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Improved performance of a newly prepared composite phase change material for solar energy storage

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Abstract

This paper investigates the enhanced thermal performance of a newly prepared nanomaterials incorporated phase change material (NiPCM) containing myristic acid and SiO_2 nanoparticles (NPs). SiO_2 NPs with mass fractions of 0.2, 0.5, 0.8 and 1.0 wt% were suspended in the base PCM (myristic acid) separately, so as to determine the maximum enhancement of thermal conductivity. The size and morphology of the as synthesized SiO_2 NPs were studied by FESEM. Phase change properties of composite PCMs were assessed with the help of differential scanning calorimetry (DSC) analyses. Thermal conductivity enhancement of composite PCMs was measured by means of laser flash analyzer (LFA). The test results clearly indicate that time taken for melting and solidification processes of composite PCMs were less while comparing to base PCM. Thus, the newly prepared composite PCM can be deemed to be a potential candidate to harvest the solar energy for low temperature heating systems.

Keywords: Melting; NiPCM; Thermal conductivity; Solidification

1. Introduction

Since last two decades, storing the solar energy has been a major subject everywhere as the thermal energy available from the sun is abundant and also free from pollution. There are two techniques employed for storing the solar energy namely, sensible thermal energy storage (STES) and latent thermal energy storage (LTES). Amongst these two, LTES is the most attractive method as it can store and release thermal energy almost at constant temperature with little fluctuation and also, it has higher energy storage density while comparing to STES. The PCMs used in the LTES system have inherently very low thermal conductivity and therefore, the energy store/release rate capacities of the PCMs are reduced significantly [1-4]. So, the PCMs for solar energy storage system are expected to have higher thermal conductivity. Otherwise, solar energy can't be stored in the PCMs efficiently, because the intensity of solar radiation tends to vary during day time.

In order to overcome the aforementioned issue, many techniques were introduced in the past [5-9]. These techniques were able to improve the performance of the PCMs but, not expected level. Further, an introduction of these techniques increased the weight and volume of the LTES system because, these methods use metal fins with different profiles, metal screens, metal beads, expanded graphite, etc. Thus, developing a novel technique for improving the performance of the PCMs has been a great thrust to the energy experts. An application of nanotechnology has led a way to disperse solid NPs in the PCM so as to achieve larger enhancement of the thermal conductivity [10-15]. Thermal conductivity of the composite PCMs relies on structure, morphology and weight fraction of the NPs [16]. If size of the NPs is decreased, thermal conductivity of composite PCMs would be increased. Therefore, smaller sizes of the NPs are widely preferred for achieving larger enhancement of thermal conductivity.

Wang et al. mentioned that the dispersion of treated carbon nanotube (TCNT) in base PCM achieved the considerable improvement in the thermal conductivity [17]. For mass fraction of 0.01wt% TCNT, an enhancement of PCM was found to be 46%. A comprehensive investigation was studied to ascertain the thermal conductivity enhancement of the TiO_2 based $BaCl_2$ nanofluids as latent thermal storage material [18]. It was concluded that thermal conductivity enhancement of $BaCl_2$ was obtained by 12.76% for 1.13vol% TiO_2. Harikrishnan et al. [19] performed an experimental study on melting and solidification behaviors of TiO_2 NPs embedded stearic acid as composite PCM for LTES system. According to the experiment results, it was observed that the dispersed TiO_2 NPs expedited the phase change behavior of the composite PCM at a faster rate while comparing to stearic acid alone.

In another work, CuO NPs were dispersed in oleic acid for

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