TECHNOLOGY FACT SHEET

HIGH CYCLE LIFE CATHODE FOR HIGH VOLTAGE (5V) LITHIUM ION BATTERIES

(Allen, Wolfenstine, Jow)

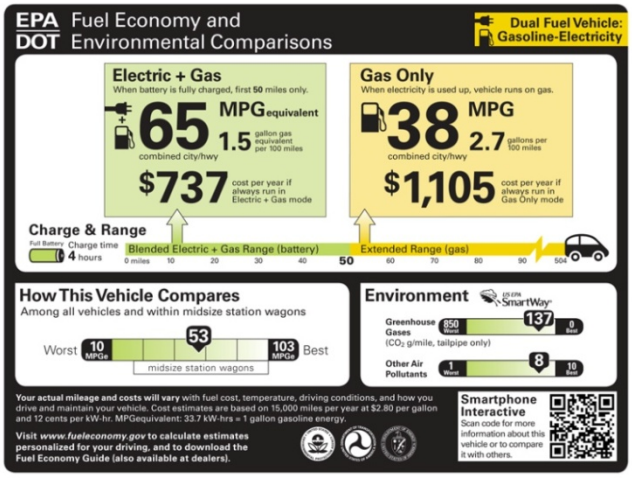
Introduction

This invention is a major breakthrough in producing lithium ion (Li-ion) batteries with significantly greater operating voltages. Researchers at the U.S. Army Research Laboratory, Adelphi, Maryland designed, built and performed successful tests of a long life, lithium cobalt phosphate ($LiCoPO_4$) cathode material designed to operate reliably up to its redox potential of 4.8 volts (V), a level unsustainable with current cathodes. This innovation, especially when coupled with the 5V electrolyte recently announced by ARL, represents a very significant step in bringing a stable, more powerful grade of Li-ion battery to market.

Concept

The use of Li-ion batteries in many of today's consumer electronic products has increased significantly, particularly in the transportation vehicle arena. This is due to the advantages of high energy density, high cell voltage and longer shelf life when compared to other battery chemistries.

However, continued advancement in Li-ion technology is limited by a number of challenges, including the need for more robust cathodes that can handle increased power requirements. Metal-oxide electro active materials, such as lithium cobalt dioxide ($LiCoO_2$), are commonly used in cathodes. They offer high electrochemical performance, but at the cost of poor thermal stability. This condition has restricted wider application of $LiCoO_2$ or similar metal oxide electrodes. Recently, lithium-conducting phosphates have attracted great attention as a new class of cathode material. They carry many of the desirable performance traits of metal oxides, but without the instability penalty. The ARL innovation improves upon this by providing lithium phosphate cathodes the capability to operate at a much higher voltage.



The SEDD innovation will lead to lighter, more powerful batteries that can further improve the remarkable fuel economy today's high performance hybrid electric vehicles (Image source: U.S. EPA)

Invention Overview

- *Ground breaking invention; enables Li-ion batteries to operate reliably at high voltage (~5V)*
- *Pathway to new lightweight, safer and more capable Li-ion batteries*
- *Method is straightforward to practice*
- *Multiple battery formats*
- *TRL 4– Fully functioning cell prototypes using SEDD cathode*
- *Laboratory test data available*

Doing Business with ARL

- *ARL 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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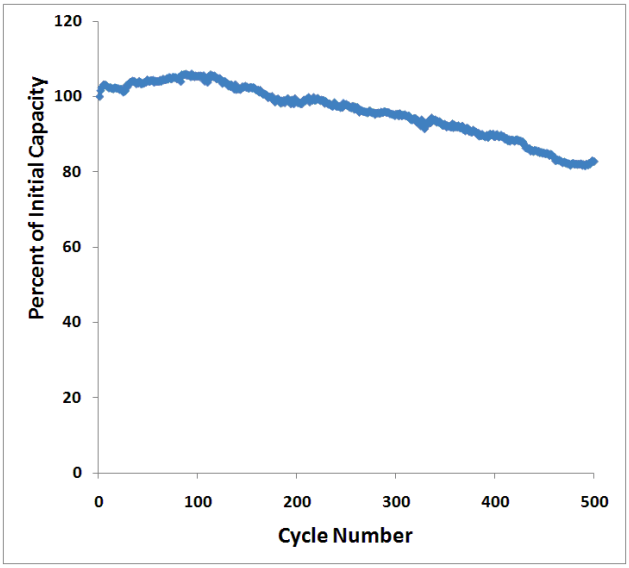
Features/Capabilities/Intellectual Property

$LiCoPO_4$ is a promising lithium-conducting phosphate material studied previously by researchers for use in high performance secondary Li-ion batteries. It has a high discharge potential (4.8 V) and a larger discharge capacity, *i.e.*, 170 milliamp-hours per gram (mAh/g) – a desirable combination of attributes not available in today's Li-ion batteries. However, previous attempts to utilize $LiCoPO_4$ in high-voltage applications have generally resulted in rapid charge-capacity fade and an extremely short cycle life (*e.g.*, greater than 50 percent loss after only 10 cycles).

The ARL innovation involves modification of $LiCoPO_4$, which stabilizes electrochemical cycling and greatly reduces capacity loss. When coupled with the high voltage-stabilized electrolyte created by ARL, the system demonstrates capacity retention of more than 80 percent after 500 cycles. Other features/capabilities/intellectual property offered by this invention include the following:

- Cathode expected to last far beyond 500 cycles
- Preparation method adaptable to existing cathode process lines
- IP includes novel composition of matter and preparation method



ARL innovation produces capacity retention of more than 80 percent after 500 cycles (source: ARL)

Potential Markets/Applications

This SEDD innovation enables the development of a new, high-voltage class of Li-ion batteries. There are numerous potential applications and markets that can benefit from more powerful batteries:

• Electric, hybrid electric and plug-in hybrid electric vehicles (EV/HEV/PHEV),
• Consumer electronics, such as laptops, cell phones and power tools
• Power management/grid services for utilities and homeowners

Key Advantages & Benefits

- *More than 15 percent energy than $LiFePO_4$; expected to increase with further R&D up to a 40 percent*
- *Maintains structurally integrity with high voltage-stabilized electrolyte created by ARL electrolyte*
- *Uses commonly-available materials of construction*
- *Inventor team available to work with commercialization partner*

Contact Information

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

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