Thermal Conductivity Enhancement of adipic acid as a Phase Change Material (PCM) by boehmite nanoparticles for Thermal Energy Storage at 150°C

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ABSTRACT

Phase change materials (PCM) store and release a considerable amount of thermal energy during their transition thanks to their high latent heat. A large amount of energy used is in the form of thermal energy. Therefore, integrating a technology that can enhance energy efficiency in our daily life such as avoiding energy loss and providing the required energy seems necessary and still challenging. A thermal energy storage (TES) based on PCM can be integrated with renewable energy resources such as solar energy systems to store energy whenever it is available. In a more efficient and green approach, PCMs can also recover waste heat at different energy grades. For example, in the current study, the objective is to develop a PCM to be used at 150°C to be integrated in a compressed air energy storage system to store heat after compression during the charging phase and reuse it before the turbine during the discharging phase. Adipic acid is selected as an organic and non-hazardous PCM that stores around 250 J/g of thermal energy at 150°C. Most PCMs, especially organic ones, offer promising properties such as significant storage capacity, non-hazardous, and non-corrosive effect for thermal energy storage. However, the low thermal conductivity is a common disadvantage of PCMs that hinders their application. The low thermal conductivity of PCMs leads to the increase of charge and discharge times by suppressing the heat transfer to and out of the PCM. The main goal of this study is to increase or customize thermal conductivity of a PCM without reducing their storage property. To improve the thermal conductivity, boehmite nanoparticles (AlOOH) at low weight percentages (0.05, 0.1, 0.2 and 0.5 wt%) are added to melted adipic acid. To have a more uniform dispersion, the mixture is prepared under continuous stirring and non-continuous sonification. The boehmite nanoparticles are cost-effective, widely available with an uncomplicated synthesis process (that justifies its application at large scale for thermal energy storage). The thermal conductivity of nano-PCMs is measured using modified transient plane source technique (MTPS). To do so, disk-shape samples are prepared through cold press with the diameter and thickness at 20 mm and 6 mm, respectively. An improvement in the range of 11 to 17% ±2% has been observed for the thermal conductivity of boehmite-adipic acid nano-PCM. Furthermore, according to the differential scanning calorimetry (DSC) tests, the changes in terms of latent heat and melting point were negligible due to the low amount of added nanoparticles (less than 1 wt%). Subcooling phenomenon in adipic acid is reduced by 0.5°C as a result of adding nanoparticles.