⁶ cm^2 s⁻¹ to 1.68 × 10⁻¹¹ cm² s⁻¹.



Figure S10. (a)(b) SEM images of $Cu_{1.81}$ Te electrode after 50 cycles.



Figure S11. (a) High-angle annular dark field (HAADF) image of Cu_{1.81}Se electrode at the initial discharged state and corresponding EDS mapping images of (b) Cu, (c) Te and (d) Al in the selected region.

| material | Initial discharge | Last cycle discharge | | Discharge Voltage |
|---|--|-------------------------------------|------------------------|-------------------|
| $Ni_3S_2@graphene^4$ | 350 mAh g ⁻¹ (100 mA g ⁻¹) | 60 mAh g ⁻¹ (100 cycle) | 100 mA g ⁻¹ | 1.0 V |
| G-SnS ₂ ⁵ | 392 mAh g ⁻¹ (100 mA g ⁻¹) | 70 mAh g ⁻¹ (100 cycle) | 20 mA g ⁻¹ | 0.68 V |
| Mo ₆ S ₈ ⁶ | 148 mAh g ⁻¹ (6 mA g ⁻¹) | 70 mAh g ⁻¹ (50 cycle) | 12 mA g ⁻¹ | 0.55 V |
| TiS ₂ ⁷ | 70 mAh g ⁻¹ (5 mA g ⁻¹) | 65 mAh g ⁻¹ (20 cycle) | 5 mA g ⁻¹ | N/A |
| MoS ₂ ⁸ | 253 mAh g ⁻¹ (20 mA g ⁻¹) | 66 mAh g ⁻¹ (100 cycle) | 40 mA g ⁻¹ | N/A |
| CuHCF ⁹ | 60 mAh g ⁻¹ (10 μA g-1) | 10 mAh g ⁻¹ (10 cycle) | 10 mA g ⁻¹ | 0.5 V |
| Mo _{2.5+y} VO _{9+z} ¹⁰ | 114 mAh g ⁻¹ (10 mA g ⁻¹) | 85 mAh g ⁻¹ (25 cycle) | 10 mA g ⁻¹ | 0.75 V |
| V ₂ O ₅ ¹¹ | 200 mAh g ⁻¹ (22.1 mA g ⁻¹) | 70 mAh g ⁻¹ (30 cycle) | 10 mA g ⁻¹ | 1.0 V |
| Cu _{2-x} Se ¹² | 247 mAh g ⁻¹ (100 mA g ⁻¹) | 100 mAh g ⁻¹ (100 cycle) | 100 mA g ⁻¹ | 0.5 V |
| Cu _{1.81} Te | 272 mAh g ⁻¹ (10 mA g ⁻¹) | 50 mAh g⁻¹ (66 cycle) | 40 mA g ⁻¹ | 0.85 V |

Table S1. Comparison of electrochemical performance of $Cu_{1.81}$ Te cathodes with other AIBs cathode.

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