TECHNOLOGY FACT SHEET

IMPROVING CAPACITY RETENTION AND TEMPERATURE RANGE OF LITHIUM ION BATTERIES

(Jow, Zhang, Xu, Ding)

Introduction

This invention signals a significant advance in lithium-ion (Li-ion) secondary (rechargeable) battery technology. Researchers at the Sensors and Electron Devices Directorate of the U.S. Army Research Laboratory (ARL-SEDD), Adelphi, Maryland designed, synthesized and performed successful trials on a series of solvent systems for electrochemical cells utilizing non-aqueous electrolytes based upon lithium hexafluorophosphate ($LiPF_6$). The use of these systems shows capacity retention and other performance characteristics at elevated temperatures are superior to earlier generation Li-ion cells currently on the market.

Zero-emissions bus powered by19.4 kW Li-ion battery (image source: DOE)

Concept

ARL researchers envision this new technology being utilized in multiple fields of use as an enhancement to any electrochemical device that employs "intercalation" electrodes (*i.e.,* electrodes that reversibly store and release ions – like Li^+ – migrating back-and-forth across a cell's electrolyte during charge and discharge cycles). One such use is in Li-ion batteries. These are one of the most popular types of rechargeable battery, used in portable consumer electronics with growing interest in military, aerospace and electric vehicle applications due to their high energy density and durability. For electric vehicles, one of the most difficult the challenges for further development is the increase in stored energy, which is the product of its voltage and capacity to cycle lithium ions between the anode and cathode.

High performance anodes use carbon-based materials for a number of positive reasons. Unfortunately, formation of a solid electrolyte interface layer (SEI) on carbon anodes at initial charge produces an irreversible loss of charge capacity. The ARL invention reduces irreversible capacity loss by creating a highly stable and conductive SEI layer. This results in improved cyclic and storage life, charge retention and maintains these improvements through an extended operating temperature range up to 75^oC.

Invention Overview

- *Significantly enhances cycle life, especially at elevated temperatures*
- *Method is simple to practice and adaptable for mass production*
- *Multiple areas of use in any electrochemical storage device employing non-aqueous electrolytes based on LiPF6*
- *TRL 5 – Fully functioning battery prototypes*
- *Laboratory test data available*
- *US Patent 7,442,471*

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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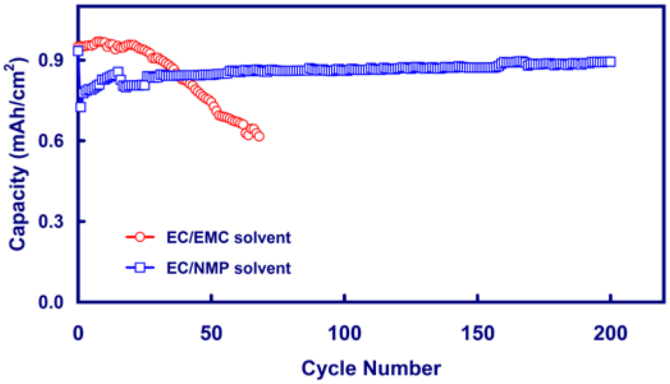
Features/Capabilities/Intellectual Property

High voltage and high energy-density rechargeable Li-ion batteries widely employ a non-aqueous electrolyte. However the various solvent systems used to create the electrolyte generally represent a tradeoff between performance and safety. These batteries are limited typically to one end (high or low) of the operating temperature spectrum of the electronic device in which they are deployed

Therefore the ARL invention provides a greatly improved non-aqueous electrolyte system that overcomes such tradeoffs. The invention features a novel combination of $LiPF_6$ salt dissolved in a solvent mixture formed from a lactam-based solvent, one or more cyclic esters, and/or one or more chain esters. These combinations produce an electrolyte that is chemically and electrochemically stable with respect to the anode, cathode and separator materials and has excellent energy capacity, capacity retention and maintains stability and safety at an expended upper temperature range without losing low temperature performance

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

- Materials used are commonly found in the industry
- Scalable for use in large and small format batteries
- IP includes novel composition of matter and method for creating same



Use of a lactam-based solvent in electrolyte significantly increases capacity retention of Li-ion batteries (source: SEDD)

Potential Markets/Applications

The novel solvent system described by this invention can be applied in any electrochemical energy storage device based on non-aqueous electrolytes, such as high energy density batteries and high power electrochemical capacitors:

- Ultracapacitors – As their energy density continues to improve, the vehicle industry is exploring ultracapacitors as a replacement for chemical batteries, which should expand this international $275 million business
- Hybrid capacitors – Combines the best features of both electrochemical and electrolytic capacitors, which in turn offers deep reserves and fast cycling.

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*
- *Cost increase is minimal over existing electrolyte formulations*
- *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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