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ELECTROLYTE FORMULATIONS FOR WIDE TEMPERATURE LITHIUM ION BATTERIES

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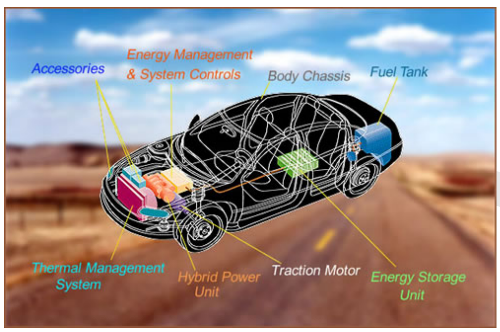
Introduction

This invention represents an important advance in extending the capability of lithium-ion (Li-ion) batteries, especially for hybrid electric vehicles (HEV). Researchers at the Sensors and Electron Devices Directorate of the U.S. Army Research Laboratory (ARL-SEDD), Adelphi, Maryland formulated and successfully tested a series of non-aqueous electrolytes that allow cells to operate at substantially higher temperatures without significant loss of cycle life, energy and power density. This expanded temperature window increases the market possibilities for Li-ion batteries.

Concept

In recent years, tech-product companies have broadened their use of Li-ion cells. They are now the dominant battery type in consumer electronics and are gaining an increasing share in the power tool market. Large format Li-ion cells are also being developed and fielded for hybrid electric vehicles (HEVs) and the military/aerospace industry, where the operational environment is much more demanding and the required temperature scale is notably broader.



The ARL innovation could allow hybrid electric vehicles to operate under more strenuous conditions, such as warmer climates or stop-n-go traffic (Source: DOE)

To date, one of the greatest roadblocks to widening the temperature range of Li-ion batteries has been the electrolyte. Nearly every commercially-available electrolyte formulation contains the salt, lithium hexa-fluorophosphate ($LiPF_6$), and the solvent, ethylene carbonate (EC). These two components are essential for protecting electrode surfaces while maintaining good ionic conductivity. However, they also restrict operating conditions of a Li-ion cell. At low temperatures, EC becomes more viscous leading to poor ion transfer. At high temperatures, $LiPF_6$ is unstable and decomposes, which can cause rapid degradation of battery components and gas generation and compromise safety.

To overcome these limitations, SEDD developed a novel set of electrolytes making battery power viable for high-temp applications that were previously uneconomic or impractical.

Invention Overview

- *Increases operating temperature upper limit by 25 percent from 60ºC to 75ºC without significant loss in performance*
- *Method is simple to practice and adaptable for mass production*
- *Less expensive than current state-of-art*
- *TRL 6 – Fully functioning cell prototypes*
- *Laboratory test data available*
- *"Evaluating LiBOB/Lactone Electrolytes in Large-Format Lithium-Ion Cells Based on Nickelate and Iron Phosphate" J. of Electrochem Soc, Vol.155, No.12, 2008*

Doing Business with ARL

- *ARL-SEDD is a leader in partnering with domestic firms*
- *Successfully developed and implemented innovative tools to ease the technology transfer process*
- *Tools includes Patent License Agreements (PLAs); Cooperative Research and Development Agreements (CRADAs); Test Services Agreement (TSA); and others*
- *Visit www.arl.army.mil for more information*

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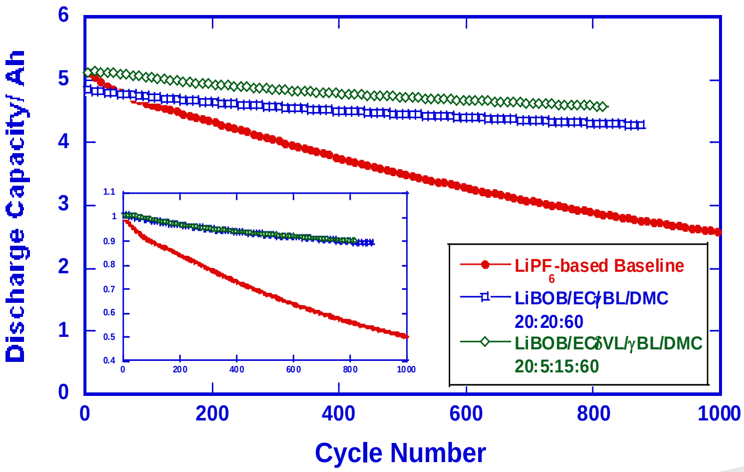
Features/Capabilities/Intellectual Property

Previous efforts by researchers to raise the upper temperature bound of Li-ion cells by using thermally stable lithium salts have been scarce and rarely successful. Generally, these experiments have resulted in batteries that may perform well at lower temperatures, but suffer poor performance at room or higher temperatures and vice versa.

The SEDD team solved this problem developing novel electrolyte compositions with unique combinations of an advanced lithium salt and organic esters. The salt, lithium bis(oxalate)borate (LiBOB), is more stable at higher temps than $LiPF_6$. The ratio of LiBOB/organic esters varies depending upon the cathode used and other operating factors. Lab trials demonstrate that these electrolytes produce a cell that can operate between -20°C and 75°C without capacity loss, power loss, gas-generation and compromises in safety at the low and high end of this expanded temperature range.

Other features/capabilities/ intellectual property offered by this invention include the following:

- More than 90 percent capacity retention at 800 cycles at 60 °C (see chart below)
- Materials used are common to the industry
- Scalable for use in large and small format batteries
- IP includes novel composition of matter (electrolytes) and method for creating same



More than 90 percent capacity retention at 800 cycles at 60 °C

Potential Markets/Applications

From commercial and military perspectives, the SEDD electrolyte innovation will benefit large format Li-ion batteries used in HEV and plug-in hybrid electric vehicle (PHEV) applications, especially in operating environments that routinely reach in high temperatures. Additionally, the invention can also benefit military auxiliary power unit (APU) applications.

Key Advantages & Benefits

- *Improves the cyclic life, storage life, and charge retention, especially at elevated temperatures (up to 75ºC) without reducing low-temp capability*
- *Compatible with current electrolyte manufacturing processes*
- *Less toxic materials*
- *Wide variety of potential applications*
- *Inventor team available to work with commercialization partner*

Contact Information

This technology was developed by ARL-SEDD. It is now available for licensing and CRADA opportunities.

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