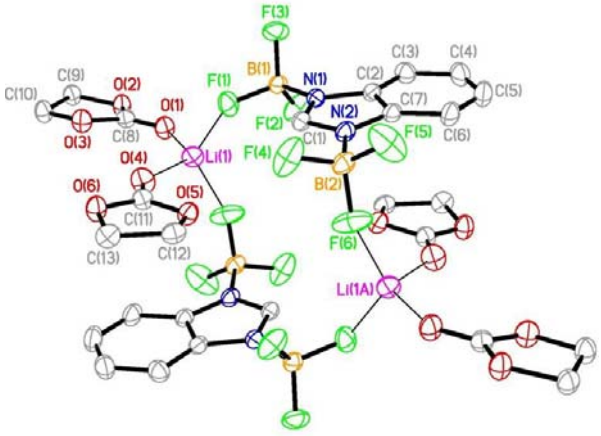
Energy Solutions

IMPROVE PERFORMANCE.

DECREASE COST.

IMPROVE MANUFACTURABILITY.

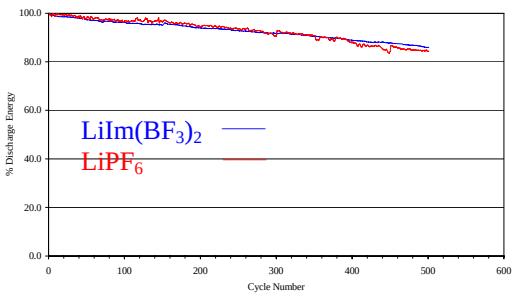
Advanced Salt for Li-ion Batteries $LiIm(BF_3)_2$



- Finding a low-cost salt replacement for $LiPF_6$ with suitable performance characteristics is a major challenge.
- We discovered and patented* a new family of Li salts and electrolytes using them, including $LiIm(BF_3)_2$.
- Improved thermal stability and low cost make $LiIm(BF_3)_2$ a highly desirable replacement for use in Li primary batteries.

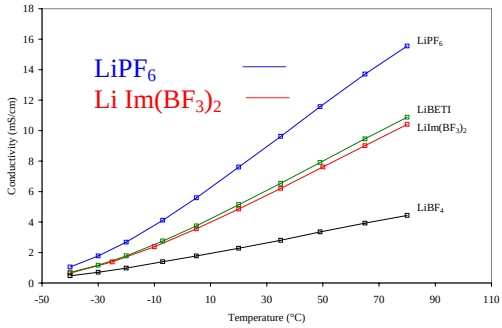
Performance in Lithium-Ion Cells

In terms of battery performance, our salt has excellent cycle life, comparable to $LiPF_6$. It has electrochemical stability up to 4.9 V as revealed by cyclic voltammetric data and has demonstrated good cycle life with cathodes having a voltage of 4.2 V versus lithium. It is compatible with standard cell materials. Conductivity measurements show that the salt is highly conductive, comparable to LiBETI and LiBOB in organic carbonate solvents. Seven Ah Li-ion cells containing our salt have comparable cycle life and capacity fade rate to cells containing $LiPF_6$ at 100 % depth-of-discharge cycling containing $LiPF_6$.



Electrolyte Conductivity

In our new family of salts, $LiIm(BF_3)_2$ is the most conductive. The conductivity of a 1 M solution in 1/3 EC/EMC from –40°C to +80°C is shown below compared with of $LiPF_6$ and $LiBF_4$, and 3 M's of LiBETI in the same solvent mixture. At 20°C, the conductivities of $LiIm(BF_3)_2$, $LiPF_6$, and LiBETI are 4.86, 7.61, and 5.14 mS/cm, respectively. Our salts have excellent solubility even at low temperatures.



*U.S. Patent 6,852,446 Non-aqueous electrolytes for lithium electrochemical cells

MysticMD

Advanced Salt for Li-ion Batteries

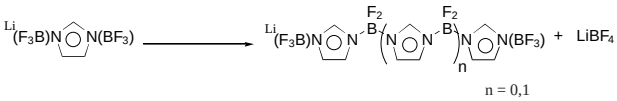
COMPETITIVE ADVANTAGE.

PATENTED TECHNOLOGY.

TECHNICAL SUPPORT.

Thermal Stability

Our salt has greater thermal stability than $LiPF_6$. Our salt and its solutions in organic carbonate solutions maintain stability indefinitely at room temperature. After three days of storage at 80°C, there's no loss in conductivity; under similar conditions, $LiPF_6$ solution loses 24% of its conductivity after just one day. During extended storage at 85°C, our salt under goes partial ligand disproportionation in organic carbonate solutions according to the reaction shown below, reaching equilibrium prior to three months.



No further disproportionation is observed, even after seven months at 85°C. The disproportionation products are Li salts expected to be electrochemically stable and compatible with Li-ion cell materials. Due to formation of these new salts, conductivity decreases somewhat after storage at 85°C. For most commercial applications this has no significant effect.

Additive for Thermal Stabilization of $LiPF_6$

Studies show that small amounts of our salt thermally stabilize solutions of $LiPF_6$. In a matter of days, at temperatures above about 60°C 1 M, $LiPF_6$ solutions in organic carbonates experience severe decomposition and gassing. Adding about 5% of $LiIm(BF_3)_2$ results in a solution that is stable for months.

Cost Advantage

$LiPF_6$ costs about $15/mol. The cost of our best performing salt is estimated at $8.40/mol, a cost savings of about 40% over that of $LiPF_6$.

For more information on any of our products or services, please visit us on the Web at:
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