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Preparation and characterization of stearic acid/ olive pomace powder composite as form-stable phase change material

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ABSTRACT

This paper mainly includes the preparation, characterization and thermal properties of Stearic Acid/Olive Pomace Powder (SA/OPP) and Stearic Acid/Olive Pomace Powder/ Graphite (AS/OPP) as a new form-stable composite phase change material for thermal energy storage, which are prepared by impregnation method followed by uniaxial compression. The graphite is added to improve thermal conductivity of SA/OPP form-stable composite PCM. Environmental Scanning Electron Microscope (ESEM), Fourier Transform Infrared (FT-IR), Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis and Hot Disk Analyzer measurements are using to characterized morphology, chemical structure, thermal performances, thermal stability and thermal conductivity of form-stable composite PCMs, respectively. The DSC analysis reveals that the melting and freezing temperatures and the latent heats of the SA/OPP form-stable composite PCM are measured as 55 °C and 51 °C, 111 J/g and 109 J/g, respectively. In addition, thermal conductivity of the form-stable composite PCM is increased by adding 7 wt % of graphite.

Introduction

Thermal energy storage becomes one of the most important applications for the researchers during these last years. The thermal energy can be stored as latent heat, sensible heat and thermochemical heat. Among the thermal energy storage methods accumulation by latent heat using a phase change material (PCM) is the most useful method for the storage of thermal energy because of its high density storage and its small change in storage temperature. PCM have the ability to change state with a certain temperature range and allows to store and release large amounts of energy during the phase change process. Therefore, they were potentially used for storage of thermal energy in many applications such as the storage of solar energy, the recovery of waste heat, the building heating or cooling the inner temperature control and insulating clothing [1–3].

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A wide range of PCMs candidates, such as inorganic or organic substances, salt hydrates, paraffin waxes and organic non -paraffinic compounds, esters of fatty acids and their binary and ternary mixtures have been studied as PCMs for Latent Heat Thermal Energy Storage (LHTES) applications because of their different phase change intervals [4].

Compared with the inorganic PCMs, organic PCMs have properties of low prices, no phase segregation, no phenomenon of undercooling and no corrosion [5].

Among the MCPs studied, the fatty acids are considered as potential candidates for the storage of thermal energy at low temperature due to their interesting thermal properties and of their chemical stability [4–6]. As a fatty acid, stearic acid is an important MCP is widely preferred because of its high volumetric storage density, excellent thermal properties (a high latent heat of fusion, a chemical stability, non-toxicity and a low sub cooling …).

However, two of its properties limit its use in thermal energy storage. One is its low thermal conductivity, which can be improved by the addition of small amounts of material with high thermal conductivity materials such as expanded graphite (GE). The other is the leakage of liquid during the phase change process, which can be improved by impregnation porous materials with PCM. This method of impregnation is simple, low cost and provided stability of the PCM.

Many form stabilized composites made of phase change material and porous materials have been prepared and characterized in terms of potential thermal energy storage [5–8] in various applications such as the storage of solar energy, the recovery of waste heat, the building heating or cooling the inner temperature control and insulating clothing [9].

No information has been found in the literature on the use of Olive Pomace Powder for form-stable composite PCMs, which is the main motivation of this work. This work is focused on the preparation, characterization and determination of thermal properties of SA/OPP and AS/OPP/Gr composite PCMs as a new form-stabile phase change materials for low temperatures thermal energy storage applications. The choice of olive pomace as a carrier enters into the valorization of organic trash which exists in nature abundance.

Experimental

Materials

Stearic acid (90% pure) with melting temperature of 59 °C and latent heat of 190 J/g is used as thermal energy storage material. It is purchased from Prochima Sigma (Tlemcen, Algeria). Physical properties of SA are listed in Table 1. The Fig. 1 represents the Cp curve of SA.

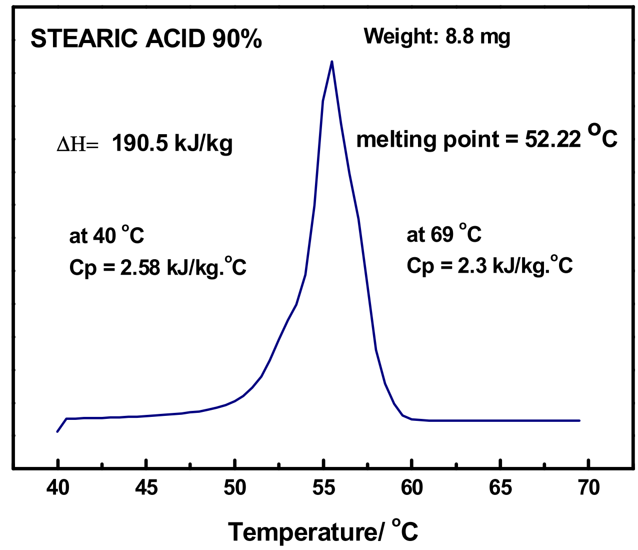

Fig. 1 – Cp curve of SA.

The Olive Pomace Powder obtained after grinding and milling of olive cake extracts cores, is used as support material for the PCM.

The OPP used in this study is recovered from a modern oil mill operating with a two-phase system, located in a region olive growing (Tizi-Ouzou, Algeria North).

Cores fragments are separated from the pulp by screening. These fragments are then washed with water to eliminate any dust or other water-soluble impurities. The cores are degreased by solvent (75% acetone and 25% hexane) to remove the remaining oil, and then they are washed with distilled water and finally the solid is dried at 105 °C. The solid washed and dried undergoes grinding with a grain mill electrum then sieved. The Olive Pomace Powder size distribution curve is shown in Fig. 2 and its size distribution parameters are listed in Table 2.

Preparation of SA/OPP and SA/OPP/Gr form-stable composite PCMs

The SA/OPP and SA/OPP/Gr form-stable composite PCMs are prepared by impregnation method followed by uniaxial cold compression. The samples SA and OPP are mixed and put in the water bath, when the temperature is adjusted to 70 °C above the melting temperature of SA. In order to determine the highest fraction without leakage, the composite PCMs are prepared at different mass fraction of SA (the fraction of 50% is retuned). In order to improve thermal conductivity of SA and SA/OPP form-stable composite PCM, mass fraction of Gr is selected as 7%. The Fig. 3 shows the nature of OPP, graphite powder and SA/OPP (designed with Sampl1) and SA/OPP/Gr (designed with Sampl2) form-stable composite PCMs.

Table 1 – Physical properties of SA.

Samples	Alternative name	Molecular formula	Melting point (°C)	Latent heat of fusion (J/g)	Heat specific C_p (kJ/kg °C)	
					Solid	Liquid
Octadecanoic acid	Stearic acid	$CH_3(CH_2)_{16}COOH$	52.20	190	2.58	2.3