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Experimental investigation of tailoring functionalized carbon-based nano additives infused phase change material for enhanced thermal energy storage

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ABSTRACT

The advancement of phase change materials (PCMs) as potential thermal energy storage (TES) materials for building envelopes holds promise for efficient energy utilization. However, the PCMs have a major drawback during energy storage, which is lower thermal conductivity, leading to inadequate heat transfer performance and energy storage density. The foremost objective is to formulate a nanocomposite by dispersing functionalized multi-walled carbon nanotubes in salt hydrate PCM with the presence of surfactant. A two-step technique is employed to formulate the nanocomposites with different weight concentrations (0.2, 0.4, 0.6 and 0.8 %) of carbon-based nanoparticles and these nanocomposites are thoroughly characterized to explore the thermo-physical properties. Resulting the nanocomposite demonstrates a significant improvement in thermal conductivity, increasing by 91.45 %, which can be attributed to the well-developed thermal networks with the PCM matrix. The nanocomposite samples exhibit extreme thermal stability up to 477 °C with a slight enhancement of 4.6 %. Optical investigations further confirmed that the transmissibility of PCM decreased to 8.3 % from 62.8 %, indicating an enhanced absorption capability due to the dark color nature of the nanoparticles. Moreover, the formulated nanocomposite demonstrated both chemical and thermal stability, with negligible changes in melting enthalpy even after 300 cycles of heating and cooling operations. Additionally, a numerical simulation analysis of 2D heat transfer was performed using Energy 2D software to demonstrate the efficacy of thermal conductivity in heat transfer. The thermally energized nanocomposite is suitable for medium-temperature TES applications such as photovoltaic thermal systems, building applications, textiles, electronic cooling, and desalination systems.

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