

A LOW-COST AL-GRAPHITE BATTERY WITH UREA AND ACETAMIDE-BASED ELECTROLYTES

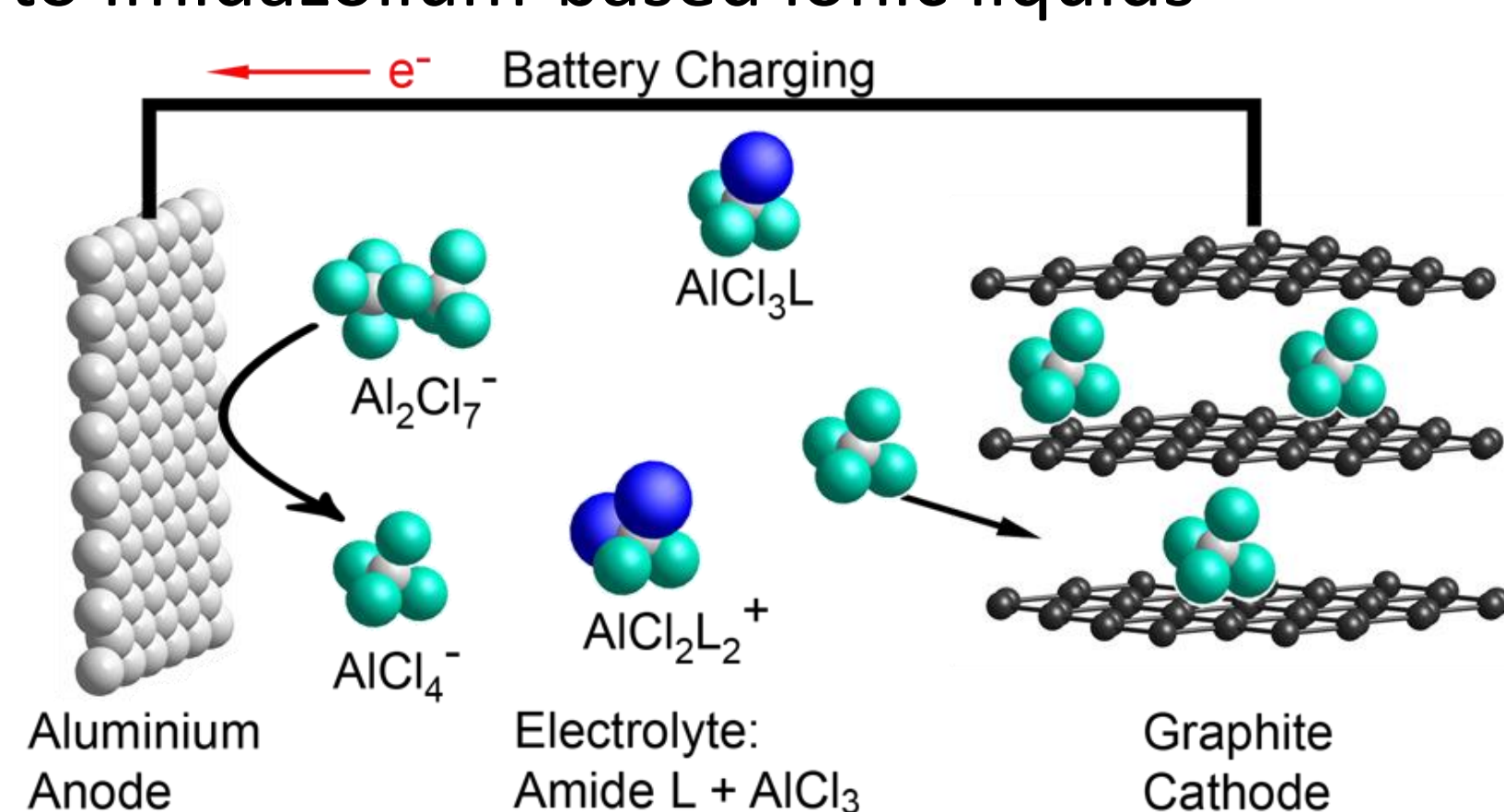
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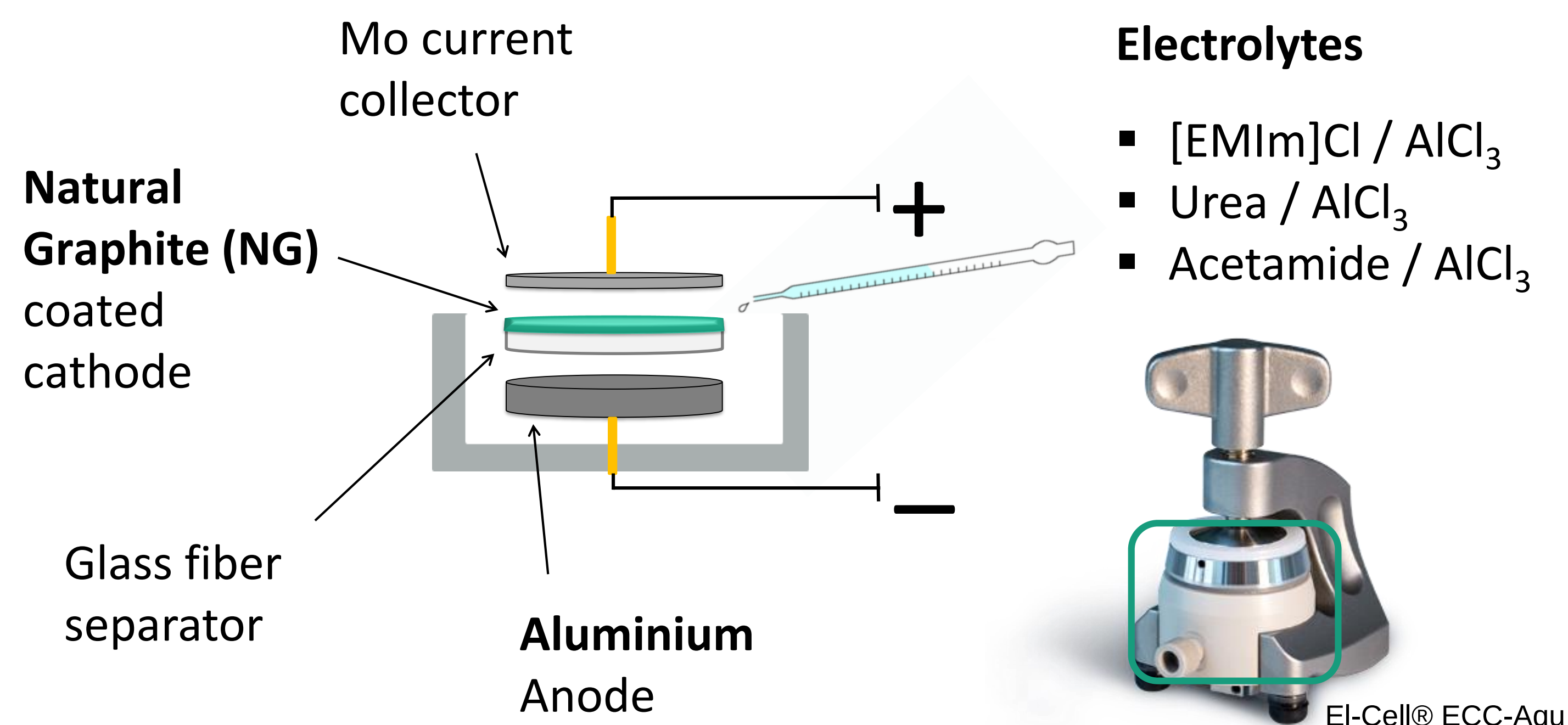
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Motivation

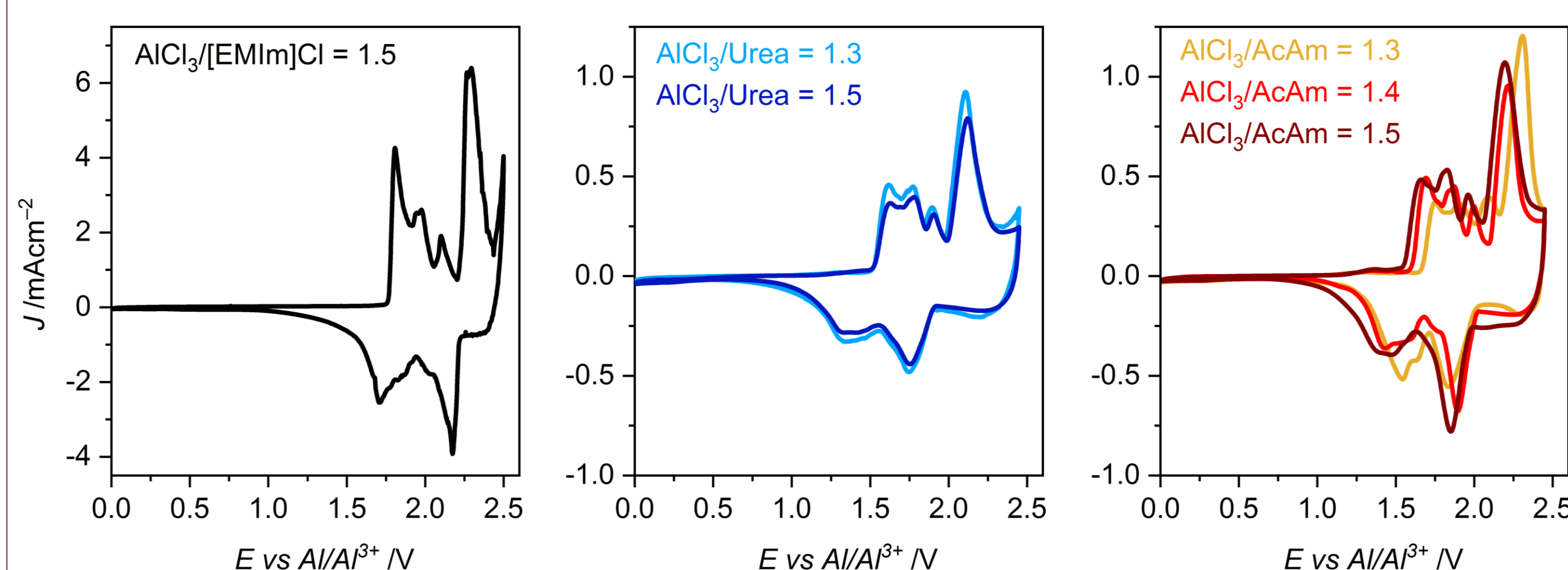
- Aluminium-graphite batteries as promising alternatives to Li-Ion systems due to sustainability & long cycle life^[1,2]
- Deep eutectic solvent based electrolytes (Amide/ AlCl_3) as low-cost alternative to Imidazolium-based ionic liquids^[3-5]



Experimental Setup

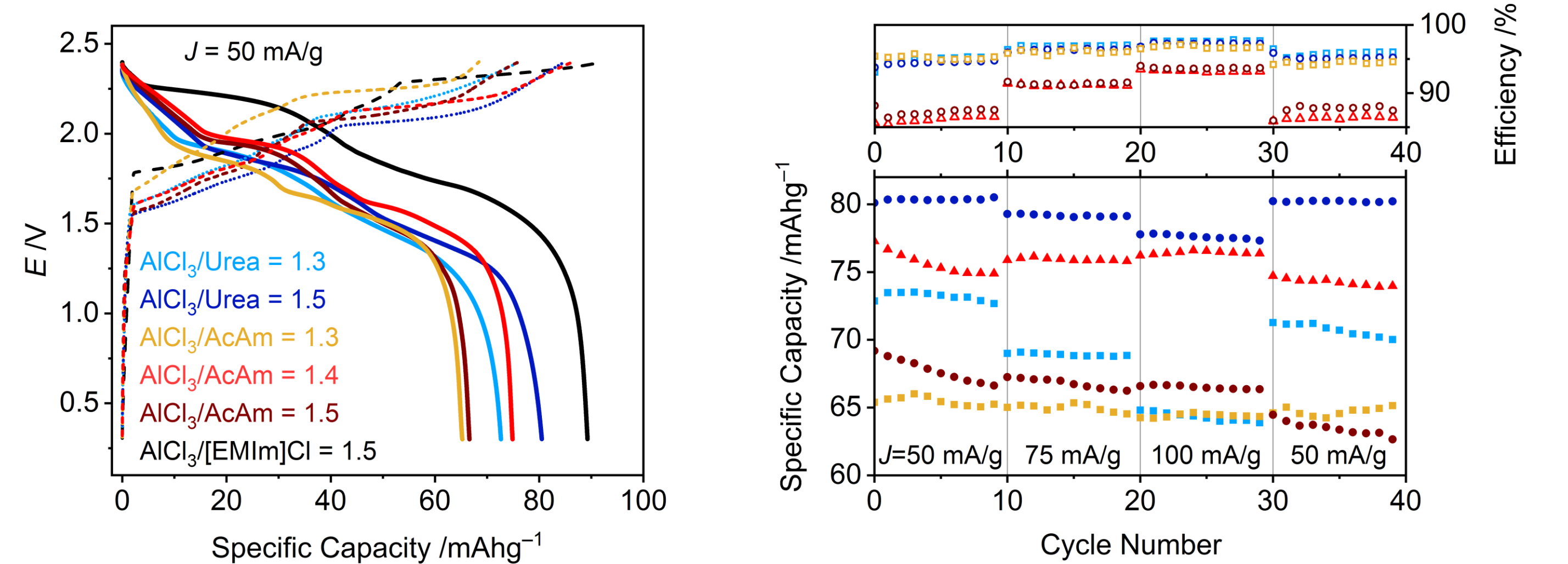


Cyclovoltammetry



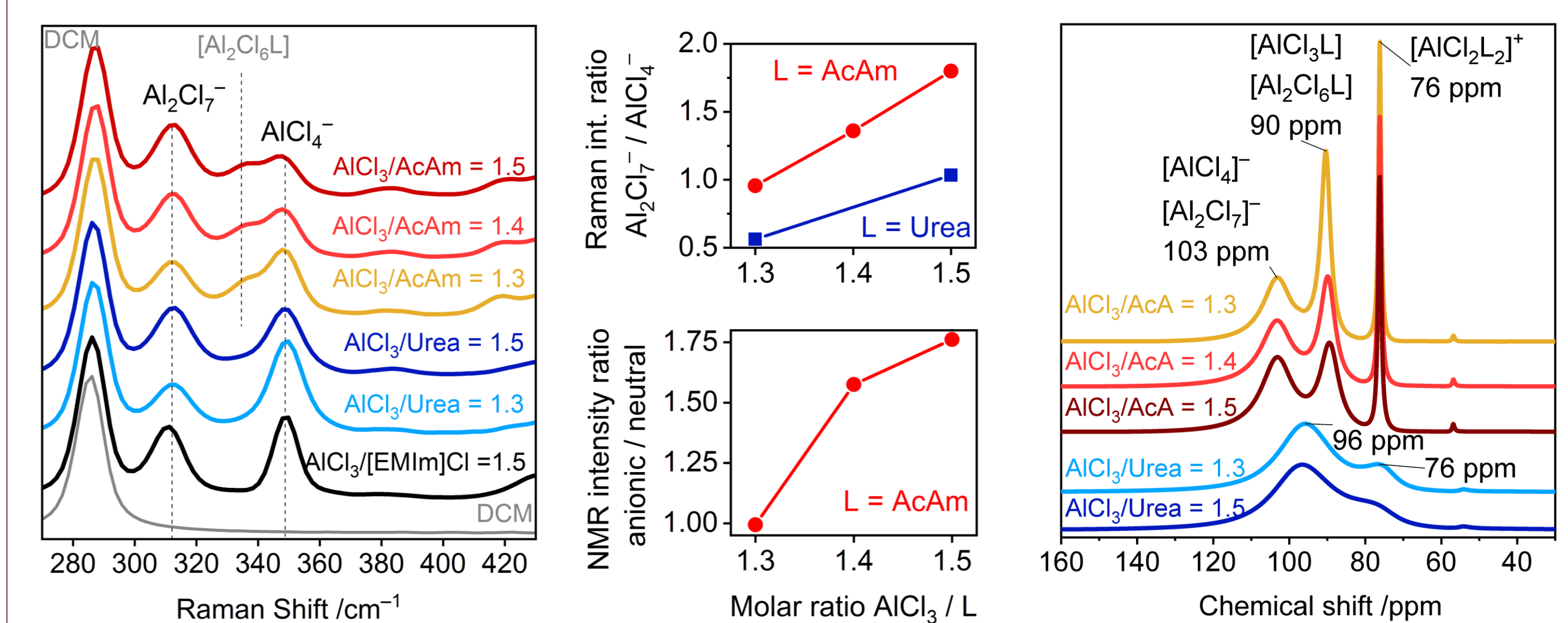
- In principle similar intercalation processes with deviations depending on electrolyte composition

Charge / Discharge Cycles



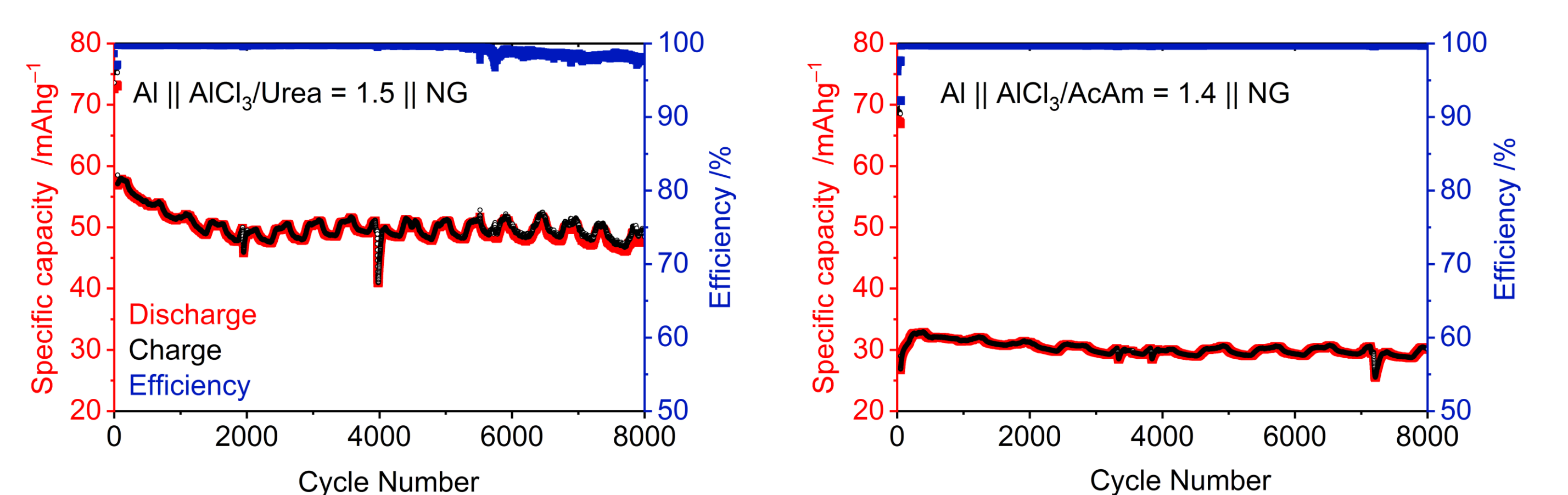
- Electrochemical performance strongly influenced by amide type and amide/ AlCl_3 ratio
- Energy densities in Wh/kg NG: Urea/ AlCl_3 135, [EMIm]Cl/ AlCl_3 170

Aluminium Speciation



- DES equilibria:^[6] $2 \text{AlCl}_3 + 2 \text{L} \rightarrow \text{AlCl}_4^- + [\text{AlCl}_2\text{L}_2]^+ \rightleftharpoons 2 [\text{AlCl}_3\text{L}]$
 $\text{AlCl}_4^- + [\text{AlCl}_2\text{L}_2]^+ + \text{AlCl}_3 \rightarrow \text{Al}_2\text{Cl}_7^- + [\text{AlCl}_2\text{L}_2]^+ \rightleftharpoons [\text{AlCl}_3\text{L}] + [\text{Al}_2\text{Cl}_6\text{L}]$
- Interplay of high ion concentration and a nearly balanced $[\text{Al}_2\text{Cl}_7^-]/[\text{AlCl}_4^-]$ molar ratio yields highest capacities

Long-term Stability



- Long lasting stable capacities for >8000 cycles at high current rates ($J = 2 \text{ A/g}$, 60C) and real life conditions

Conclusion

- Al || Urea/ AlCl_3 || natural graphite battery demonstrates practical use by an energy density of 135 Wh/kg & long-term stability
- Modification of Al species by carefully selecting amide composition allows for tuning towards better performance

Acknowledgements & References

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