Supporting Information for

Aluminum electrolytes for Al dual-ion batteries

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Supplementary Note 1

Charge storage capacity of deep eutectic solvents

The capacity of the deep eutectic solvent anolytes can be calculated as follows (considering that the electrodeposition of Al occurs only in acidic media \((r > 1, \text{in the presence of } \text{Al}_2\text{Cl}_7^- \text{ions})\):

Gravimetric \( C_{an} = \frac{Fx}{m} \text{ (mAh g}^{-1}\text{)} \) \hspace{1cm} (1)

Volumetric \( C_{an} = \frac{Fx}{V} \text{ (mAh ml}^{-1}\text{)} \) \hspace{1cm} (2)

where \( F = 26.8 \times 10^3 \text{ mAh mol}^{-1} \) (Faraday constant), \( x = \frac{3}{4} \) (number of electrons used to reduce 1 mol of the \( \text{Al}_2\text{Cl}_7^- \) ions as follows from the equation: \( 4\text{Al}_2\text{Cl}_7^- + 3e^- \leftrightarrow 7\text{AlCl}_4^- + \text{Al} \)) and \( m \) and \( V \) are the mass (in g) and volume (in ml) of anolyte containing 1 mol of the \( \text{Al}_2\text{Cl}_7^- \) ions.

The mass and volume of an anolyte containing 1 mol \( \text{Al}_2\text{Cl}_7^- \) ions can be calculated as follows:

\[ m = \frac{\rho}{M} \times 10^3 \text{ (g)} \] \hspace{1cm} (3)

\[ V = \frac{1}{M} \times 10^3 \text{ (ml)} \] \hspace{1cm} (4)

where \( M \) is molarity of \( \text{Al}_2\text{Cl}_7^- \) ions in the anolyte (mol L\(^{-1}\)) and \( \rho \) is density of the anolyte (g mL\(^{-1}\)).

Substituting Eq. 3 and Eq. 4 into Eq. 1 and Eq. 2, one obtains:

Gravimetric \( C_{an} = \frac{FxM}{\rho \times 10^3} \text{ (mAh g}^{-1}\text{)} \) \hspace{1cm} (5)

Volumetric \( C_{an} = \frac{FxM}{10^3} \text{ (mAh ml}^{-1}\text{)} \) \hspace{1cm} (6)