Redox Shuttle Additives

Additives could help make batteries safer, more economical.

The Invention

A series of novel redox shuttle additives for lithium ion batteries for the purpose of overcharge protection and increased battery safety.

The additives not only can provide excellent overcharge protection in lithium-ion batteries but are also compatible with conventional carbonate-based electrolytes. These novel shuttle additives also provide improved solubility in carbonate based electrolyte.

As the demand for hybrid and electric vehicles continues to grow, so does the demand for lithium-ion batteries that are safer, more powerful, and less expensive. These Argonne additives will help meet that demand.

Benefits

- Prevent overcharge and improves safety,
- Balance cell in a battery pack,
- Reduce cost, and
- Increase battery reliability.

Applications and Industries

Electrodes used in batteries for

- Electric and plug-in hybrid electric vehicles;
- Portable electronic devices;
- Medical devices; and
- Space, aeronautical, and defense-related devices.

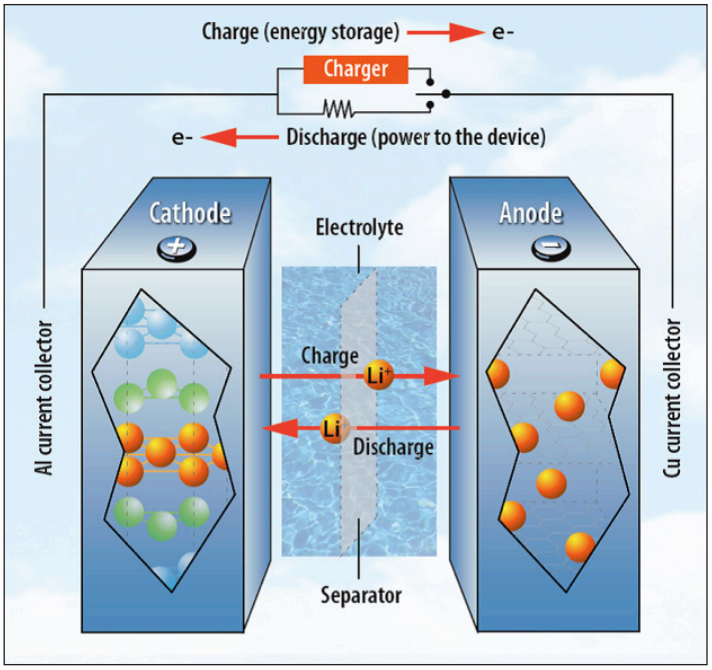

Figure 1. Charge Transfer Mechanism for Li-ion Battery Overcharge Protection — The boron and fluorine additive is in the electrolyte. When the battery is overcharged, the redox shuttle will be oxidized by losing an electron to the positive electrode. The radical cation formed will then diffuse back to the negative electrode, causing the cation to obtain an electron and be reduced. The net reaction is to shuttle electrons from the positive electrode to the negative electrode without causing chemical damage to the battery.

Developmental Stage

The various redox shuttle technologies are at several stages of development.

Availability

The various redox shuttle technologies are at several stages of availability.

Intellectual Property

- ANL-IN-05-012, "Novel Redox Shuttles for Overcharge Protection of Lithium Ion Batteries", U.S. Patent 7,851,092, GB issued patent 2,437,902; Inventors: Khalil Amine, Qingzheng Wang and Zonghai Chen
- ANL-IN-08-024, "Electrolyte Salts for Lithium Batteries", combined with ANL- IN-08-033, "Ionic Metal Complex Redox Shuttle for Lithium Ion Batteries", U.S. Published Application 12/192,452; Inventors: Khalil Amine, Zhengcheng Zhang and Zonghai Chen
- ANL-IN-09-082, "Polyether-Functionalized Redox Shuttles for Lithium Ion Batteries", U.S. Published Application 13/114,452; Inventors: Zhengcheng Zhang, Lu Zhang and Khalil Amine
- ANL-IN-09-084, "Redox Shuttle Additives for High Voltage Cathodes", U.S. Published Application 13/114,468; Inventors: Lu Zhang, Zhengcheng Zhang, and Khalil Amine
- ANL-IN-09-086, "Redox Shuttle for Overcharge Protection of Lithium Ion Batteries", U.S. Published Application 13/113,499; Inventors: Wei Weng, Zhengcheng Zhang and Khalil Amine
- ANL-IN-10-076, "Redox Shuttles for Overcharge Protection of Lithium Batteries", U.S. Provisional Application 61,529,413; Inventors: Zhengcheng Zhang, Lu Zhang, and Khalil Amine
- ANL-IN-11-128, "Redox Shuttle for Overcharge Protection of Lithium Ion Batteries," U.S. Patent Pending 13/457,239; Inventors: Wei Weng, Zhengcheng Zhang and Khalil Amine

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