SAND2012-1515P

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Chloride-Insertion Electrodes for Rechargeable Aluminum Batteries

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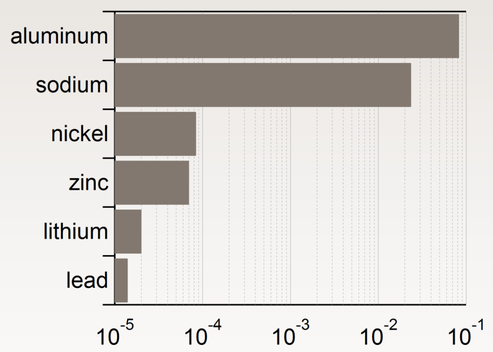
Early Career LDRD Program, New Start Project for CY12

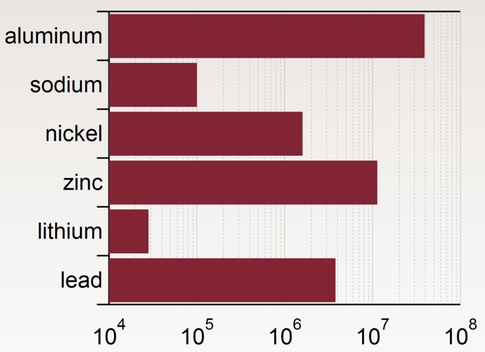
Problem and Motivation

- Demand for rechargeable battery systems continues to increase
  - Electric vehicles already commercially available
  - Stationary energy storage being introduced to electrical grid
- Aluminum can be the energy-carrying material (active electrode material) in rechargeable batteries
  - Competitive material in terms of abundance, cost, and charge-storage capacity
  - Alternative to lithium, zinc, etc.
- The use of ionic liquids enables room-temperature plating and stripping of Al^0 (the negative electrode in an aluminum battery)

Aluminum is abundant and widely produced compared to other energy-storage metals.

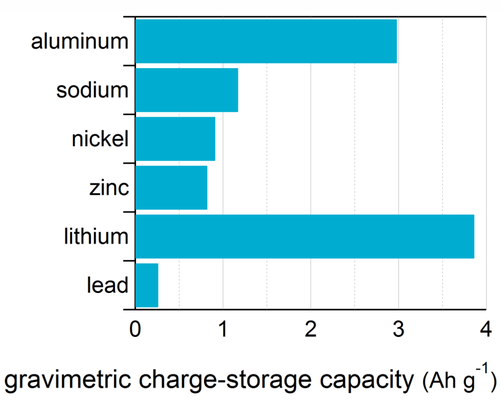


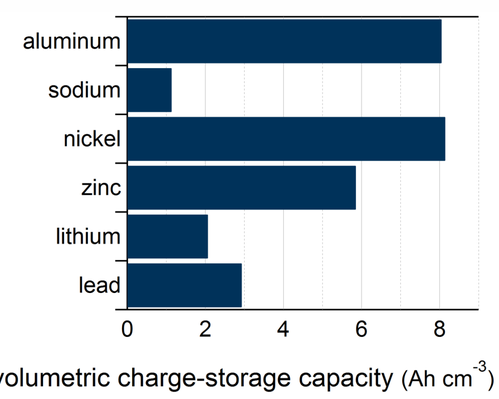
CRC Handbook of Chemistry & Physics



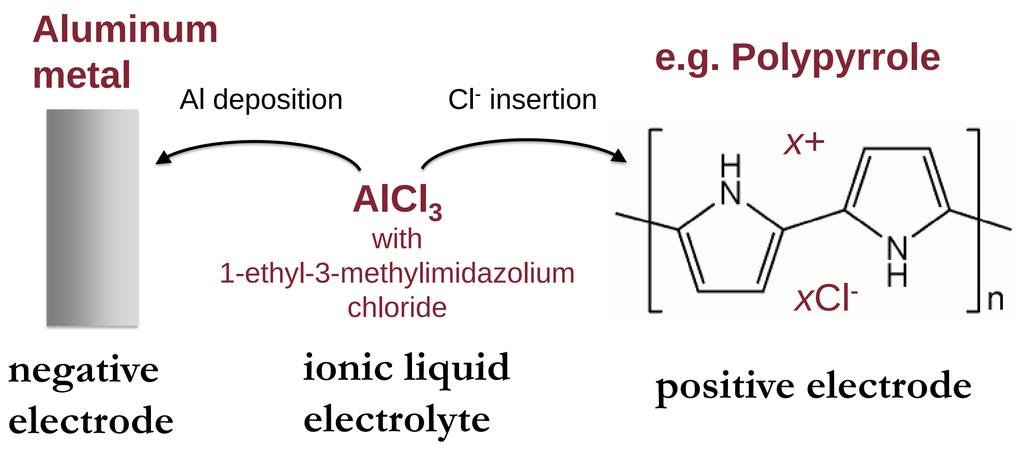
U.S. Geological Survey

Aluminum's capacity for charge storage is competitive on gravimetric *and* volumetric scales.



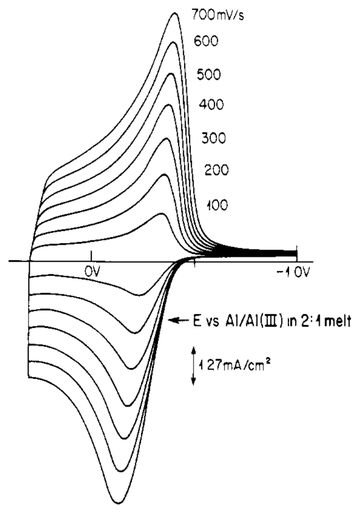


The positive electrode in the proposed battery is a conductive polymer that electrochemically inserts chloride-ion from $AlCl_3$.



Approach and Goals

- Demonstrate electrochemical synthesis of chloride-doped conductive polymers
  - e.g. electropolymerization of pyrrole or thiophene in $AlCl_3$ ionic liquid
  - effects of electrochemistry on polymer composition
- Demonstrate galvanostatic cycling of aluminum cells
  - conductive, conjugated polymer as positive electrode (via chloride insertion)
  - effects of polymer composition on cell performance
  - quantify charge-storage capacity, energy density, cycle life for comparison to other battery systems



Cyclic voltammetry for a Pt/polypyrrole electrode in 0.8:1 $AlCl_3$:N-1-butylpyridinium chloride ionic liquid.

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Potential Impact

- May lead to development of rechargeable batteries made of inexpensive, domestically available materials
- Increased understanding of conductive polymers and electrochemistry in ionic liquids

Programmatic Interest

- Basic energy science
- Electricity delivery and energy reliability (grid-scale storage)
- Energy security
- Proposed batteries may be commercially relevant if performance proves to be competitive

U.S. DEPARTMENT OF ENERGY
National Nuclear Security Administration

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SAND No. 2011-XXXXP