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Impact of Next Generation Electrode Materials on Abuse Response

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The application space for lithium ion cells is rapidly expanding to include transportation, grid storage, space system, and military power needs. Increasingly demanding mission requirements in these applications has necessitated higher energy and higher power energy storage systems. As the size and capacity of these power systems increases, so do the consequences of an off normal battery event (thermal runaway, short circuit, mechanical crush, etc.). Significant scientific efforts have been made to understand the consequences and requirements for runaway, understand policy decisions pertaining to battery safety, understand safety response in packs, and model thermal abuse of cells. Despite great progress, the overall technology still poses safety concerns for the public which, along with other considerations, have hindered the widespread adoption of many lithium based storage technologies. Several high-profile safety occurrences in recent history have brought the subject of lithium ion battery safety into the forefront of discussion within the community. While many solutions have been proposed, there has yet to be a robust and cost effective solution for the issue of battery safety, particularly in high capacity storage systems. Additionally, next generation materials such as silicon graphite/graphene anodes and high voltage cathodes are posed to increase the electrochemical performance of future systems, but little is known with regards to the abuse response of these materials.

Our research efforts have focused on developing understanding and strategies to develop intrinsically safe lithium ion based systems. This material science based strategy to ensure battery safety offers benefits over engineered solutions to battery safety. As next generation materials mature, it becomes increasingly important to apply similar methodologies to understand and optimize the abuse response and safety envelope for these batteries. Intrinsically safe battery research topics have focused on materials development and coating efforts for anode and cathode safety, electrolyte flammability and reactivity reduction efforts, separator instability considerations, and solutions targeted at the mitigating the energy released in the case of a cell abuse. The understanding of next generation silicon carbon composites will be discussed to compare with current graphite based systems. Industrially relevant 18650 cell were built using silicon carbon composite anodes versus NMC 523 cathodes to understand both electrochemical and abuse performance, see Figure 1. Initial experiments show similar performance for specific capacity and rate capability for these cells. However, these next generation anode materials appear to have some potential differences in the degradation mechanisms and overall response during abuse conditions. These results may help to inform future development efforts, particularly as industry pushes towards higher silicon content in anode materials or towards significantly higher energy dense materials.

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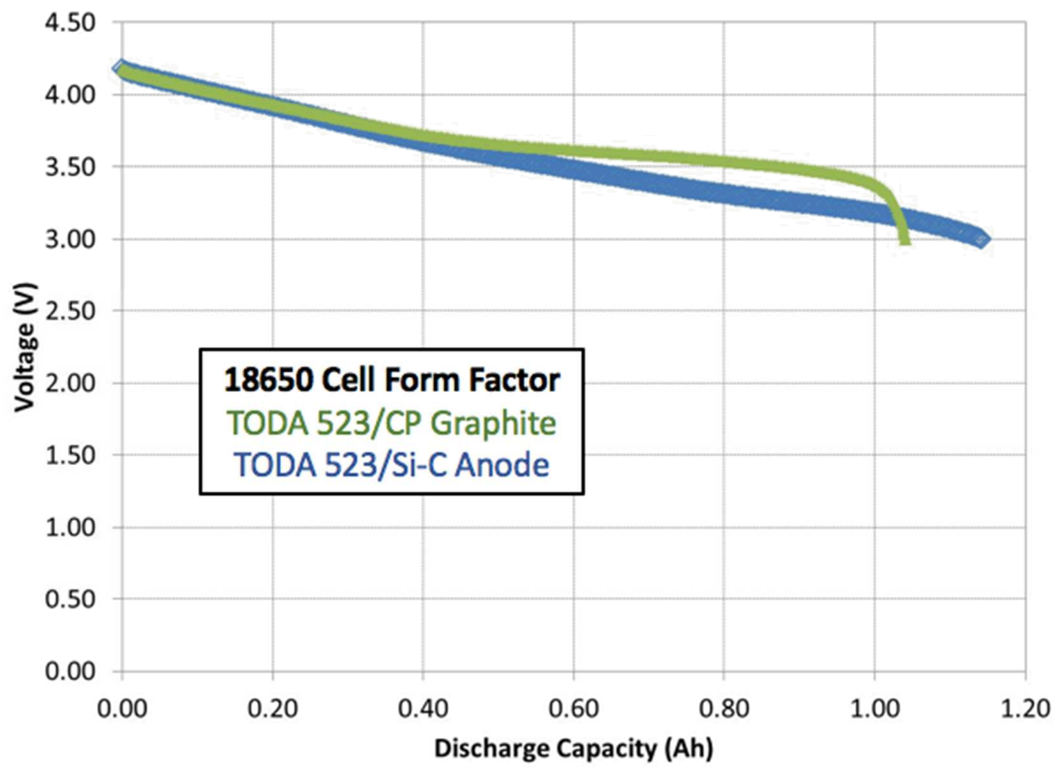

Figure 1 – Discharge comparison between NMC523 cathodes vs graphite (green) and silicon carbon composite anodes (blue) in 18650 cells.