TECHNOLOGY FACT SHEET

PREPARING A UNIQUE LITHIUM SALT FOR AN IMPROVED ELECTROLYTE FOR LI-ION BATTERIES

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Introduction

This invention enables the mass production of lithium-ion (Li-ion) rechargeable batteries with significantly expanded capabilities. Researchers at the Sensors and Electron Devices Directorate of the U.S. Army Research Laboratory (ARL-SEDD), Adelphi, Maryland designed and successfully tested a method to synthesize an alternative to the electrolyte salt, lithium hexafluorophosphate ($LiPF_6$). $LiPF_6$ is an industry standard that is fast reaching its limits to meet growing power requirements in a variety of technological fields. In response, ARL developed lithium oxalyldifluoroborate, $LiBF_2C_2O_4$ (LiODFB), a novel salt composition that offers significant improvements in Li-ion cell charge/discharge performance and cycling efficiency at both ends of the operating temperature range.

Concept

Rechargeable Li-ion batteries have been commercially available for nearly two decades. $LiPF_6$ has been commonly employed as the electrolyte salt in Li-ion batteries. However, $LiPF_6$ has limited applicability in future Li-ion systems owing primarily to its lack of thermal stability. This instability not only impedes safe handling but it can also lead to physical degradation of internal battery components, performance penalties and a shortened service life.

ARL invention can be used to increase the capabilities of Li-ion arrays for hybrid electric vehicles (source: DOE)

In recent years, considerable effort has been made to create alternatives to $LiPF_6$. While a number of promising formulations have been developed, collectively they suffer a litany of key flaws: cannot passivate aluminum current collector; difficult to produce and purify; add to production costs; poor solubility in conventional organic solvents; low ionic conductivity; process is inherently dangerous and inefficient.

The ARL solution to these shortcomings is LiODFB. This promising metal borate combines the most favorable attributes of two other alternative salts, lithium bis(oxalato) borate (LiBOB) and lithium tetrafluoroborate ($LiBF_4$), to create a cost-effective electrolyte for high-performing Li-ion batteries that operate well in harsh operating environments.

Invention Overview

- *Synthesis process for LiBF2C2O4 (LiODFB,) a new salt alternative to LiPF6 with better performance characteristics in cold and warm environments and higher safety margin against abusive operating conditions*
- *Can be used to synthesize other ammonium borate salts for use in double layer supercapacitors.*
- *Method is simple to practice and adaptable for mass production*
- *TRL 5 – Synthesis process used successfully to create functioning battery prototypes*
- *Laboratory test data available*
- *US Patent 7,820,323 B1*

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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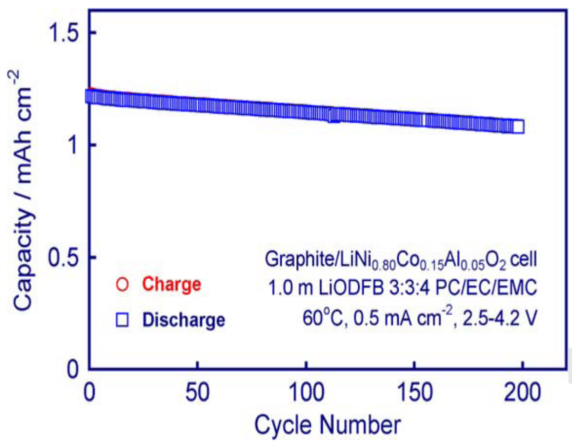
Features/Capabilities/Intellectual Property

LiBOB and $LiBF_4$ have been studied extensively as electrolyte salts and have shown significant merits and yet some notable limitations. LiBOB can create a stable solid electrolyte interface (SEI) on graphite anodes, which minimizes capacity loss. It also has excellent overcharge tolerance. LiBOB works well at higher temperatures but its limited solubility in common solvents and relatively high viscosity of such solutions reduces power and rate capability at low temperatures. Cells with $LiBF_4$ -based electrolytes exhibit better low temperature performance; however, such electrolytes are relatively inefficient in forming SEI, resulting in high capacity loss.

The salt produced by the novel ARL synthesis process, LiDOBF, has the combined advantages of LiBOB and $LiBF_4$ due to the similarity of its chemical structure. Tests demonstrate cells with a LiDOBF-based electrolyte operate well at high and low temperatures (-30ºC to 60ºC), form a conductive SEI promoting excellent charge/discharge rates and cycling efficiencies and offer improved overcharge protection. For example, a LiDOBF-based cell suffered only about 10% capacity loss after 200 cycles at 60ºC while maintaining nearly 100 percent charge efficiency.



The chart illustrates performance of a LiDOBF-based cell , which suffers only about 10% capacity loss after 200 cycles at 60ºC while maintaining nearly 100 percent charge efficiency

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

• Materials used are already common in the industry
• Scalable for use in large and small format batteries
• IP includes process for creating the electrolyte salt

Potential Markets/Applications

Expanded capabilities in Li-ion cells open up new opportunities for use in hybrid electric vehicles and other high energy density applications:

• Transportation – US auto manufacturers are producing and continuing to develop transportation systems featuring Li-ion technology

• Ultracapacitors – The vehicle industry is exploring ultracapacitors as a replacement for chemical batteries, which should expand this international $275 million business

• Electroplating Cells – More elements would be available for plating; current plating operations would also see improved process efficiency

Key Advantages & Benefits

❖ *Synthesis process produces stable lithium salts with high solubility in a number of electrolyte solvents common to the industry providing excellent ionic conductivity over a wide temperature range*

❖ *Salts from this process can extend or improve the life and performance of battery cells, capacitors, electro-chemical cells and supercapacitors*

❖ *Compatible with current electrolyte manufacturing processes*

❖ *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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