Materials Development for Improved Lithium-Ion Battery Safety

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Lithium ion batteries have proven to be a widely used power source for many commercial applications. The use of these cells is growing in higher capacity applications such as electric vehicle (EV) and power storage for renewable energy sources. With this increasing demand for higher capacity comes an increased demand for safer cells and systems. Among the safety issues associated with lithium-ion batteries, thermal stability of the cell components (anode, cathode, electrolyte, and separator) has the largest impact on overall cell safety.

There have been many developments towards inherently safer batteries. Many of these developments involve the use of additives to increase stability of the solid-electrolyte interphase (SEI), increase ionic conductivity, reduce electrolyte flammability, and increase onset temperatures for thermal breakdown during cell runaway. These methods have proven effective to incrementally increase cell stability and overall safety, but have yet to provide dramatic benefits.

The salt LiF has been shown to be a very stable and safe electrolyte for use in lithium-ion batteries. The difficulty with this salt is that it does not dissolve in standard carbonate based electrolytes. We have developed an electron acceptor compound, which can be used to directly solubilize LiF in carbonate electrolytes. This anion binding agent (ABA) not only allows for the use of the stable LiF electrolyte salt, but also increases the thermal stability of the cell. Figure 1 shows a differential scanning calorimetry (DSC) comparison of two identical $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ (NMC) battery cathodes tested using standard 3:7 EC:EMC (w/w) with 1.2 M $LiPF_6$ electrolyte and 3:7 EC:EMC (w/w) with 1 M LiF and 1 M ABA. The overall heat output of the cathode using the ABA electrolyte formulation is reduced by ~ 30% as compared to the standard $LiPF_6$ based electrolyte.

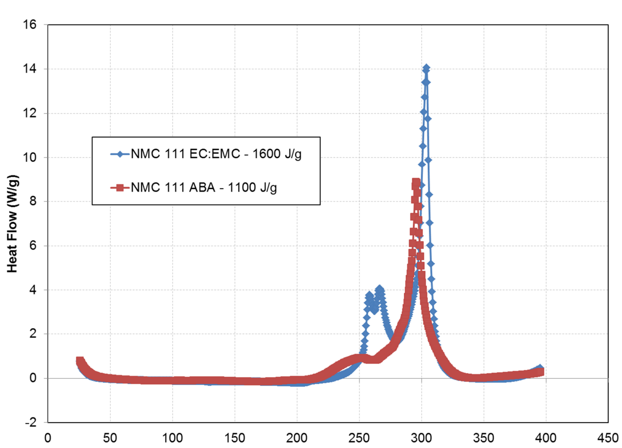

Figure 1 – DSC comparison of $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ cathodes using both 3:7 (w/w) EC:EMC with 1.2 M $LiPF_6$ and 3:7 (w/w) EC:EMC with 1 M LiF and 1 M ABA.

During a cell vent, the ABA electrolyte exhibits increased cell safety due to the intrinsically more thermally stable nature of the electrolyte and results in substantially less gas generation than the $LiPF_6$ based electrolytes. This compound has been shown to be stable to temperatures above 200 °C.

The development of new materials for increased lithium-ion safety via modification of the cell components has the potential to revolutionize the application space for lithium-ion batteries. Our current efforts aim to develop materials which perform similarly to the state-of-the-art, but offer improvements in cell thermal stability. This becomes increasingly important for large format applications, where the consequences of a safety incident could be devastating. This talk will focus on methods to increase the thermal stability and decrease the consequence of a runaway event with lithium-ion cells.

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