

# The effect of Lithium Salts on the Stability of Plastic Li-ion Batteries with Bonded Microporous Separators at Room and Elevated Temperatures

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The detrimental effect of elevated temperatures on Li-ion battery capacity, internal resistance and internal gas pressure is well-documented. Several recent reports have shown that such degradative processes can be substantially alleviated by a judicious choice of reactive electrolyte additives which form a more stable solid-electrolyte interphase (SEI) than do typical electrolyte components, such as ethylene carbonate,<sup>1</sup> or form it without evolving any gaseous byproducts.<sup>2</sup> For practical reasons, such screening studies are often carried out using electrochemical glass cells or coin-type cells with metallic lithium counter-electrodes. While such methods may provide a valuable insight in the mechanism of action of such additives, they seldom reflect the effect of these components on the long-term capacity fade, the discharge rate capability, the changes in the internal resistance and the amount and the composition of the evolved gases in practical Li-ion cells.

The purpose of this work was two-fold: one was to develop a process to fabricate long-lived Li-ion cells with high discharge rate capability without the use of expensive, specialized coating, calendaring, winding and packaging equipment. Another goal was to use such cells as a realistic test vehicle to study the effect of several lithium salts on capacity fade, cell impedance and evolved gas volume during storage at high temperatures.

We report here two methods of fabricating flat-plate, high-performance Li-ion cells by bonding plasticized, highly loaded electrodes based on LiCoO<sub>2</sub> and an MCMB-type carbon to either untreated<sup>3</sup> or polymer-coated microporous polyolefin separators. After an exhaustive characterization of the bonded-electrode batteries activated with a 1 M LiPF<sub>6</sub> solution in a mixture of carbonate ester solvents at low (-20°C), room and elevated (+60°C) temperatures, we investigated the effect several lithium bis(perfluoroalkylsulfon)imides, i.e., (CF<sub>3</sub>SO<sub>2</sub>)<sub>2</sub>N<sup>-</sup> (TFMSI), (C<sub>2</sub>F<sub>5</sub>SO<sub>2</sub>)<sub>2</sub>N<sup>-</sup> (BETI), (CF<sub>3</sub>SO<sub>2</sub>)-(C<sub>4</sub>F<sub>9</sub>SO<sub>2</sub>)N<sup>-</sup> (MBI) and their mixtures with LiPF<sub>6</sub> on a wide range of battery characteristics. The properties studied included the discharge rate capability at various temperatures, capacity fade during cycling and storage at elevated temperatures, the changes in internal resistance and the amount and composition of evolved gases. The last factor is of particular importance in the case of batteries packaged in multi-layer aluminum-plastic foil bags.

We conclude that batteries fabricated by both reported methods exhibit excellent performance and can be used as a realistic and convenient test vehicle to study the effect of electrolyte composition and electrolyte additives on battery performance. We found that batteries activated with a 1 M solution of LiBETI in a mixture of carbonate esters showed the best overall stability during 3 weeks of storage at 60°C, including the smallest increase in internal resistance and no measurable gas evolution after the 3-week-long storage at 60°C in a fully charged state.

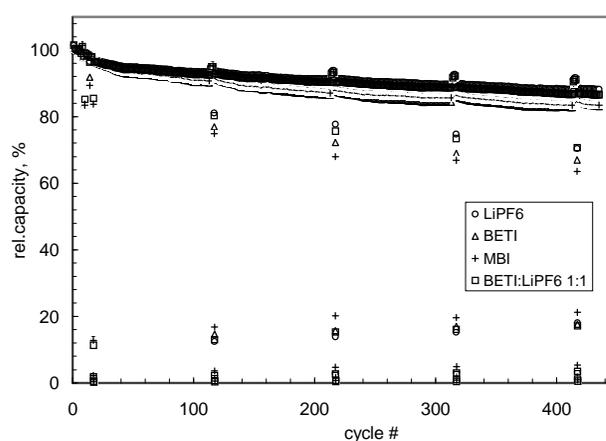


Fig. 1. Capacity fade during cycling at a 1C rate at RT for bonded-electrode cells containing various Li salts.

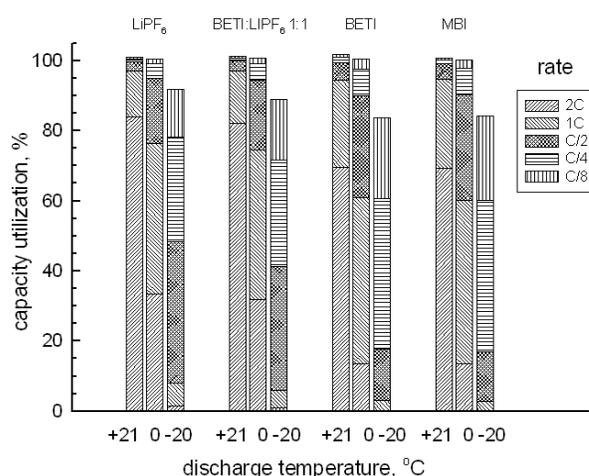


Fig. 2. Discharge rate capability at -20, 0 and 21°C of bonded-electrode batteries activated with four Li salts

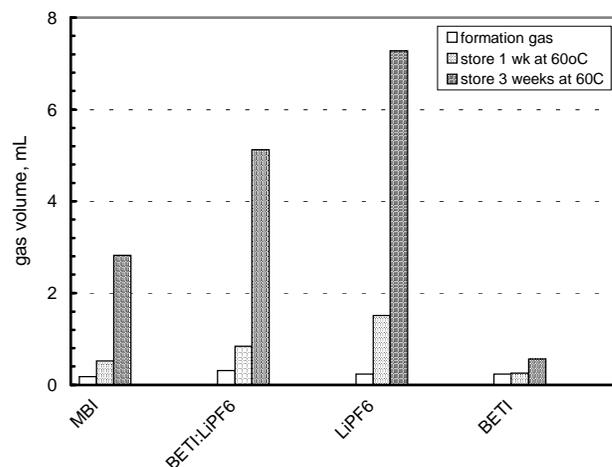


Fig. 3. The volume of evolved gas in 0.3 mAh cells activated with several Li salts after storage at 60°C

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## References

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