Argonne NATIONAL LABORATORY

Chemical Engineering Division

Lithium-Ion Battery Development

Meeting the Challenge

Lithium-ion batteries offer several advantages over other types of secondary batteries, including lighter weight and higher energy density. They are ideal for portable electronic devices such as notebook computers, and offer great advantage in hybrid electric vehicles. As battery developers work to create larger lithium-ion batteries, however, they are faced with three main challenges: safety, cost, and calendar life. Gary Henriksen, Manager of the Battery Technology Department in Argonne's Chemical Engineering Division, explains what Argonne is doing to help meet these challenges.

What are Argonne researchers doing to address safety issues associated with lithium-ion batteries?

The safety issues associated with lithium-ion batteries grow as the cell size increases beyond what is currently used for consumer electronics, especially to the sizes needed for electric vehicle and hybrid electric vehicle applications. Argonne is working on enhancing the inherent safety of lithium-ion cells and batteries by:

- Studying the thermal properties of lithium-ion cells and the mechanisms that control thermal runaway in conventional lithium-ion cell chemistries.

- Developing safer lithium-ion cell materials, such as:

    - Advanced carbon-based anode materials with rounded-edge morphology that are surface-treated or coated to stabilize the electrode/electrolyte interface, and stable intermetallic anode materials, which operate farther away from the potential of metallic lithium than do carbon-based anodes.
    - Multi-doped lithium nickel-oxide cathode materials, using dopants that stabilize the structure and oxidation states of the nickel, and lithium manganese oxide materials, which are stabilized against dissolution in the conventional electrolytes.
    - More stable salts, propylene carbonate-based electrolyte solvent systems (more stable than the common DEC, DMC, and EMC solvents) and electrolyte additives, which form more stable passivation films on the electrodes or that retard the flammability of the electrolyte solvents.

How are Argonne researchers working to reduce the costs associated with lithium-ion batteries?

Recognizing that the cost of lithium-ion batteries becomes more prohibitive on a large scale, Argonne researchers are:

- Developing low-cost, long-life, flexible packaging for lithium-ion cells. This involves developing barrier layer materials that can reduce, to extremely low levels, the permeation of moisture and air into the cell and the permeation of electrolyte solvents out of the cell. Organoclays are being used to reduce the permeation rates of these species by several orders of magnitude through polymeric films that are chemically compatible with the cell environment.
- Developing lower-cost cell component materials, such as coated or treated natural graphites for the anode, stabilized lithium manganese oxide materials for the cathode, alternative electrolyte salts, and propylene carbonate-based electrolyte systems.

What are Argonne researchers doing to extend the calendar life of lithium-ion batteries?

Argonne researchers are working on extending the typical three-year calendar life of conventional lithium-ion batteries by:

- Conducting accelerated aging of sealed cells and extensive detailed diagnostic studies on these cells, to establish the mechanisms that control power fade and capacity loss in conventional lithium-ion cell chemistries.

- Addressing the instability of conventional passivation films, which contributes to both power fade and capacity loss in conventional lithium-ion cell chemistries. This involves developing advanced cell materials that stabilize the cell chemistry for longer life, such as coated and/or treated graphites, which form more stable passivation films with conventional electrolytes. Also, some of the electrolyte additives being developed at Argonne are designed specifically to decompose and form more stable passivation films on both the anode and the cathode.

- Developing multi-doped lithium nickel oxide cathodes, with optimal particle morphologies, that employ dopants to stabilize the surface of the cathode, retarding film growth and extending calendar life. Argonne researchers have identified surface film growth on lithium nickel oxide cathodes as a primary cause of power fade in two conventional lithium-ion cell chemistries.

- Studying new lithium-ion conducting salts that are more stable chemically and thermallly than LiPF6. LiPF6 is believed to play a role in both the power fade and capacity fade processes for lithium-ion cells.

For More Information

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