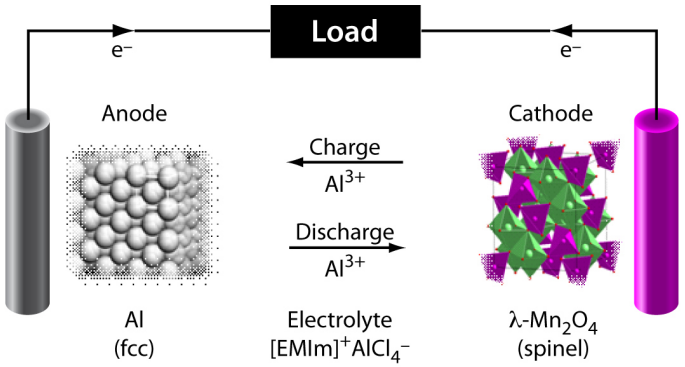
Aluminum-Ion Battery to Transform 21st Century Energy Storage

UT-B IDs 201002383, 201002387, 201002388



Technology Summary

Scientists at ORNL are developing a high energy density, rechargeable aluminum-ion battery that will be a significant contribution to 21st century energy storage technologies. Current electrical energy storage falls far short of the requirements for transportation, commercial, and residential electrical and heating needs. The high energy and power densities of ORNL's new battery could even allow electric vehicles to perform comparably to vehicles powered by petroleum-fueled internal combustion engines.

As increasing amounts of electric power are derived from natural sources (solar, wind), transformational storage technologies become ever more important. These power sources need effective battery storage both to meet demand and to level the cyclical nature of natural energy sources. Because an aluminum battery is trivalent, it has a distinct advantage in its capacity for energy density over the existing lithium-ion battery (1060 Wh/kg vs. 406 Wh/kg). The ORNL technology uses multielectron redox couples and has the potential to increase the energy density of a cell by several orders of magnitude.

Previous attempts to use aluminum anodes in batteries resulted in high corrosion rates, parasitic hydrogen evolution, and sluggish response due to the formation of an oxide layer on the aluminum electrode surface. To overcome these problems, the ORNL battery is composed of an aluminum anode, and a cathode material capable of inserting aluminum ions during a discharge cycle and removing the ions during a charge cycle. The battery features an electrolyte that is electrochemically stable within the operation window of the electrodes. As a result, the electrolyte is capable of supporting the deposition or the stripping of aluminum at the anode, and the insertion or removal of aluminum at the cathode.

This new aluminum-ion battery technology includes a broad menu of compositions and methods. In other variations, the battery is a secondary device that is capable of maintaining a discharge capacity of at least 50% of its initial capacity after 50 cycles.

Advantages

- **Significantly higher specific energy density:** The aluminum-ion battery can achieve 3–4 times the specific energy density of a lithium-ion battery.
- **Cost effective:** The aluminum-ion battery can potentially provide a battery-system-level energy density exceeding 200 Wh/kg (mass density) and 300 Wh/L (volumetric density) at system-level costs below $250/kWh.
- **Cheaper materials:** Aluminum is an abundant and relatively inexpensive metal.
- **Safety:** The aluminum-ion battery uses nonflammable materials.
- **Reduced internal losses**: A Solid Electrolyte Interface/Interphase (SEI) layer is not formed in the aluminum-ion battery.

Potential Applications

- Battery manufacturers
- Energy storage systems for electricity generated from solar and wind power
- Electrical vehicles

Patent

Gilbert M. Brown, Mariappan P. Paranthaman, Sheng Dai, Nancy J. Dudley, Arumugam Manthiram, Timothy J. McIntyre, and Xiao-Guang Sun, A High Energy Density Aluminum Battery, U.S. Patent Application12/895, 487, filed September 30, 2010.

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