Argonne patents technology that increases safety of Li-ion batteries

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Scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory have patented a new, extremely stable, 4-volt redox shuttle molecule that provides overcharge protection for lithium-ion batteries containing lithium-iron-phosphate based cathodes across hundreds of charging cycles.

Overcharge is a major safety concern for Li-ion batteries because it could cause thermal runaway. Thermal runaway is a concern for large batteries—such as those used for transportation, satellite and storage applications—because they contain a large amount of active material.

"When a battery pack is being charged, each cell in the pack may have varying levels of charge," said Argonne materials scientist Khalil Amine, who leads the research group that developed the shuttle. "Overcharge generally occurs when a current is forced through a battery and the charge that is delivered exceeds the charge-storing capacity of the battery, which can damage the entire battery." Modern, well-designed batteries prevent overcharge from occurring through the use of external battery monitoring and control systems that function both at the cell and battery level. This new material offers a tool for addressing some of the concerns associated with overcharge using an approach that functions inside each cell.

"The new redox shuttle, known as 2,5-di-tert-butyl-1,4-bis(2-methoxyethoxy)benzene or DBBB, works by halting the charging process of individual cells as they come to a full state of

charge," Amine said. "Being able to discontinue the charging process on a cell-by-cell basis protects the entire battery pack by preventing individual cells from overcharging."

DBBB, which dissolves in the electrolyte, works by moving back and forth from the anode and cathode in place of the Li-ion, Amine explained. The shuttle technology achieved up to 300 cycled overcharges in the lab.

The shuttle is currently undergoing validation test by industry, and the results to date are very encouraging, he said.

Researchers in Argonne's Advanced Battery Materials Synthesis and Manufacturing Research & Development Program have already scaled up production of DBBB to 1.5 kilograms from the sub-gram amounts Amine's group required for bench-scale research and development (See related story). The larger amount of the redox shuttle material is needed by companies that want to test the material for possible commercialization.

The stability and repeated long-term overcharge cycling capability of this new shuttle molecule was demonstrated by Amine and his Argonne colleagues Zhengcheng Zhang, Lu Zhang and Wei Weng.

The redox shuttle is part of a suite of advanced battery materials developed by scientists at Argonne. This research was funded by the DOE Office of Energy Efficiency and Renewable Energy.

Provided by Argonne National Laboratory

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