A Thermally Stable Li-ion Battery Electrolyte Using LiTDI

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In recent decades, Li-ion batteries have become ubiquitous, with widespread use not only in portable electronics, but also in commercial airliners, electric vehicles, and even grid-level energy storage systems. Li-ion batteries, however, have been constantly plagued by thermal instabilities with cell performance degrading significantly after short term exposure to moderately elevated temperatures (~60°C). $LiPF_6$, the primary lithium salt in state-of-the-art electrolytes, is well known to be the main culprit causing this instability (1-3). In some cases, additives such as LiDFOB have been shown to improve the high temperature performance of Li-ion batteries (4). It is desirable, however, to completely circumvent the persistent challenge of thermal instability by finding a suitable replacement for $LiPF_6$ that can withstand higher temperatures. Doing so has proven difficult though, as primary salts to replace $LiPF_6$ must fulfill the many roles necessary for a high performance Li-ion battery electrolyte. These include high conductivity, and stability towards common electrode materials, among others.

A relatively unknown lithium salt, lithium 4,5-dicyano-2-(trifluoromethyl)imidazole (LiTDI) shows promise as a primary lithium salt for use in thermally stable, next-generation electrolytes. Reports have shown that LiTDI-based electrolytes are stable with respect to various cathode materials and have a high conductivity, thus facilitating fast Li^+ cation transport across the cell (5,6). In stark contrast to $LiPF_6$, however, TGA and DSC experiments indicate that LiTDI does not degrade or volatilize until a temperature well above 100°C, making it a candidate for Li-ion battery electrolytes with a wider temperature range.

Coin cells containing either LiTDI or $LiPF_6$ in EC/DEC were cycled at 25°C and 60°C using a $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ cathode material and Li metal counter electrode (Figure 1). Whereas the state-of-the-art $LiPF_6$ electrolyte degrades at 60°C—evidenced by the abrupt drop in cell capacity—cells containing the LiTDI electrolyte show an increased capacity at elevated temperature. The relatively stable high capacity of the LiTDI-containing cell at elevated temperature is also noteworthy. LiTDI thus has the potential to be a thermally stable electrolyte salt which may be suitable for replacing $LiPF_6$, thus making Li-ion batteries safer and more robust.

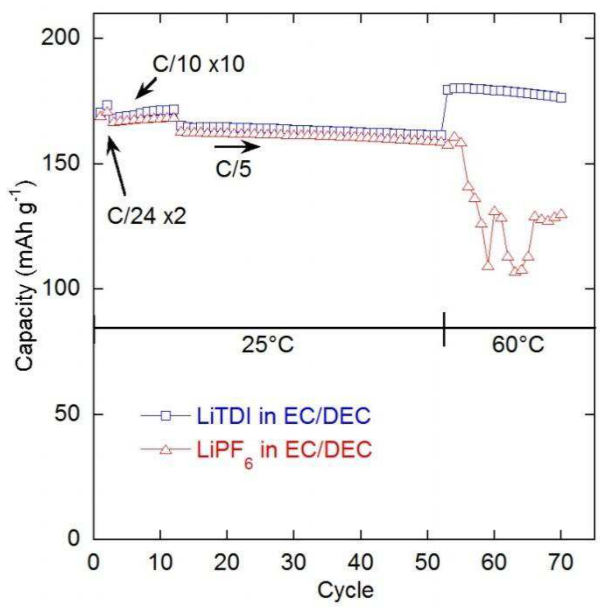

Figure 1. Discharge capacity of $LiNi_{0.5}Mn_{0.3}Co_{0.2}O_2$ half-cells containing EC/DEC electrolytes with either LiTDI (squares) or $LiPF_6$ (triangles).

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