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Research Papers

Analyzing long-term reliability and potential of organic eutectic Phase Change Material as thermal batteries

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A B S T R A C T

The current century is experiencing a notable and expeditious transition toward environmentally sustainable and renewable energy sources to mitigate the effects of climate change. Solar energy is a widely utilized renewable energy source due to its abundance and cleanliness despite its disparate distribution. Integrating Latent Heat Energy Storage (LHES) components into solar energy storage systems can potentially mitigate anomalies in solar radiation. Phase Change Materials (PCMs) are widely regarded as the most commonly utilized substance for Thermal Energy Storage (TES). The thermal management potential of a TES system is substantially hindered due to the limited thermal conductivity of PCMs. The present study attempts to create a binary eutectic PCM for employment in desalination systems, electronic thermal management, and other medium-temperature applications. The melt blending approach was used to synthesize a Binary Eutectic PCM (BEPCM), mixing paraffin and palmitic acid, and the composite's thermophysical properties were evaluated. The stability of BEPCM was confirmed by using the techniques of Thermogravimetric Analysis and Fourier Transform Infrared Spectroscopy. The synthesized BEPCM's thermal conductivity was 0.256 $W \cdot m^{-1} \cdot K^{-1}$ (an increase of 11.3 % above palmitic acid). The melting point and latent heat values were found to be 55 °C and 160 J/g. An in-depth morphological and thermophysical analysis following 4000 thermal cycles validated the EPCM's long-term reliability. Thus, a cost-effective, robust, and reliable PW-PA-based BEPCM was manufactured. The composite benefits TES systems operating at moderate temperatures due to their improved thermophysical capabilities.

1. Introduction

1.1. Background

Environmental degradation due to greenhouse gas emissions backed up by extensive usage of fossil fuels has become one of the major concerns around the globe. To limit fossil fuel usage, there exists a sheer need for a global shift toward renewable energy sources [1]. Overdependence on fossil fuels can be curtailed by transforming renewable energy sources into thermal, electric, chemical, and even light energy. Currently, many researchers are focusing on promoting clean, renewable energy sources and sustainable development goals [2]. Among the acquirable renewable resources, solar energy remains highly promising, as it is a green, economical, and readily accessible energy source [3]. Solar irradiations can be swiftly converted into electrical and thermal energy using solar photovoltaic and solar thermal systems. The intermittent nature of solar radiation makes it hard to use in real-time applications. Energy storage techniques can be used to resolve this issue to a great extent [4]. The energy generated from solar photovoltaic systems is generally stored in electrochemical batteries [5].

Thermal Energy Storage (TES) methods could be utilized for storing the excess heat (thermal energy) collected from solar thermal systems [6]. During the 1970s energy crisis, TES was initially introduced and explored [7]. TES methods collect surplus thermal energy (by a melting

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