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Wheat husk derived microparticle infused organic phase change material for efficient heat transfer and sustainable thermal energy storage

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ABSTRACT

The utilization of phase change materials (PCMs) in thermal energy storage (TES) has garnered widespread recognition and application within advanced TES systems. Nevertheless, PCMs have challenges during TES operations, notably poor thermal conductivity, and a limited temperature range. Despite their high cost, commercialised carbon-based nanoparticles overcome a low thermal conductivity problem of organic PCMs. As such, biomass waste microparticles have become an environmentally friendly and economically viable alternative, enabling waste to be employed more effectively for heat storage while decreasing dependency on the more expensive carbon nanoparticles. Hence, the primary objective of an ongoing study was to synthesise bio-based microparticles derived from the wheat husk (WH) to reduce the use of expensive carbon-based nanoparticles with organic phase change materials (OPCMs) for TES. The WH microparticles are synthesised through pyrolysis at a temperature of 1000 °C, and the size of the WH particle reduced via ball milling. Furthermore, a two-step ultrasonication method was employed to develop composites by dispersing WH microparticles. Moreover, the PEG + WH composite's morphology, chemical stability, optical absorptivity and transmissivity, thermal stability, and heat transfer rate are comprehensively explored in extensive experiments. Remarkably, present research revealed that incorporating bio-based 1.0 wt% of WH microparticles, thermal conductivity enhanced by 103 % compared to the base PCM. Notably, 500 thermal cycles were carried out and developed composites were found to be thermally stable with minimal changes in thermophysical properties. Moreover, a numerical analysis using 2-D energy modeling software was performed to determine the heat transfer rate of PEG composites.

1. Introduction

Thermal energy storage (TES) plays a crucial role in adequately capturing solar energy. Although light from the sun reaches its maximum during daylight hours, the challenge lies in storing this energy for utilization during nights or periods of inadequate sunlight. Phase change materials (PCMs) represent a potential strategy for addressing the problem [1]. The substances undergo phase transitions between solid and liquid states, efficiently storing and releasing enormous amounts of energy during these changes. It is emitted as thermal energy when required, such as during nighttime [2]. The newly developed technique guarantees consistent and dependable energy availability. Incorporating PCMs into TES systems is essential for the progress of sustainable and continuous solar energy utilization [3]. Furthermore,

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