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PREPARATION AND PROPERTIES OF $ZrO_2/SiC-H_2O$ NANOFLUIDS TO USE FOR ENERGY STORAGE APPLICATION[†]

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More than half of the energy used in total comes in the form of heat energy. An essential environmental protection technique to increase energy efficiency is learning how to employ thermal energy storage (TES) technology to fully use intermittent and unstable heat, such as solar heat utilization and industrial waste heat. Sensible heat storage, latent heat storage, and thermochemical heat storage are all types of thermal energy storage. This work describes the creation of $ZrO_2/SiC-H_2O$ nanofluids and their characteristics for use in energy storage applications. Results reveal that increasing the concentration of ZrO_2/SiC NPs from 0.3 gm/L to 1.2 gm/L at photon wavelength (=380nm) increased absorbance by roughly 83.7% and reduced transmittance by 81.2%. Additionally, when ZrO_2/SiC NP concentrations rise, the absorbance rises as well, indicating improved nanofluid dispersion. Additionally, when the concentration of ZrO_2/SiC NPs reached 1.2gm/L, the electrical conductivity of ZrO_2/SiC- H_2O nanofluids improved by nearly 74%, and the melting time reduced with an increase in the concentration of ZrO_2/SiC nanoparticles.

Keywords: *Energy storage; nanofluids; transmittance; absorbance; melting*
PACS: 61.25.he, 61.46.-w, 44.35.-c, 47.57.Ng, 84.60.-h

1. Introduction

As heat transfer fluids, conventional fluids like water, motor oil, and ethylene glycol are often utilized. Other conventional fluids include methanol. The poor heat transfer performance of these typical fluids impedes both the performance increase and the compactness of heat exchangers, despite the fact that a variety of methods are used to improve heat transfer. Increasing the rate of heat transmission may be accomplished by the use of a method that involves the use of solid particles as an additive that is suspended within the base fluid. To enhance the heat transfer properties of traditional fluids, the most important concept is to increase the thermal conductivity of the fluid. It is anticipated that the thermal conductivity of a base fluid may be improved by suspending metallic solid tiny particles inside the base fluid. This is due to the fact that the thermal conductivity of a solid metal is higher than that of a base fluid. For a good number of years now [1-10], people have been aware of the fact that the suspension of solid particles, such as those measuring millimeters or micrometers in size, may increase the thermal conductivity of typical fluids. [Such particles] The thermophysical parameters of a nanofluid, including its density, viscosity, thermal conductivity, and specific heat capacity, have a significant impact on the flow and heat transfer performance of the nanofluid. Enhancing or degrading the thermophysical characteristics of a nanofluid is one method that is being used in a number of different activities with the goal of improving the performance of nanofluids. For example, it is generally known that the majority of metallic nanoparticles have a much better thermal conductivity compared to traditional heat transfer fluids (HTFs) such as water and ethylene glycol. This finding has been backed up by extensive research. Organic particles, such as those manufactured from rice husk or wood, on the other hand, have a lower density and a lower heat conductivity than traditional HTFs. Therefore, the concept of attempting to improve the thermal conductivity of nanofluids by adding metallic particles and reducing the viscosity of traditional HTFs by adding organic particles is an innovative one [11-16].

Rocha et al. [17] studied water-based nanofluids of Al_2O_3 and ZrO_2 with relation to their potentially useful uses in heat transfer. Dispersed solutions of mentioned nanofluids were created with three distinct concentrations (0.01% vol., 0.05% vol., and 0.1% vol.) using commercial nanofluids. These concentrations were 0.01% vol., 0.05% vol., and 0.1% vol. Experiments conducted by Shajahan et al. [18] evaluated the thermal hydraulic performance of ZrO_2, a water-based nanofluid with varying volume concentrations of 0.1%, 0.25%, and 0.5%, and staggered conical strip inserts with three different twist ratios of 2.5, 3.5, and 4.5 in forward and backward flow patterns under a fully developed laminar flow regime of 0–50 lph through a horizontal test pipe section with a Using a mechanical dispersion approach to construct a shape-stable composite phase change material for thermal energy storage, Song et al. [19] enhanced the specific heat capacity and thermal conductivity of molten salt. This allowed for the material to have a higher thermal capacity. Nitrate ($NaNO_3$), which has a greater phase change latent heat, was selected to be coupled with a variety of nanoparticles (SiO_2, SiO_2+TiO_2) in order to enhance its specific heat capacity. Expanded graphite (EG) was used as a carrier matrix in order to improve its thermal conductivity. In this research, we discuss the synthesis of $ZrO_2/SiC-H_2O$

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nanofluids as well as their characteristics for usage in applications involving energy storage. There are several studies on SiC doped different materials to employ in various biomedical, electronics and sensors applications[20-27].

2. MATERIALS AND METHODS

Zirconium oxide nanoparticles (also known as ZrO_2 NPs) and silicon carbide nanoparticles (also known as SiC NPs) were used in this study. Various concentrations of ZrO_2/SiC NPs were used during the synthesis of the ZrO_2/SiC-H_2O nanofluids. These concentrations include 0.3 gm/L, 0.6 gm/L, 0.9 gm/L, and 1.2 gm/L. The optical and electrical properties of ZrO_2/SiC-H_2O nanofluids were investigated in this research. Using a double beam spectrophotometer (Shimadzu, UV-18000A), the optical characteristics of ZrO_2/SiC-H_2O nanofluids were analyzed throughout a wavelength range of (200-1000) nm. In the process of storing thermal energy, it is necessary to do an analysis of the melting properties of ZrO_2/SiC-H_2O nanofluids while the system is being heated. The ZrO_2/SiC-H_2O nanofluids were utilized as the heat transfer fluid. The temperature of the heat transfer fluid may be changed from 40ºC to 100ºC using a stirrer, and a digital device was used to measure the temperature of the ZrO_2/SiC-H_2O nanofluids as they were being heated.

3. RESULTS AND DISCUSSION

Figures 1 and 2 show, at varying concentrations of ZrO_2/SiC NPs, the behavior of the absorbance and transmittance spectra of ZrO_2/SiC-H_2O nanofluids with photon wavelength. According to the figures, increasing the concentration of ZrO_2/SiC NPs from 0.3 gm/L to 1.2 gm/L at photon wavelengths (380nm) resulted in an increase in absorbance of about 83.7% and a decrease in transmittance of 81.2%. This behavior can be useful in solar collectors, heating systems, and cooling systems. The absorbance, which indicates greater nanofluid dispersion, will increase as ZrO_2/SiC NP concentrations rise [28].

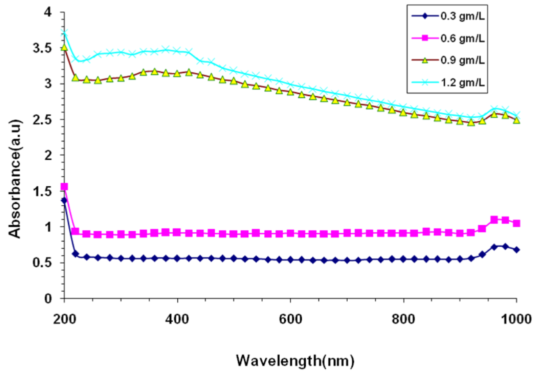

Figure 1. Behavior of absorbance of ZrO_2/SiC-H_2O nanofluids with photon wavelength for various concentrations of ZrO_2/SiC NPs

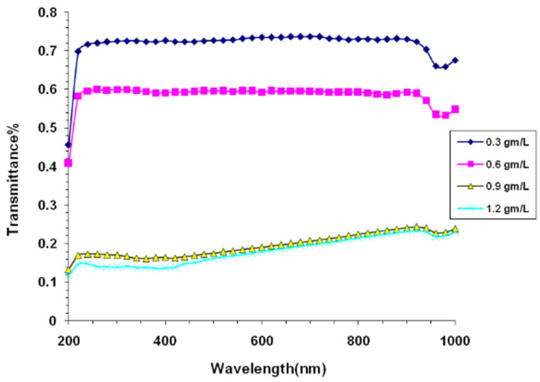

Figure 2. Behavior of transmittance of ZrO_2/SiC-H_2O nanofluids with photon wavelength for various concentrations of ZrO_2/SiC NPs

The relationship between the concentration of ZrO_2/SiC nanoparticles and the electrical conductivity (EC) of ZrO_2/SiC-H_2O nanofluids is shown in Figure 3. When the concentration of ZrO_2/SiC NPs reached 1.2 gm/L, an increase in electrical conductivity of ZrO_2/SiC-H_2O nanofluids occurred that was about 74% higher than before. The reason for this is because the increased electrical conductivity of nanofluids is due, in large part, to the surface charges of nanoparticles [29].

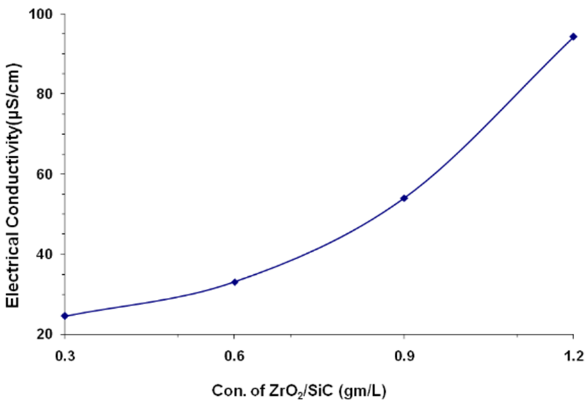

Figure 3. Variation of electrical conductivity (EC) of ZrO_2/SiC-H_2O nanofluids with concentrations of ZrO_2/SiC NPs

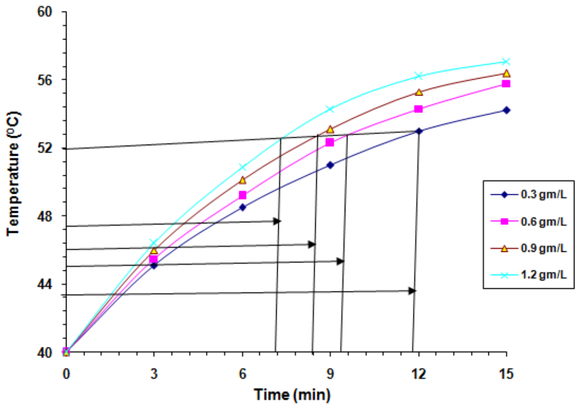

Figure 4. Melting curves of ZrO_2/SiC-H_2O nanofluids

The curves of melting for ZrO_2/SiC-H_2O nanofluids are shown in Figure 4. When there was a greater concentration of ZrO_2/SiC nanoparticles, the melting time was cut down significantly. Increases in thermal conductivity lead to increases in heat transmission, which in turn lead to reductions in melting times for ZrO_2/SiC-H_2O nanofluids that are used for energy storage [30-35]. The decrease in melting time reached 41.2% when the concentration of ZrO_2/SiC NPs rose from 0.3 gm/L to 1.2gm/L after 15 minutes. This is one of the reasons why ZrO_2/SiC-H_2O nanofluids may be beneficial in a variety of heating and cooling industries.

4. CONCLUSIONS

This study focuses on the creation and use of ZrO_2/SiC-H_2O nanofluids for energy storage. The conclusions that may be drawn from this are as follows:

1. With an increase in ZrO_2/SiC NP concentrations from 0.3 gm/L to 1.2 gm/L at photon wavelength (=380nm), the absorbance increased by about 83.7% and the transmittance decreased by 81.2%. 2. The increase in ZrO_2/SiC NP concentrations will increase the absorbance, which refers to the better nanofluid dispersion.

3. When the concentration of ZrO_2/SiC NPs reached 1.2 gm/L, the electrical conductivity of ZrO_2/SiC-H_2O nanofluids improved by nearly 74%.

4. As the concentration of ZrO_2/SiC nanoparticles increased, the melting time reduced.

5. When the concentration of ZrO_2/SiC NPs increases from 0.3 gm/L to 1.2 gm/L after 15 minutes, the decrease in melting time reaches 41.2%.

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ОТРИМАННЯ ТА ВЛАСТИВОСТІ НАНОРІДИН ZrO_2/SiC-H_2O ДЛЯ ВИКОРИСТАННЯ У НАКОПИЧУВАЧАХ ЕНЕРГІЇ

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Більше половини споживаної енергії в цілому надходить у формі теплової енергії. Важливою технікою захисту навколишнього середовища для підвищення енергоефективності є вивчення того, як використовувати технологію накопичення теплової енергії (TES) для повного використання переривчастого та нестабільного тепла, такого як утилізація сонячного тепла та тепла промислових відходів. Відчутне накопичення тепла, зберігання прихованого тепла та термохімічне накопичення тепла – це всі види накопичення теплової енергії. У цій роботі описується створення нанофлюїдів ZrO_2/SiC-H_2O та їхні характеристики для використання в програмах зберігання енергії. Результати показують, що збільшення концентрації наночастинок ZrO_2/SiC з 0,3 г/л до 1,2 г/л при довжині хвилі фотона (=380 нм) збільшило поглинання приблизно на 83,7% і зменшило пропускну здатність на 81,2%. Крім того, коли концентрація ZrO_2/SiC наночастинок зростає, поглинання також зростає, що вказує на покращену дисперсію нанофлюїдів. Крім того, коли концентрація наночастинок ZrO2/SiC досягла 1,2 г/л, електропровідність нанофлюїдів ZrO_2/SiC-H_2O покращилася майже на 74%, а час плавлення скоротився зі збільшенням концентрації наночастинок ZrO_2/SiC.

Ключові слова: *накопичувач енергії; нанофлюїди; пропускання; поглинання; плавлення*