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# TECHNOLOGY FACT SHEET

## INCREASING PERFORMANCE BY REDUCING RESISTANCE IN LITHIUM ION BATTERIES
**(Xu)**

### Introduction

This invention signals a major advance in Li-ion rechargeable battery technology. Researchers at the U.S. Army Research Laboratory-Sensors and Electron Devices Directorate (ARL-SEDD) in Adelphi, Maryland designed, synthesized and performed successful trials on a series of novel additives for non-aqueous electrolytes. The presence of these additives effectively lowers the so-called "charge transfer" resistance associated with commonly-used electrolyte systems and allows the cell to charge and discharge safely at rates significantly faster than standard Li ion cells.

*The SEDD innovation increases cell chemistry kinetics, creating cells that deliver power much more rapidly and make better use of EV regenerative braking (Image sources: 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 particularly useful application would be in electric vehicles (EVs). Li-ion batteries are sufficient when small amounts of energy are needed over a long time period, *e.g.*, maintaining an EV at cruising speed. However, they have significant difficulty providing bursts of power over the short run when an EV is accelerating hard or climbing hills. They also struggle to absorb regenerative braking power, thus wasting an important energy-scavenging resource. As such, current Li-ion batteries could weaken vehicle performance to the point where consumers may reject EVs. The SEDD invention would be particularly attractive in this arena by increasing the kinetics of the Li-ion cell chemistry, creating cells that deliver power much more rapidly and make better use of EV regenerative braking.

### Invention Overview

- *Greatly reduces power-robbing effects of "charge transfer" resistance.*
- *Method is simple to practice and adaptable for mass production*
- *Multiple areas of use, including ultracapacitors, electroplating and electrowinning*
- *TRL 5 – Fully functioning battery prototypes using coin and pouch cell formats*
- *Laboratory test data available*
- *Patent application filed 2/3/2010*

### 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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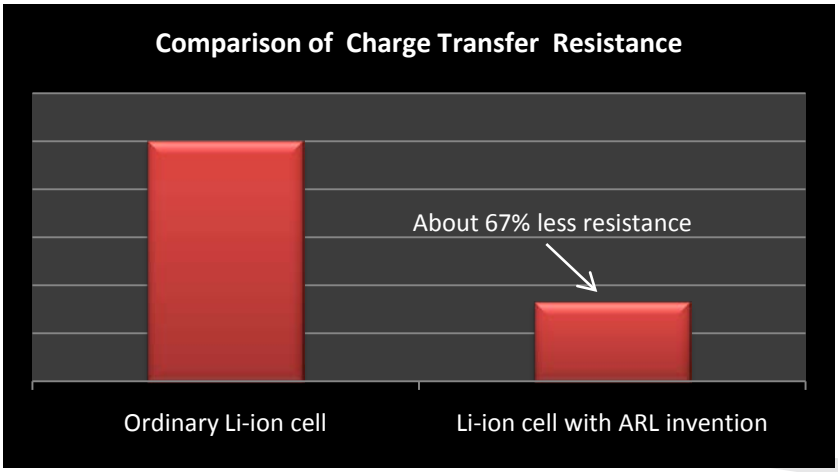
## Features/Capabilities/Intellectual Property

"Charge-transfer" resistance at the interface between electrolytes and intercalation-type electrodes constitutes a major energy barrier to the kinetics of Li-ion cell chemistry. In fact, recent studies identified this process as the rate determining step in the operation of a Li-ion device, and largely responsible for the high cell resistance observed in low temperature and high drain applications.




The invented electrolyte additives provide a simple but highly effective way to reduce the kinetic resistance that plagues Li-ion devices at the electrode/electrolyte interface. Preliminary results obtained in coin and pouch cell prototypes confirm that incorporating these additives lowers interfacial resistance by 2/3 over unenhanced electrolytes, thus boosting performance approximately 2X, even under high-drain rate or sub-ambient temperature conditions. Other features/capabilities/ intellectual property offered by this invention include the following:

- Materials used are commonly found in the industry
- Uncomplicated additive manufacturing process
- Scalable for use in large and small format batteries
- IP includes novel composition of matter and the assembled device (machine)

## Potential Markets/Applications

The novel additives described in this invention can be applied in any device employing to any electrochemical device that employs intercalation-type electrodes:

- Ultracapacitors – As 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

- *Enables significantly higher charge and discharge rates , particularly under low temperature and high drain conditions*
- *Reduced anode wear from absorbing Li ions during charge cycle*
- *Uses commonly-available materials of construction*
- *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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*ARL 09-18*