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Solid-Solid Phase Change Materials for the Thermal Management of Li-Ion Batteries

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Amidst the growing reliance on lithium-ion batteries for a range of applications, from mobile devices to electric vehicles, the imperative for robust thermal management strategies becomes evident. This study explores the efficacy of hybrid organic-inorganic layered 2D perovskites, a class of solid-solid phase change materials (SS-PCMs), in enhancing battery safety, longevity, and performance. These materials exhibit remarkable thermal stability, which curtails leakage risks, present a notable increase in energy density, extended battery cycle life, and improved heat management capabilities. Through an upscale synthesis and in-depth characterization, our findings elucidate the potential of these perovskites in thermal regulation, emphasizing their reversible phase transitions between crystalline and semi-crystalline or amorphous states, and minimal volumetric changes during heat absorption and release due to the absence of solid-liquid changes present in commercial PCMs [1]. In addition, compared to form-stable PCMs reported in literature, our materials offer a cheaper, less complex system, with comparable performances [2]. In this context, this research advances the possible successful design of the first thermally stable Li-ion battery employing SS-PCMs, offering a promising avenue for optimized thermal control and performance enhancement in energy storage systems. Despite being identified as promising materials for thermal management in the 1980s [3], employing 2D perovskites as hybrid SS-PCMs have received little attention until now [4]. In fact, hybrid SS-PCMs with a generic chemical formula $(C_nH_{2n+1}NH_3)_2M^II X_4$ (M = divalent metal; X = halogen) have demonstrated potential for heat transfer with tailorable phase change temperatures [5]. Herein, we present hybrid materials with high latent heat storage efficiency and thermal stability, even at temperatures double their transition temperature. Their unique thermal properties allow versatile shaping for optimized thermal exchanges. The employed advanced characterization techniques (synchrotron XRD-PDF, in-situ TEM, SAXS, STA, micro DSC, etc.) provided detailed insights into their structural and functional qualities. The aliphatic chain length and the type of cation influence the materials' energy capacity and transition temperatures, allowing for customization. Future research may focus on functionalizing these materials by diverse molecules, and advancing integration into diverse energy storage systems.

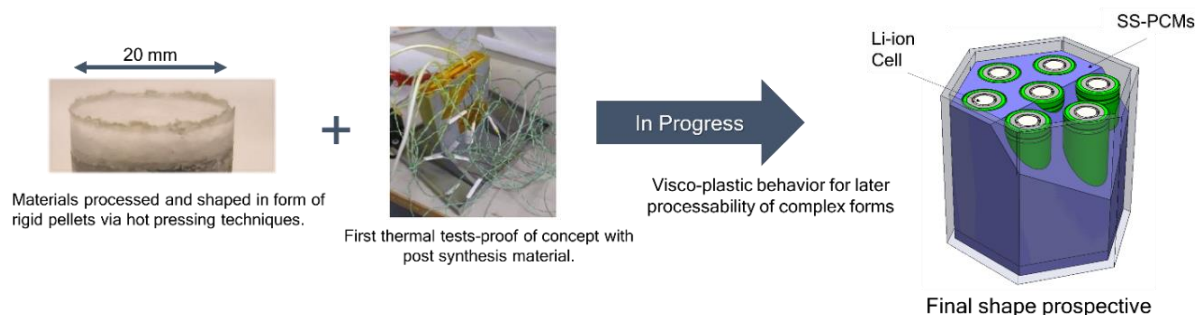


Figure 1. Work in progress covering the testing and shaping of materials for applying in a Li-ion battery system.

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