International Journal of Mechanical Engineering and Robotics Research

ISSN 2278 – 0149 www.ijmerr.com
Vol. 4, No. 1, January 2015

Research Paper

PREPARATION AND CHARACTERIZATION OF PARAFFIN/PALMITIC ACID EUTECTIC MIXTURE IN THERMAL ENERGY STORAGE APPLICATIONS

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Thermal Energy Storage using phase change materials has become an interesting area of energy research because of its high energy storage density, isothermal nature of storage process and small volume changes. There are wide ranges of phase change materials available commercially. This work deals with paraffin and Palmitic acid eutectic mixture in three different proportions as phase change materials and made an attempt to improve the properties.

Keywords: Thermal energy storage system, Phase change material, Differential scanning calorimeter, SEM

INTRODUCTION

Over the last three decades the world is concentrating more in storing of the available thermal energies because of the depletion of fossil fuels and the intermittent nature of Solar radiations. One of the methods is Latent heat storage of thermal energy using Phase change materials. Although there are number of Organic, Inorganic and Eutectic PCMs are available commercially, organic PCMs have been chosen in the current research due to abundant and thermal stability. But the problem with organic PCMs is low thermal conductivity (Atul Sharma *et al.*, 2009).

Many researchers have worked with paraffin wax and palmitic acid PCMs separately with different composites to improve its properties. Keeping Chen *et al.* (2014) in their work they have prepared a series of paraffin/polyurethane composites (n-octadecane, n-ecicosane and paraffin wax) by bulk polymerization with different mass fraction of n-octadecane. The results from DSC analysis indicated that the enthalpy of 25%w/w n-eicosane was as high as 141.2j/g. which is suitable for solar energy storage and building applications.

Hadi Fauzi *et al.* (2013) have blended myristic acid and Palmitic acid at various compositions by jacketed flask reactor at 80 °C to form a homogeneous eutectic mixture. DSC test results shown that the lowest melting

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temperature occurs at the composition ratio of 70/30 wt% (myristic/Palmitic acids). Surfactants such as sodium myristate, sodium palmitate and sodium stearate were added to this mixture as controlling agents to improve thermal properties and to minimize the undercooling problems. The results shown that the addition of 5% sodium stearate has the highest latent heat of fusion of 191.85J/g and the addition of 5% sodium myristate reduces the undercooling to 0.34 °C and the highest thermal conductivity of 0.242 W/m K.

Mohammad Mehrali *et al.* (2013) have concentrated on the shape stability and thermal conductivity of palmitic acid and graphene nanoplatelets (GNPs) composite phase change materials. They prepared shape stabilized composite phase change material by impregnation method for three different surface areas. SEM, TEM, XRD and FTIR were applied to determine the microstructure and chemical structure of the composite PCM respectively and concluded that the chemical structure was not affected by GNPs after 2500 cycles also. The TGA results shown that the thermal stability of Palmitic acid was increased. DSC test results shown that the thermal conductivity was increased by 10 times that of the Palmitic acid.

MATERIALS

The material used are paraffin wax and palmitic acid were chosen as reference PCM's. DSC test was conducted for the base materials, where paraffin wax has a melting point 58.8 °C-67.2 °C is of a commercial grade of Fischer Scientific product, has a latent heat of thermal energy storage about 138 J/g (Figure 1). The palmitic acid (98% purity) has a melting point of about 62.2 °C-67.9 °C is for synthesis of Lobal product, has a latent heat of thermal energy about 193.7 J/g (Figure 2).

Figure 1: Pure Paraffin Wax

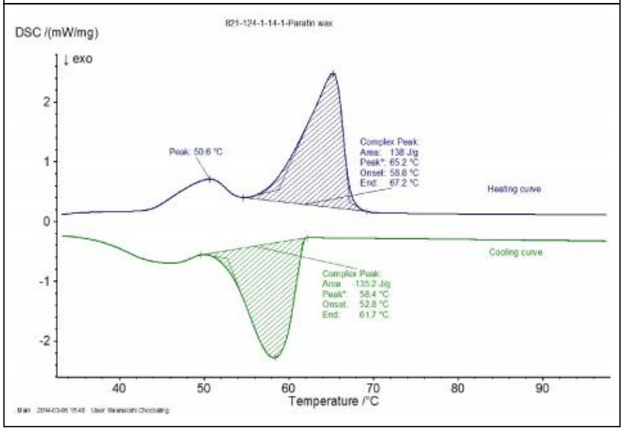
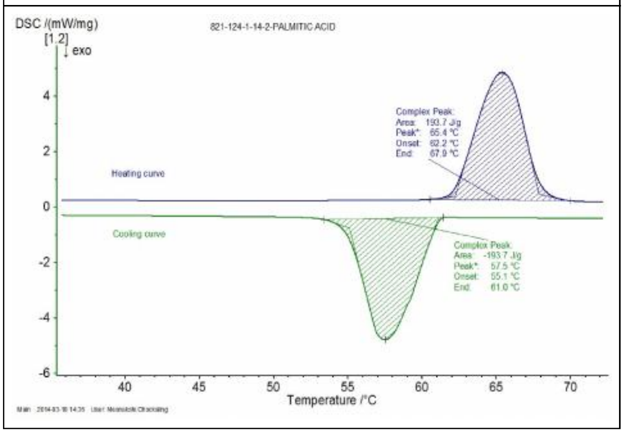


Figure 2: Pure Palmitic Acid



PREPERATION OF THE EUTECTIC PCM'S

The Paraffin wax and Palmitic acids are phase change materials are chosen of 40-60%, 50-50% and 60-40% respectively as EUTECTIC mixtures. These proportions are mixed in a sonication or ultra-sonication method at a temperature of about 70 °C for a time period of 30 mins. These mixtures where it undergoes ultrasonic waves produce by sonication, which further breaks the bonding of the molecules to form both eutectic mixtures in a unique bonding.

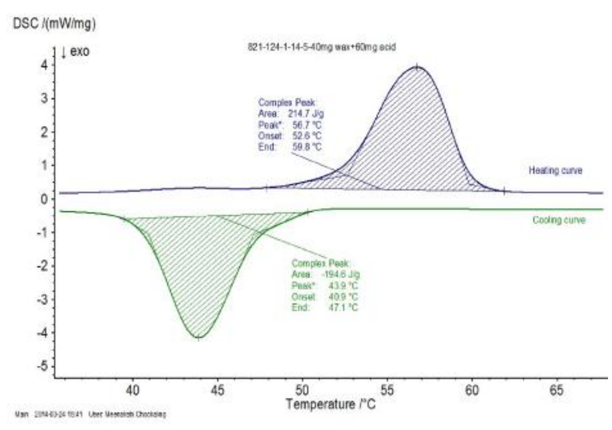
RESULTS

DSC Analysis

Paraffin (40%) and Palmitic Acid (60%)

The result from the graph shows the DSC analysis of paraffin wax and palmitic acid of 40-60% eutectic mixture respectively, from the heating curve obtaining a melting point range of 52.6 °C-59.8 °C and latent heat of thermal energy storage is about 214.7 J/g. From the cooling curve obtaining solidification starts at 47.1 °C-40.9 °C, maximum solidification is obtained at 43.9 °C with a latent heat capacity of 194.6 J/g.

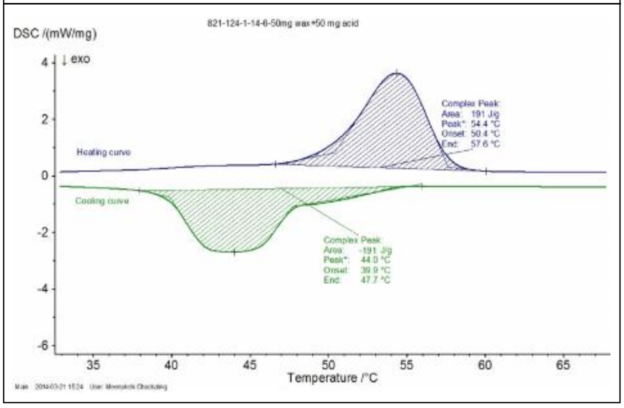
Figure 3: 2:3 Ratio of Praraffin and Palmitic Acid



Paraffin (50%) and Palmitic Acid (50%)

The result from the graph shows the DSC analysis of paraffin wax and palmitic acid of 50-50% eutectic mixture respectively, from the heating curve obtaining a melting point range of 50.4 °C-57.6 °C and latent heat of thermal energy storage is about 191 J/g. From the cooling curve obtaining solidification starts at 47.7 °C-39.9 °C, maximum solidification is obtained at 44 °C with a latent heat capacity of 191 J/g.

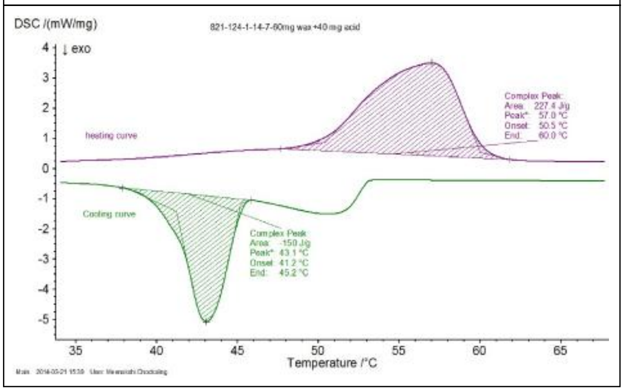
Figure 4: 1:1 Ratio of Paraffin and Palmitic Acid



Paraffin (60%) and Palmitic Acid (40%)

The result from the graph shows the DSC analysis of paraffin wax and palmitic acid of 60-40% eutectic mixture respectively, from the heating curve obtaining a melting point range of 50.5 °C-60 °C and latent heat of thermal energy storage is about 227.4 J/g. From the cooling curve obtaining solidification starts at 45.2 °C-41.2 °C, maximum solidification is obtained at 44 °C with a latent heat capacity of 150 J/g.

Figure 5: 3:2 Ratio of Paraffin and Palmitic Acid



Sem Analysis for Paraffin Wax and Palmitic Acid (50-50%)

The SEM images of the paraffin wax and palmitic acid at a ratio 50-50% shows the topography of the eutectic mixture. This shows the eutectic mixture has been combined in a deserving of esteem.

Figure 6: Microstructure Obtained at 500X

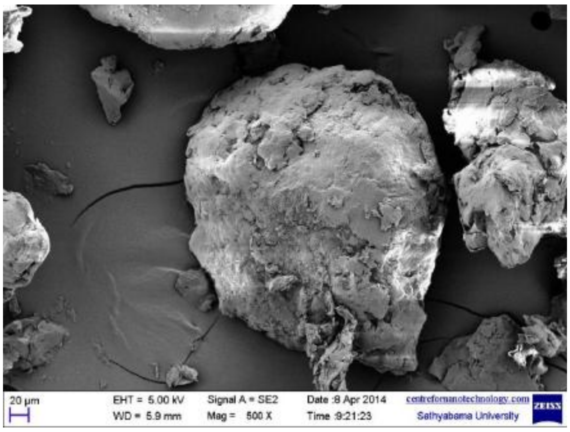


Figure 7: Microstructure Obtained at 1.00 KX

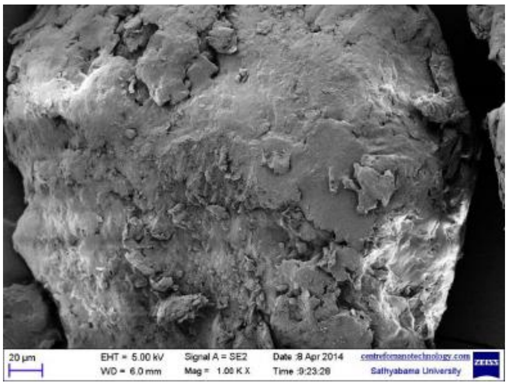


Figure 8: Microstructure Obtained at 5.00 KX

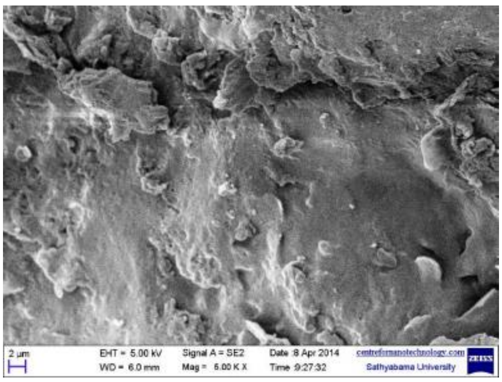
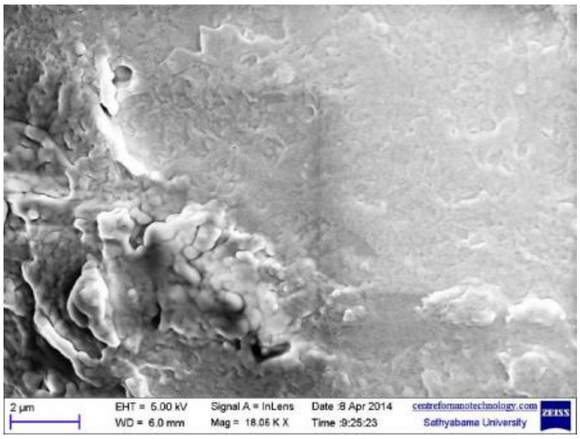


Figure 9: Micro Structure Obtained at 18.06 KX



CONCLUSION

The heating and cooling curves of the DSC analysis show the amount of energy can be stored in the PCM and the amount of energy can be retrieved from the PCM respectively. Results show that the optimum value is in 50-50% ratio of paraffin and palmitic acid, since the exothermic and endothermic is perfect when compared to the rest of other two ratio of proportion. The phase change temperatures of the eutectic mixtures are slightly low when compared with the pure materials. Based on the results, the eutectic mixture 50-50% of paraffin-palmitic acids are suitable for low temperature to medium temperature range thermal storage applications. Further analysis to determine the effective time of storage is in progress.

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