

Mitigation of Lithium-ion Battery Thermal Runaway Propagation Through the Use of Phase Change Materials Containing Expanded Graphite

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Abstract : In recent years, lithium-ion batteries have been used increasingly for electric vehicles and large energy storage systems due to their high-power density and long lifespan. Despite this, thermal runaway remains a significant safety problem because of its uncontrollable and irreversible nature - which can lead to fires and explosions. In large-scale lithium-ion packs and modules, thermal runaway propagation between cells can escalate fire hazards and cause significant damage. Thus, safety measures are required to mitigate thermal runaway propagation. The current research explores composite phase change materials (PCM) containing expanded graphite (EG) for thermal runaway mitigation. PCMs are an area of significant interest for battery thermal management due to their ability to absorb substantial quantities of heat during phase change. Moreover, the introduction of EG can support heat transfer from the cells to the PCM (owing to its high thermal conductivity) and provide shape stability to the PCM during phase change. During the research, a thermal model was established for an array of 16 cylindrical cells to simulate heat dissipation with and without the composite PCM. Two conditions were modeled, including the behavior during charge/discharge cycles (i.e., throughout regular operation) and thermal runaway. Furthermore, parameters including cell spacing, composite PCM thickness, and EG weight percentage (WT%) were varied to establish the optimal material parameters for enabling thermal runaway mitigation and effective thermal management. Although numerical modeling is still ongoing, initial findings suggest that a 3mm PCM containing 15WT% EG can effectively suppress thermal runaway propagation while maintaining shape stability. The next step in the research is to validate the model through controlled experimental tests. Additionally, with the perceived fire safety concerns relating to PCM materials, fire safety tests, including UL-94 and Limiting Oxygen Index (LOI), shall be conducted to explore the flammability risk.

Keywords : battery safety, electric vehicles, phase change materials, thermal management, thermal runaway

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