Journal of Energy Storage 82 (2024) 110523

Contents lists available at ScienceDirect

Journal of Energy Storage

journal homepage: www.elsevier.com/locate/est

Research Papers

# Optimizing graphene-silver embedded phase change composite synthesis using design of experiments

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ARTICLE INFO

*Keywords:*
Optimization
Response Surface Methodology
Central composite design
Thermal conductivity
Thermal interface material

ABSTRACT

The paradigm shift from fossil fuels to renewable ones is at stake with the underdeveloped energy storage technology. However, Phase Change Materials (PCMs) are congruent with batteries but possess degraded thermophysical properties, which can be tuned by dispersing nanofillers. Numerous trials are needed to find the optimum responses for maximal thermophysical properties. This research aims to apply statistical methods for hybrid nanocomposite synthesis to deliver maximal favourable thermophysical properties. Response Surface Methodology with a central composite design was sourced to generate optimal input response conditions for maximal thermal conductivity. The present work also focuses on the synthesis and thermophysical characterization of nanocomposite with nanofillers (graphene: silver) at optimum input response. The maximal thermal conductivity value for the optimum input response of nanofiller and surfactant concentration was 0.412 W/mK, 0.310 %, and 0.313 %, respectively. Statistical parameters (f-values, predicted $R^2$, observed $R^2$, adjusted $R^2$) were used to validate the experimentally developed Response Surface Methodology (RSM) model. The reliability of the predicted model was proved as there was little distinction between simulation data and validation experiments. The induction of statistical methods will significantly reduce the experimental trials and deliver insight into major input parameters and their effects on responses. Moreover, the macro-packed nano phase change composite reduced the surface temperature by 7 °C. The thermophysical characterization and experimental results validate the usage of NPCCs as a thermal interface material for building thermal management applications.

## 1. Introduction

Global socioeconomic advancements mainly rely on energy utilization patterns, making energy a vital parameter that even assists in attaining sustainable development [1]. The world faces two severe dilemmas: a severe energy crisis and a resource shortage. To a maximal extent, harnessing renewable energy sources can effectively resolve the above cruxes greenly [2]. The effective utilization of energy and storage has been the subject of investigation by numerous researchers due to the demand for structural energy transformation [3]. Energy storage is a potential remedy to the problem mismatch between energy utilization in space and time [4]. Latent heat Thermal energy storage (LHTES), a niche research area, holds immense potential. Phase change materials (PCMs) are generally deployed in LHTES applications as they hold high latent heat, which lets them act as thermal batteries [5]. Mostly PCMs could be grouped into three tiers mainly organic, inorganic & eutectic. As cited by researchers, the primary limitation associated with organic PCM is its inherent poor thermal conductivity [6]. Extensive studies on organic PCMs revealed favourable properties like improved thermal and chemical stability, poor subcooling, higher enthalpy, economical, non-toxic, and anti-corrosive [7]. They can collect and release thermal energy with exceptional energy storage density by phase transformation

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https://doi.org/10.1016/j.est.2024.110523
Received 9 August 2023; Received in revised form 24 December 2023; Accepted 7 January 2024
Available online 19 January 2024
2352-152X/