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Structural and Optical Properties of PVP/PAA/MnO_2 Nanofluid for Solar Collectors' Systems

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In this paper, preparation of PVP/PAA/MnO_2 nanofluid and studying its structural and optical properties for solar collectors' systems are investigated. Optical characteristics of PVP/PAA/MnO_2 nanofluid are measured at wavelength of 220–820 nm. Results indicate that the absorption of H_2O/PVP/PAA fluid enhances, while the transmission reduces as the MnO_2 ratio increases. The optical microscope images show homogeneous distribution of MnO_2 nanoparticles in H_2O/PVP/PAA medium. The thermal-energy storage application of H_2O/PVP/PAA/MnO_2 nanofluid is tested. The results of application indicate that the time of heating decreases with the increase in MnO_2 nanoparticles' concentration.

У даній роботі досліджено підготовку нанофлюїду ПВП/ПАК/MnO_2 та вивчення його структурних і оптичних властивостей для систем сонячних колекторів. Оптичні характеристики нанофлюїду ПВП/ПАК/MnO_2 вимірюються на довжині хвилі 220–820 нм. Результати показують, що поглинання рідини H_2O/ПВП/ПАК підвищується, в той час як пропускання зменшується в міру збільшення співвідношення MnO_2. Зображення оптичного мікроскопа показують однорідний розподіл наночастинок MnO_2 в середовищі H_2O/ПВП/ПАК. Тестується застосування нанофлюїду ПВП/ПАК/MnO_2 щодо акумулювання теплової енергії. Результати застосування свідчать про те, що час нагрівання зменшується зі збільшенням концентрації наночастинок MnO_2.

Key words: nanofluid, PAA, PVP, nanoparticles, optical properties, solar energy, energy storage.

Ключові слова: нанофлюїд, поліакрилова кислота, полівінілпіролідон, наночастинки, оптичні властивості, сонячна енергія, акумулювання енергії.

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1. INTRODUCTION

Energy is a significant entity for the improvement of economics of any country. Today, solar energy systems function is a significant part in the energy creation from the renewable sources by means of converting the solar radiation into electricity or useful heat [1]. Solar energy is a better renewable source related to its natural distribution, availability and absence of requirement for transportation [2]. It has huge advantages more than other kinds of renewable energy. Solar energy may be divided to two main kinds: solar photovoltaic one, which is converted from the light of Sun to electricity directly, and solar thermal collectors, which concentrate the light of Sun to produce heat and, hence, use the heat to run the heat engines [3]. The storage of thermal energy may be given as the provisional storage of thermal energy at low or high temperatures. Storage of energy may decreases the rate or time mismatch between supply of energy and demand of energy, and it plays a significant function in conservation of energy [4]. Polymers are generally used relating to their cost, high manufacturability, lightweight and chemical resistance [5]. Polyacrylic acid (PAA) is a water-soluble thermoplastic polymer with high water sorption; it has carefully been used in the numerous clinical fields [6, 7]. The MnO_2 is a significant efficient metal oxide, which is scientifically attractive for fields in

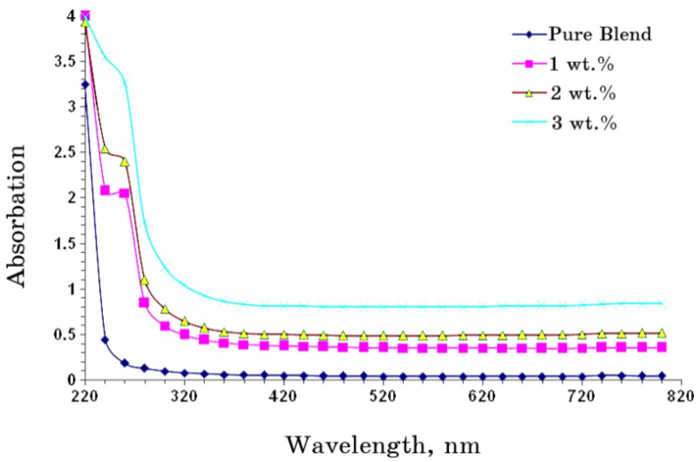

Fig. 1. Variation of absorbance of H_2O/PVP/PAA/MnO_2 nanofluid with photon wavelength.

various applications like catalysts, ion-sieves, artificial oxidase, molecular sieves, absorbent of toxic metals, component of the dry cell, electrochemical batteries' electrodes, inorganic pigment in ceramics, and supercapacitors' electrodes [8]. This paper deals with preparation and characterization of PVP/PAA/MnO_2 nanofluid for storage of thermal energy.

2. MATERIALS AND METHODS

The nanofluid of H_2O/PVP/PAA/MnO_2 by dissolving of PVP/PAA in H_2O with concentration of 40 g/L with weight percentage 67 wt.% PVP/33 wt.% PAA. The MnO_2 nanoparticles were added to the H_2O/PVP/PAA with concentrations of 1%, 2% and 3%. The optical properties of H_2O/PVP/PAA/MnO_2 nanofluid are measured using the spectrophotometer (UV/1800/Shimadzu) at wavelength of 220–820 nm. The microscope images of samples are obtained by optical microscope. The storage of thermal energy includes the melting characteristics of H_2O/PVP/PAA/MnO_2 nanofluid during heating processes. The H_2O/PVP/PAA/MnO_2 nanofluid is tested as the heat transfer, at which the temperature is varied (from 30°C to 90°C) with measuring the temperature by digital device of H_2O/PAA/MnO_2 nanofluid with stirrer.

3. RESULTS AND DISCUSSION

Figures 1 and 2 show the variation of absorbance and transmittance of H_2O/PVP/PAA/MnO_2 nanofluid with photon wavelength, respec-

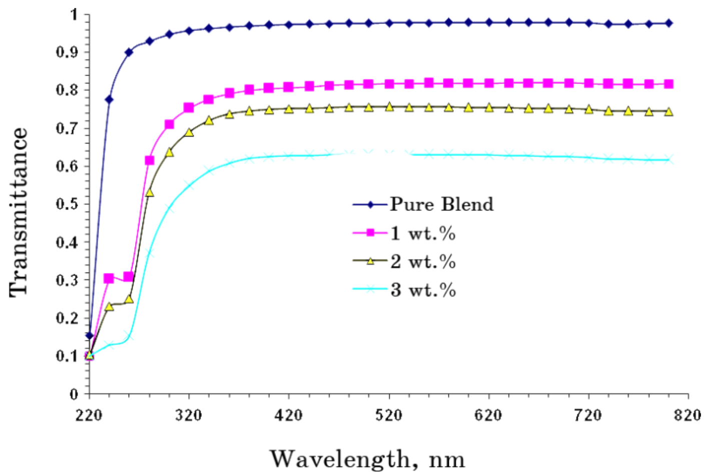

Fig. 2. Variation of transmittance of H_2O/PVP/PAA/MnO_2 nanofluid with photon wavelength.

tively. From these figures, the $H_2O/PVP/PAA/MnO_2$ nanofluid demonstrates high absorption in UV range.

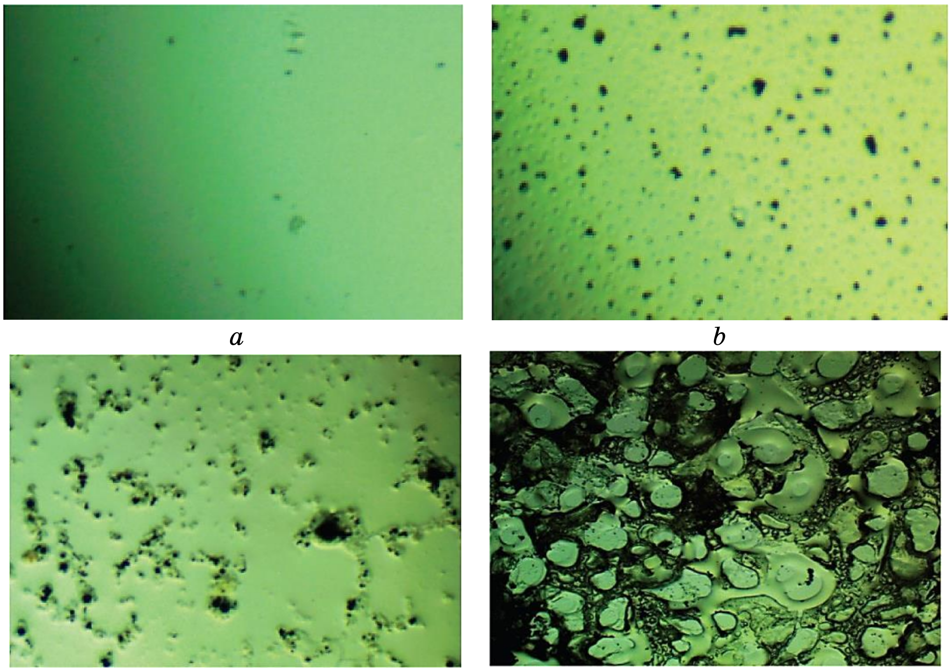

Fig. 3. Microscopy images of nanofluid: *a*—blend; *b*—1% MnO_2; *c*—2% MnO_2; *d*—3% MnO_2.

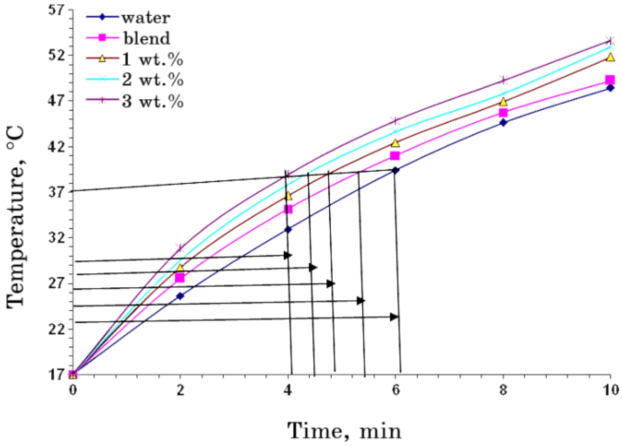

Fig. 4. Heating curve for $H_2O/PVP/PAA/MnO_2$ nanofluid.

The absorbance of H_2O/PVP/PAA fluid increases, while the transmittance decreases with the increase of the MnO_2 ratio that is related to the raise of the charge carriers' numbers [9–13]. As shown in Fig. 3, there is the distribution of MnO_2 nanoparticles, which absorb the photons of incident light.

Figure 4 represents the heating curve for H_2O/PVP/PAA/MnO_2 nanofluid. The time of heating reduces with the raise in MnO_2 nanoparticles' ratio that is related to high thermal conductivity of the MnO_2 nanoparticles in comparison with the thermal conductivity of H_2O/PVP/PAA fluid [14–24].

4. CONCLUSIONS

The absorbance of H_2O/PVP/PAA fluid rises, while the transmission reduces with the raise of the MnO_2 concentration.

The H_2O/PVP/PAA/MnO_2 nanofluid has high absorbance in the UV region that makes it possible be used for solar collectors.

The heating time decreases with the increase in MnO_2 nanoparticles' concentrations.

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