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Article: *Study of Thermal Energy Storage using Oleic Acid*
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Study of Thermal Energy Storage using Oleic Acid

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Abstract: Currently, implementation of storage energy technologies is much growing. Various types of fatty acids have been used as energy storage materials. However, the use of oleic acid is required advance study. Identification of Oleic acid is conducted using FTIR test standard of ASTM E 1252-07 and the chemical composition materials are determined by GC-MS. The analysis of melting temperature and crystallize temperature are done using DSC test standard of ASTM D 3419-08. From FTIR test, it is obtained that the spectra results show the identification of oleic acid ($C_{18}H_{34}O_2$) and the GC-MS test shows that the material composition has a purity concentration of 87.317%. Meanwhile, DSC test show that oleic acid could store heat energy at 6.58^{o}C and crystallization is performed at -4.33^{o}C.

Introduction

The increase of energy consumption has given impacts on environment, in other hand, the deposit of world energy is decreased from time to time. To overcome the problem, it is necessary to employ such technologies that are efficient and friendly to the environment. One of these is technology of heat waste utilization. There are two advantages of heat waste utilization; free extracted energy and decrease the negative impacts on the environment [1].

To utilize the heat waste, thermal energy storage is required. There are two well known thermal energy storages; sensible and latent heat storage. However, latent heat storage is used wider than the sensible one. Latent heat storage is one of the most efficient ways to store the thermal energy [2]. The storing process is occurred during phase change where the thermal is stored mostly in converting it from solid to liquid form. The reason is because converting it from solid to liquid form requires relatively low volume change but with high latent heat transformation. Material used as a media for storing latent heat is called phase change material (PCM).

PCM system is very effective way to store thermal energy. The advantage of using this technique is that the energy can be stored with high density and stored isothermally [3]. PCM has been applied in many industries and commercial or non commercial buildings as a latent heat store. Currently, the development of PCM technology is very fast and already available commercially from organic and non-organic materials [4]. The availability of these various PCM, could meet the needs of both industries and buildings. The application of thermal energy storage in building using PCM could increase the thermal comfort and in the same time could save energy [5]. PCM also applicable to use as latent thermal energy storage for heating water in building [6]. Besides, PCM also applicable for air conditioning in building [7]. Using PCM in building's wall could save electrical power for room conditioning by about 11% [8]. Moreover, integrating PCM with brick wall could reduce absorbed heat flux by about 32.8% [9].

Based on its construction, PCM is suitable for any types of heat exchanger [10]. Therefore, various designs can be applied for heat storage by using PCM, for example: for room heating and cooling, water heater with solar energy and heat waste recovery.

PCM application in industries is very wide, therefore, it requires various materials. Because every single PCM type has different thermo physical properties, the application area of PCM is also

different. As mentioned above, PCM can be classified into two; made from organic and non-organic materials [11]. Organic materials consist of paraffin and fatty acid, whilst non-organics materials consist of Hydrate-Salt. Mixing PCM with 50% Butyl Stearic and 48% Butyl Palmitic as utility PCM gypsum board could reduce room temperature about 2°C [12]. Mixed solid polyethylene/paraffin with low density, also good to store heat [13]. Building's wall that is made from board and PCM for internal partition, could reduce energy consumption of that building [14]. In [15], PCM that is made from organic material has several advantages including small frozen or without supercooling, stable chemical properties and free-toxic. Oleic Acid has properties that meet the above requirements, however, research for thermal energy storage using oleic acid is still very less. The purpose of this research is to study and investigate the characteristic of thermal energy storage using Oleic Acid.

Material and Method

Oleic acid is identified using Fourier Transform Infrared Spectrophotometer (FTIR) with standard test of ASTM E 1252-07. Chemical composition of oleic acid is determined by Gas Chromatography-Mass Spectrometry (GC-MS) Agilent Type 7890 A. Characteristic analysis of transition and melting temperature is conducted by Differential Scanning Calorimetry (DSC) with standard test of ASTM D 3419-08. Experiment is done with 15-20 mg oleic acid in heating and cooling treatment at -30°C – 80°C. The heating and cooling rate used in this experiment is 5°C/min.

Results and Discussion

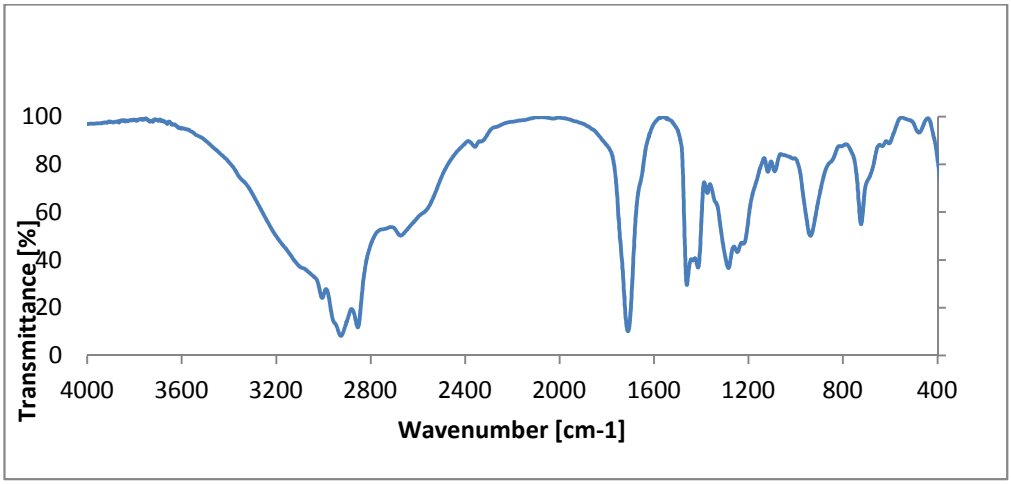

Figure 1. Experiment result of Oleic Acid using FTIR

From FTIR test as shown in Fig. 1, it is obtained that oleic acid spectra of 3006 cm^{-1}, 2926 cm^{-1}, and 2855 cm^{-1} indicates C-H bond, spectra of 2674 cm^{-1} indicates O-H bond, spectra of 1712 cm^{-1} indicates C=O bond. Spectra of 1464 cm^{-1} and 1436 cm^{-1} CH_2 and CH_3 bond respectively. Spectra of 1413 cm^{-1} and 1378 cm^{-1} indicates C-H bond, spectra of 1285 cm^{-1} to 1091 cm^{-1} indicates C-O bond, spectra 937 cm^{-1} indicates functional group of NO and spectra of 723 cm^{-1} to 480 cm^{-1} are suspected as impurities substances.

From figure 2, the material composition can be explained as follows: retention time 21.315 min indicates lauric acid 0.074%; retention time 25.704 min to 27.023 min indicates hexadecanoic acid 2.86%; retention time 27.608 min indicates Oleic acid 87.317%; retention time 28,197 min indicates heptadecene-8-carbonic acid-1 5.209%; retention time 28.448 min indicates E-2-octadecen-1-01 (2.814%); retention time 28.766 min indicates 9-octadecenoic acid (Z) 1.862%; retention time 29.351 min indicates pyrimidine-3-carboxamide peak 0.191%; retention time 29.424 min indicates pyrimidine-3-carboxamide 0.100%; retention time 29.460 min indicates pyrimidine-3-carboxamide 0.103%; retention time 31.175 min indicates 11-hexacosyne 0.228%; and retention time 31.227 min indicates 1.13-tetradecadiene 0.233%. Retention time of 29.351 min to 31.227 min

is suspected as impurities substances. From the indications, it can be explained that retention time from 21.315 min to 28.766 min indicates the existence of several types of fatty acid. However, oleic acid ($C_{18}H_{34}O_2$) dominates the number by about 87.317%.

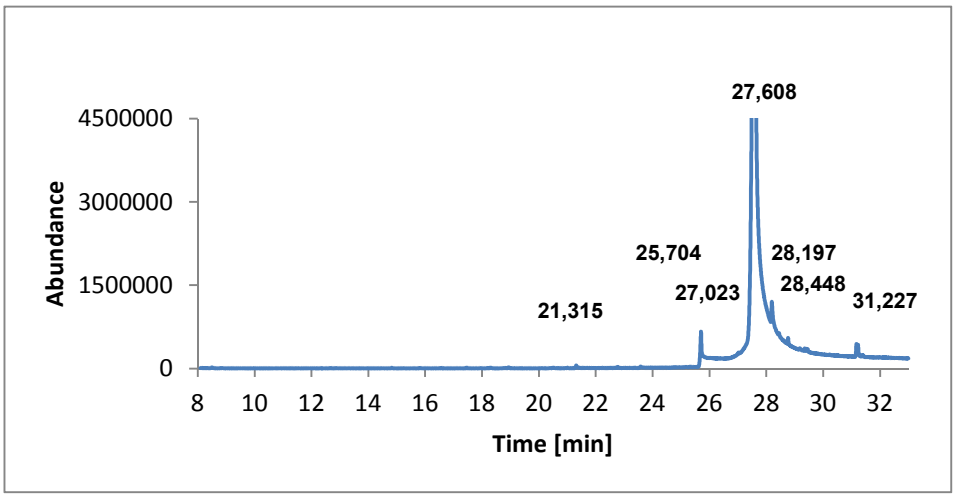

Figure 2. Experiment result of Oleic Acid using GC-MS

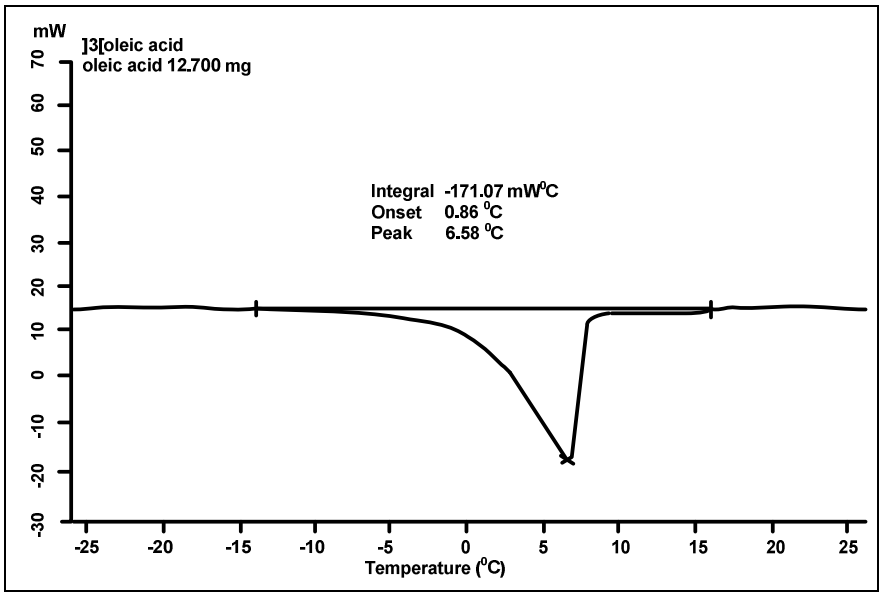

Figure 3. Experiment result of Oleic Acid using DSC

From DSC test of oleic acid as shown in Fig. 3, it is observed that heat absorption characteristic occurs at melting temperature of 6.58°C and crystallization temperature of -4.33°C. The occurrence of crystallization under melting temperature shows that on the frozen process of oleic acid, there is a supercooling event even though in very small level.

Conclusion

From FTIR test, it is obtained spectra that indicating the tested materials are oleic acids (C18H34O2). From GC-MS test, it is obtained material composition of oleic acid with the degree of purity of 87.317%. DSC test shows that oleic acid could store energy isothermally at 6.58°C and the crystallization is occurred at -4.33°C.

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References

[1] Mahon, H.P., M.G., Kiss, H.J. Leimer. Efficient Energy Management: Methods for Improved Commercial and Industrial Productifity. Prentice-Hall, Inc. Englewood Cliffs, New Jersey 07632, 1983.

[2] Farid, M.M., A.M. Khudhair, S. A. K. Razack, S. Al-Hallaj. A review on phase change energy storage: materials and applications, Energy Conversion and management 45 (2004) 1597-1615.

[3] Sharma, A., V.V. Tyagi, C.R. Chen, D. Buddhi. Review on Thermal Energy Storage With Phase Change Materials and Applications, Renewable and Sustainable Energy Review 13 (2009) 318-345.

[4] Zalba, B., J.M. Marin, L.F. Cabeza, H. Mehling. Review on thermal energy storage with phase change: heat transfer analysis and applications, Applied Thermal Engneering, 23 (2003) 251-283.

[5] Pasupatty, A., R. Velraj, R.V. Seeneraj. Phase Change Material-Based Building Architecture for Thermal Management in Residential and Commercial Establishments, Renewable and Sustainable Energy Reviews. 12 (2008) 39-64.

[6] Agyenim, F., N. Hewitt, P. Eames, M. Smyth.. A review of materials, heat transfer and phase change problem formulation for latent heat thermal energy storage systems (LHTESS), Renewable and Sustainable Energy Reviews 14 (2010): 615-628.

[7] Diaconu, B.M, S. Varga, A.C. Oliveira.. Experimental assessment of heat storage properties and heat transfer characteristics of a phase change material slurry for air conditioning, Applied Energy 87 (2010) 620-628.

[8] Zhu, N., S. Wang, Z. Ma, Y. Sun. Energy Performance and optimal control of Air-conditionined buildings with envelopes enhanced by phase change materials, Energy Concersion and Management 52 (2011) 3197-3205.

[9] Haghshenaskashani, S., H. Pasdaarshahri. Simulation of Thermal Storage Phase-Change Material in Buildings, Word Academy of Science Engineering and Technology, 58-2009.

[10] Medved, D., M. Kvakovsky, V. Sklenarova. Latent Heat Storage Systems. Intensive Programme “Renewable Energy Source”, May 2010. Zelezna Ruda-Spicak, University of west Bohemia, Czech Republic.

[11] Ravikumar, M. & PSS. Srinivasan. Phase Change Material As A Thermal Energy Storage Material For Cooling of Building, Journal of Theoretical and Applied Information Techmology pp. 503-511. 2005-2008. JATIT.

[12] Scalat, S.G. Full Scale Thermal Performance of Latent Heat Storage In PCM Wallboard, Thesis for the Degree of the Master of Applied Science Concordia University, Montreal, Quebec, Canada, 1996.

[13] Krupa, I., G. Mikova, A.S. Luyt.. Phase Change Materials Based on Low-density Polyethylene/Paraffin Wax Belnds, European Polymer Journal 43(2007) 4695-4705.

[14] Kuznik, E., J. Virgone, J. Noel.. Optimization of A phase Change Material Wallboard for Building Use, Applied thermal Engineering (2007), doi, 10. 1016/J-applthermaleng. 2007.10.012.

[15] Mehling, H., l. F. Cabeza. Heat and cold storage with PCM: An up to date Introduction into basics and applications, Springer-Verlag Berlin Heidelberg, 2008.