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Passive Thermal Management of Cylindrical Li-ion Batteries Using GO-Enhanced Micro-Encapsulated Phase Change Material

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Extended Abstract

Thermal management of fast-charging Li-ion batteries (LIBs) employed as a power source is a trending issue in electric vehicles. Solid-to-liquid phase change materials (PCMs) are extensively studied as a thermal buffer to absorb the heat generation in LIBs during high C-rate charging, owing to their excellent latent heat storage capacity. However, PCMs have a low thermal conductivity, and hence, the regeneration of solid PCM once it melts after absorbing heat is a time-consuming process, which hampers its continuous utility to be used as a reliable coolant. Moreover, the leakage of PCM melt and volume expansion are also major factors that limit the widespread adoption of solid-liquid PCM in battery thermal management [1].

To overcome the above-mentioned issues, the present work synthesizes and develops a micro-encapsulated phase change material (MePCM) [2,3] with enhanced thermal conductivity. Eicosane (melting range - 34°C-36°C) is selected as the PCM core, and the shell material is made up of PMMA. The PMMA shell is modified with graphene oxide (GO) to alter the effective thermal conductivity of the MePCM. Different concentrations of GO, ranging from 1% to 4%, are synthesized with PMMA, and their characterization and thermo-physical properties are investigated. The results show that a larger concentration of GO improves the structural integrity of the shell, which adds to the thermal stability of MePCM samples. The thermally optimized MePCM 4 (4% GO concentration) has melting and crystallization enthalpy values of 105 and 99.9 J/g, respectively, and a maximum thermal conductivity of 2 W/m K. The SEM and TEM images of the synthesised MePCMs have shown the particle diameter ranging from 4 to 7 µm, and the shell material has a thickness ranging from 200 to 500 nm, confirming their micrometer range and spherical nature. The synthesised MePCMs are also compared with pure eicosane for thermal degradation. MePCMs, due to their protective shell material, degrade at relatively higher temperatures. Further, the prepared MePCM 4 will now be tested against the solid-solid PCM for the thermal management of cylindrical lithium-ion batteries. The test will be carried out at various C-rates ranging from 1C to 5C. The test section includes a single 18650-type LIB inserted in a rectangular tank with dimensions (WxLxH = 40mm x 40mm x 65mm). Thermocouples are attached to the surface of the LIB to read the temperature. The objective of the study is to delay the critical time of LIB to reach its safe temperature limit with the employment of MePCM and to keep the LIB within its safe operating range (<50 °C) for the entire operation time. Furthermore, a cyclic charge/discharge study will be performed for both MePCM and solid-solid PCM to compare their effectiveness in the thermal regulation of the LIB. In conclusion, the present study aims to explore the effectiveness of MePCMs to be used as a potential passive coolant for the reliable thermal management of LIB packs.

Reference

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