Fluorohaloborate Salts, Synthesis and Use Thereof

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Technology Overview

This is a $LiBF_3Cl$, a new salt alternative to $LiPF_6$ and $LiBF_4$ with better performance at low temperature extremes (down to -40°C)

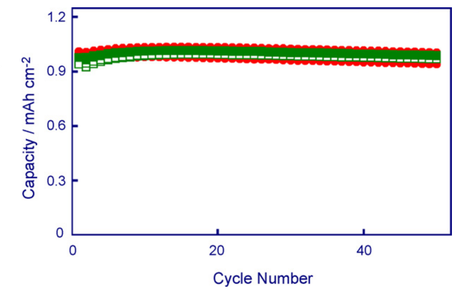
Tests demonstrate that the substitution of a chloride in LiBF4 for a fluoride to form $LiBF_3Cl$ salt created a more conductive, better performing electrolyte at lower operating temperatures.

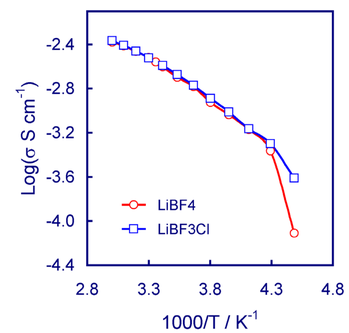
Researchers also found that the $LiBF_3Cl$ electrolyte is superior to $LiBF_4$ in forming a solid-electrolyte interphase (SEI) on anode and protecting cathode components, resulting in increased charge efficiency and prolonged battery cycle life.

- The synthesis is simple to practice and adaptable for mass production
- The method is applicable to the synthesis of other ammonium analogues for use in double layer ultracapacitors

Outstanding Performance of $LiBF_3Cl$

Identical Li-ion cells featuring LiBF3Cl maintained excellent capacity retention during prolonged cycling





Ionic conductivity of LiBF3Cl at -40°C superior to standard LiBF4 formulation

Technology Advantages

- Better thermal stability than the current $LiPF_6$ salt
- Provides higher capacity retention at high temperatures and better power capability at low temperatures than the existing $LiPF_6$ salt
- Higher solubility than the current $LiBF_4$ salt
- Material for the synthesis of $LiBF_3Cl$ is lower cost than $LiPF_6$ and $LiBF_4$
- Synthesis process can be used to create ammonium-based analogues for use in supercapacitors.

Does not require additional processing for the manufacturing line of Li-ion batteries

Proof of Concept

Experimental Work Performed:

- Demonstrated the synthesis of $LiBF_3Cl$ in lab scale (10-150 g per lot)
- Tested $LiBF_3Cl$ based electrolytes in coin cells
- Technology has been reduced to practice: Under dry atmosphere BF_3 etherate is diluted with a non-protonic solvent, followed by addition of LiCl together with small amount of methanol as the reaction initiator. Evaporating the solvent and recrystallizing the solid yields a white, pure $LiBF_3Cl$ salt
- Currently TRL-5 level – Fully functioning laboratory scale prototypes using novel salt have been developed and tested

Technology Differentiation

- Extends operation temperature range of Li-ion batteries down to -40°C without adverse impacts
- Increases power capability of the Li-ion batteries at low temperatures
- Increases capacity retention of the Li-ion batteries at higher temperatures

Technology Agreements

Patent License Agreements (PLAs) and Cooperative Research and Development Agreements (CRADAs) are sought

A collaboration between the inventor team and the commercialization partner can speed the development to the market, which is most readily be done through a PLA or a CRADA

This technology is currently at TRL 5, and it has been issued a patent (US Patent 7,833,660)

Technology Applications

Commercial:

- **Hybrid electric vehicles** (HEV) and other high energy density applications
- Portable electronic devices , such as high power drills, laptop computers, GPS
- Ultracapacitors, about $275 million in international markets

Military:

- Soldier power for a longer life rechargeable Li-ion batteries, e.g., BA-2590
- Military hybrid electric vehicle applications to reduce fuel consumption and reduce the need for dangerous logistical refueling operations
- Military electronics

The novel ARL electrolyte salt would promote more reliable operation in cold weather conditions (source: cars.com)

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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