Bridging calorimetry and battery safety: from DSC measurements to the thermal response of all-solid-state batteries

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All-solid-state batteries (SSB) are considered a promising next-generation alternative to conventional lithium-ion batteries (LIBs). They offer potential advantages in energy density and safety. In particular, replacing flammable liquid electrolytes with solid electrolytes is generally expected to improve battery safety. However, recent studies have demonstrated that solid-state battery materials can still undergo substantial exothermic reactions under thermal abuse [1,2], challenging the assumption of inherently improved safety. A better understanding of how these material-level reactions translate into the thermal response of SSB cells is therefore needed.

Calorimetric techniques such as differential scanning calorimetry (DSC) are increasingly used to characterize the thermal behavior and heat generation of battery materials. However, the implications of these measurements for the transient thermal response at larger scales are not directly evident. In this work, we present a mathematical modelling framework that bridges this gap by translating experimentally measured DSC heat-flow profiles into the transient temperature evolution of SSB configurations exposed to a thermal ramp.

The framework is applied to cathode composites containing oxide- and sulfide-based solid electrolytes and implemented in three battery formats: coin, single-layer pouch, and multilayer pouch cells. The experimentally measured heat-flow profiles are incorporated as heat-generation inputs into a transient heat-transfer model, allowing the temperature evolution resulting from exothermic reactions within the cathode composites to be evaluated under defined thermal boundary conditions.

The results reveal unique differences in the thermal response for both material chemistry and cell format. By linking material-level calorimetric measurements to the transient thermal response of battery-scale configurations, the proposed framework provides a bridge between thermal characterization and battery safety assessment. It enables the comparative evaluation of emerging SSB material combinations and cell formats using experimentally accessible calorimetric data and can support the identification of material and design combinations associated with increased thermal risk.

References:

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