Journal of Energy Storage 72 (2023) 108449

Contents lists available at ScienceDirect

Journal of Energy Storage

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

Research papers

Effect of TiO_2 nanoparticles on the thermal energy storage of HITEC salt for concentrated solar power applications

Hatem Ahmad Aljaerani [a], M. Samykano [a,*], A.K. Pandey [b,c,d,**], Zafar Said [e,f,g,***], K. Sudhakar [a], R. Saidur [b]

[a] Faculty of Mechanical & Automotive Engineering Technology, Universiti Malaysia Pahang, 26600 Pekan, Pahang, Malaysia
[b] Research Center for Nano-Materials and Energy Technology (RCNMET), School of Engineering and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya 47500, Selangor Darul Ehsan, Malaysia
[c] Center for Transdisciplinary Research (CFTR), Saveetha Institute of Medical and Technical Sciences, Saveetha University, Chennai, India
[d] CoE for Energy and Eco-Sustainability Research, Uttaranchal University, Dehradun, India
[e] Department of Sustainable and Renewable Energy Engineering, University of Sharjah, 27272 Sharjah, United Arab Emirates
[f] Department of Industrial and Mechanical Engineering, Lebanese American University (LAU), Byblos, Lebanon
[g] U.S.-Pakistan Center for Advanced Studies in Energy (USPCAS-E), National University of Sciences and Technology (NUST), Islamabad, Pakistan

ARTICLE INFO

Keywords:
Thermal energy storage
Concentrated solar power
Nanoenhanced molten salt
Latent heat
Upper working temperature

ABSTRACT

Thermal energy storage materials are substantial in concentrated solar power (CSP) plants as they absorb solar thermal energy and store it to be used for electricity production. Enhancing the thermophysical properties of these materials will positively affect the efficiency of the CSP plant system and lower electricity price. This research synthesized a novel composite of Titanium Dioxide (TiO_2) nanoparticles and the ternary nitrate molten salt (HITEC) at different nanoparticle concentrations. The nano-enhanced molten salt (NEMS) samples were characterized for compatibility and nanostructure analysis. Also, the thermophysical properties and thermal cycling behaviour of the NEMS samples were evaluated. The results indicate that 0.1 wt% can enhance the specific heat capacity of HITEC by 5.5 %, latent heat by 78 %, and upper working temperature by 5 %. The morphological analysis of the 0.1 wt% NEMS sample revealed a good dispersion of nanoparticles in HITEC and the formation of nanostructures. The FT-IR analysis showed the chemical stability of the nanofluid with no presence of chemical reaction between its components. The thermal cycling test of the optimum sample showed the chemical stability of the nanocomposite and the thermal cycling stability of the enhanced thermophysical properties.

1. Introduction

Renewable energy, particularly for electricity production, has become a high priority for sustaining modern society while attempting to decrease air pollution resulting from the dependence on burning fossil-based fuels for energy production [1], which also resulted in the depletion of the natural resources of these fuels. One method of generating electricity from solar power is using CSP systems to evaporate the water using solar thermal energy and produce steam that can be used to rotate an electric generator and produce electricity [2]. The CSP systems can generate electricity 24 h per day using the hot molten salt reservoir [3]. In CSP power towers, the thermal energy storage (TES) material is usually a molten salt that also works as a heat transfer fluid (HTF) [4].

Implementing molten salt in CSP systems has improved the overall system efficiency [5]. This efficiency can be further improved by enhancing the molten salt's thermal properties, especially its latent heat and heat capacity, to improve its heat storage, lowering its melting point and enhancing its upper working temperature to increase its working range. One way to improve molten salt is by doping it with nanoparticles, forming a nanoscale semi-solid layer adjacent to the salt and the nanoparticles. This layer has better thermal properties than nanoparticles and molten salt and is suggested to cause its thermal properties

* Corresponding author.
** Correspondence to: A.K. Pandey, Research Center for Nano-Materials and Energy Technology (RCNMET), School of Engineering and Technology, Sunway University, No. 5, Jalan Universiti, Bandar Sunway, Petaling Jaya 47500, Selangor Darul Ehsan, Malaysia.
*** *Correspondence to: Z. Said, Department of Sustainable and Renewable Energy Engineering, University of Sharjah, 27272 Sharjah, United Arab Emirates.
E-mail addresses: mahendran@ump.edu.my (M. Samykano), adarshp@sunway.edu.my (A.K. Pandey), zsaid@sharjah.ac.ae, zaffar.ks@gmail.com (Z. Said).

https://doi.org/10.1016/j.est.2023.108449
Received 15 December 2022; Received in revised form 21 May 2023; Accepted 18 July 2023
Available online 29 July 2023
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