Advanced Lithium Ion Battery Materials for Fast Charging and Improved Safety

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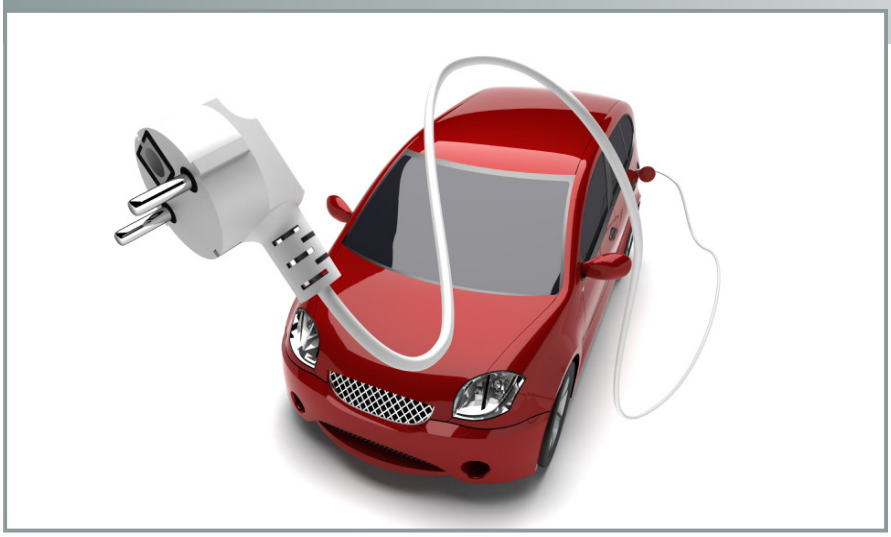

Technology Summary

High power and high energy density are essential to batteries for electric vehicles, stationary energy storage systems for solar and wind energy, and vehicle to grid and similar smart grid applications. Because conventional lithium ion batteries are inadequate to meet these needs, and because many of the current performance barriers are materials-related, researchers at ORNL are concentrating efforts on advanced materials and processing methods for next generation lithium ion batteries that will meet high power–high energy density needs.

Titanium dioxide nanomaterials have been widely investigated as lithium ion battery anode materials due to their advantages in terms of cost, safety, and rate capability. In particular, TiO_2-B has been investigated because of its favorable channel structure, which results in fast charge-discharge capability. However, TiO_2-B also has some disadvantages such as poor electronic conduction, loss of particle connection during cycling, and low packing density. Researchers at ORNL developed mesoporous TiO_2-B powders that overcome these shortcomings while maintaining the advantages of TiO_2 nanomaterials. ORNL's mesoporous TiO_2-B can increase power, energy density, and safety while dramatically reducing charge time (charging to 65% of full capacity in just 6 minutes or 45% in 1 minute). In addition, the researchers have developed a scalable, economic aerosol pyrolysis technique to make high quality TiO_2-B powders with consistent, reproducible phase content, particle morphology, size distribution, and microstructure.

Despite the need, few viable new cathode materials have emerged. To address this, ORNL researchers are looking at ways to improve existing cathode materials and cathodes in addition to new cathode materials. In one application, the conductivity of ternary metal cathode materials was enhanced (up to 625 W/kg) through surface and bulk modification. In two other applications, replacements were developed for lithium-cobalt oxide cathodes, high performing but expensive and potentially hazardous. In the first, spinel cathodes made with manganese, a great low cost substitute for cobalt, were modified with metal oxide/metal nitride coatings to provide high capacity, continuous chemical stability, improved conductivity, and reduced irreversible capacity loss. In the second, the rate capability and overall electrochemical performance of $LiFePO_4$ cathodes were boosted through surface modification with nitrogen-doped carbon layers and preparation of smaller, more homogeneous particles, leading to shorter lithium diffusion pathways in the finished cathodes and thus improved electroactivity and rate capability.

Advantages

- Greater safety
- Fast charging
- Improved performance
- Reduced costs

Potential Applications

- Electric vehicles and hybrid electric vehicles
- Stationary storage for renewable energy sources such as wind turbines
- Smart grid

Patent

Mariappan Parans Paranthaman and Craig A. Bridges. *Surface Modifications for Electrode Compositions and Their Methods of Making*, U.S. Patent Application 13/645,959, filed October 5, 2012.

Mariappan Parans Paranthaman. *Coating Compositions for Electrode Compositions and Their Methods of Making,* U.S. Patent Application 13/645,779, filed October 5, 2012.

Other patent applications in progress.

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