A Review on Pure Fatty Acid Based Phase Change Materials for Energy Storage Applications

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Abstract

Latent heat storage emerged as effective way to store thermal energy. Phase change materials (PCMs) are commonly used in latent heat storage. Among many PCMs available today as storage material, fatty acid can meet continuous supply of materials as they are derived from vegetable and animal oil. This paper summarizes potential pure fatty acid based PCMs. Emphasis is given to provide ready reference for selection of PCM based on melting temperature range and available heat capacity.

Introduction

The high energy storage density of phase change materials makes them potential candidate while designing thermal energy storage systems. An isothermal operation of storage process controls the heat absorption and rejection. PCM enabled energy storage system can store and release large amount of energy due to melting and solidification of materials. Figure 1 illustrates thermal energy majorly grouped into thermal and thermochemical options. The thermal storage can further designed to utilize sensible or latent heat phase. The main difference between the storage of sensible and latent heat is that there is no temperature change in the latent heat storage. In phase change, a huge amount of energy can be stored or released at a constant temperature.

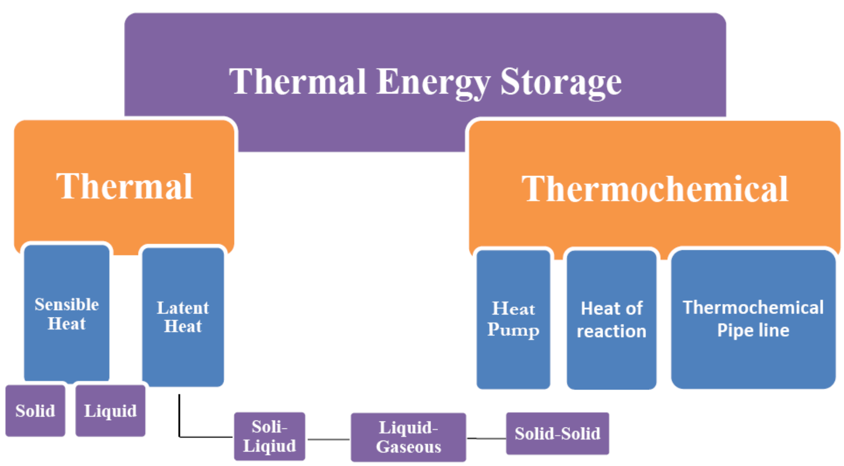

Figure 1 Thermal energy storage types [1]

Phase Change Material (PCM)

Utilizing of PCMs is an effective means of thermal energy storage application. Commonly, PCM is named any substance that has ability to reverse solid-liquid transformation and store/release a tremendous amount of energy at a constant temperature or in slight temperature range during the transformation process. In fact, PCM is a material with a capability of storing and releasing a huge amount of energy and high heat of fusion that can be melted and solidified at a particular temperature. The phase of materials change from solid to liquid or vice versa due to chemical bonds breaks in molecular structure.

PCMs classification

Generally, PCMs have classified into three major groups such as organic materials, inorganic materials, and eutectics. It is interesting to note that most materials do not respect all the properties that mentioned before. It has to be compensated with the system design and variety enhancement methods like utilizing the fins or heat pipe or composite materials in the form of matrixes.

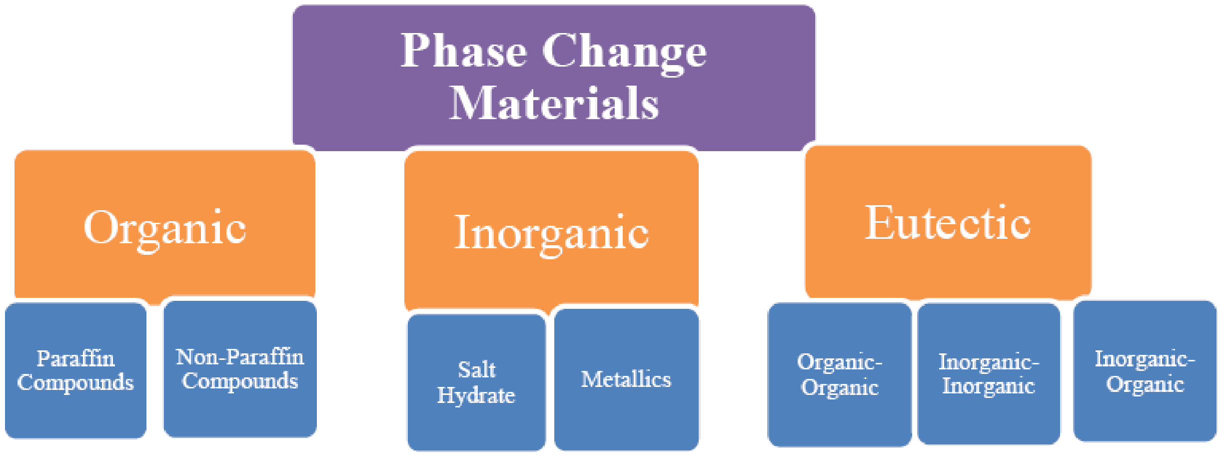

Figure 2 PCMs classification [2]

The organic materials are divided into two main groups such as paraffin compounds and non-paraffin compounds. The paraffin consisted of saturated hydrocarbons with the general formula of CnH2n+2. The most familiar PCM material that utilized in this group is Paraffin wax that is a combination of different hydrocarbons. Esters, fatty acids, and glycols are different elements of the non-paraffin group. According to the variety of properties, each of materials, can be used in different applications. The organic materials also are divided into two main groups such as salt hydrate and metallic. One of inorganic alloys salts and water is salt hydrate that has a general formula of AB·nH2O. Melting metals and metal eutectics are significant items of the metallic group. It is interesting to note that because of their high weight they are not considered as PCM. Regardless of this, they have a number of useful features such as high thermal conductivity and heat of fusion and low vapor pressure. The third group is eutectics group that related to a mixture of materials (in fixed proportions) that melts and solidifies at a specific temperature. The eutectic group classified into three different groups such as organic-organic, inorganic-inorganic and inorganic-organic that is related to the nature of the components in a composition.

Fatty acid PCMs

PCM with melting temperature range from 30°C to 70°C are useful for building and solar thermal storage systems [2]-[6]. These range of temperature can also well suited for cooling of electronic systems [7][8]. Fatty acid is a organic PCM and possesss high range of heat capacity, thermal stability, non-corrosiveness. Therefore fatty acid have been extensively used in many applications like solar energy thermal storage, buildings, textile and air-conditioning systems . For example fatty acids their mixtures shown advantages over paraffin PCMs for solar storage system [9]-[11].

Capric acid ($CH_3(CH_2)_6COOH$)

Capric acid is suitable for applications where heat absorption and release largely within range of 29.6°C to 32.14°C. The melting temperature range and heat capacity are plotted in figure 3.

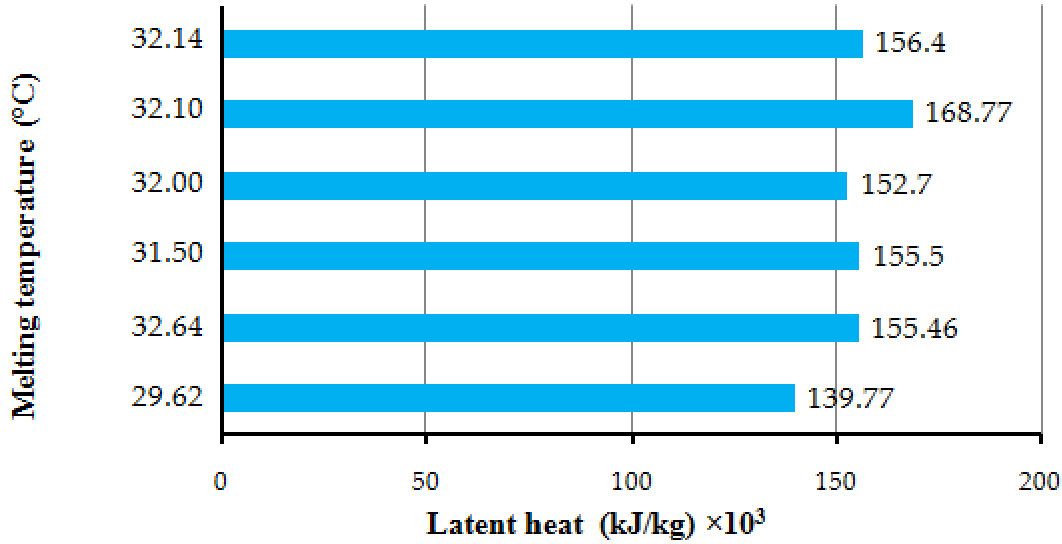

Figure 3 Melting temperature range with heat capacity for Capric acid [12][13][14][15][16][17]

Lauric acid ($CH_3(CH_2)_{10}COOH$

Lauric acid is suitable for applications where heat absorption and release largely within range of 42.40°C to 44.33°C. The melting temperature range and heat capacity are plotted in figure 4.

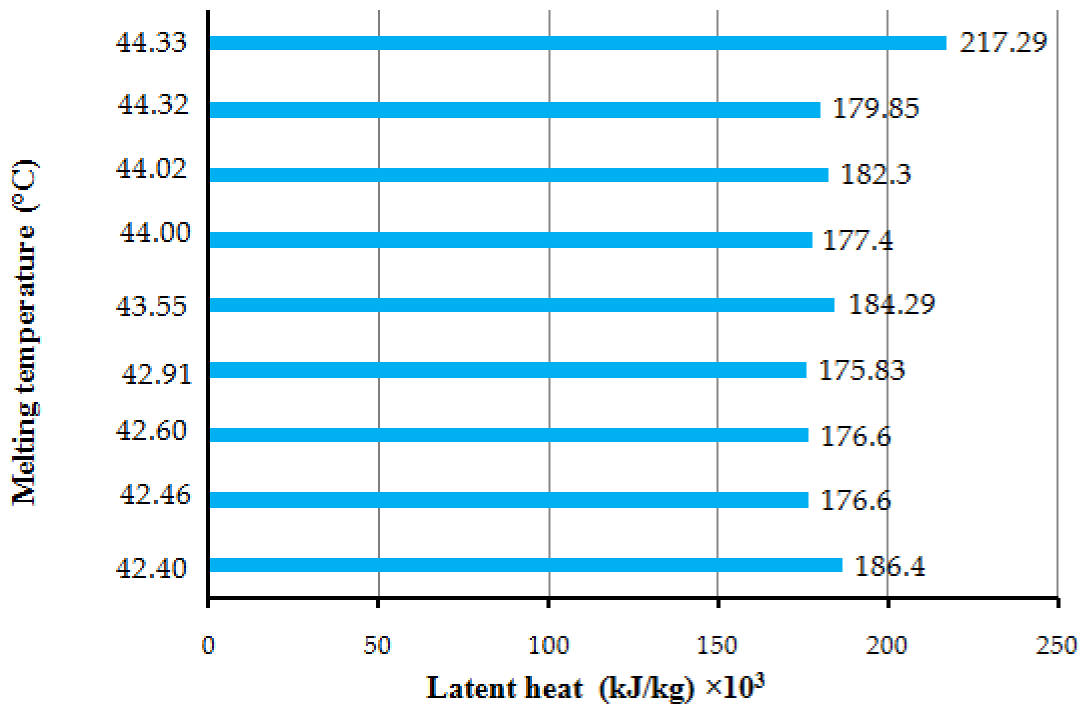

Figure 4 Melting temperature range with heat capacity for Lauric acid [13][14][15][16][18][19][20][21][22][23][24]

Myristic acid ($CH_3(CH_2)_{12}COOH$

Myristic acid is suitable for applications where heat absorption and release largely within range of 51.5°C to 58°C. The melting temperature range and heat capacity are plotted in figure 5.

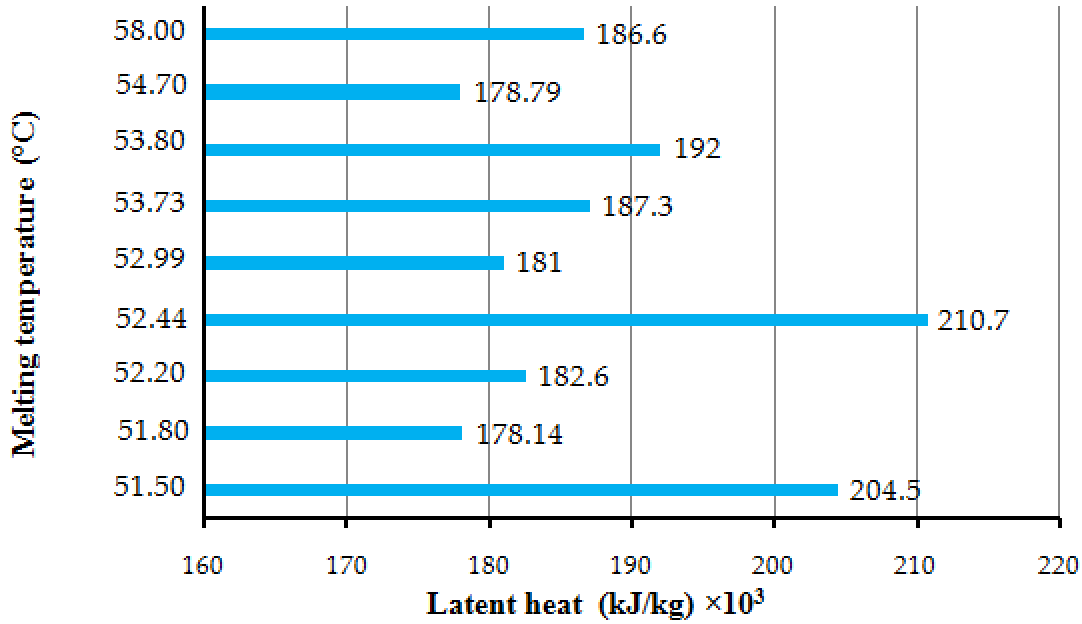

Figure 5 Melting temperature range with heat capacity for Myristic acid [15][16][18][19][20][21][23][25][26][27]

Palmitic acid ($CH_3(CH_2)_{14}COOH$

Palmitic acid is suitable for applications where heat absorption and release largely within range of 58.9°C to 65.5 °C. The melting temperature range and heat capacity are plotted in figure 6.

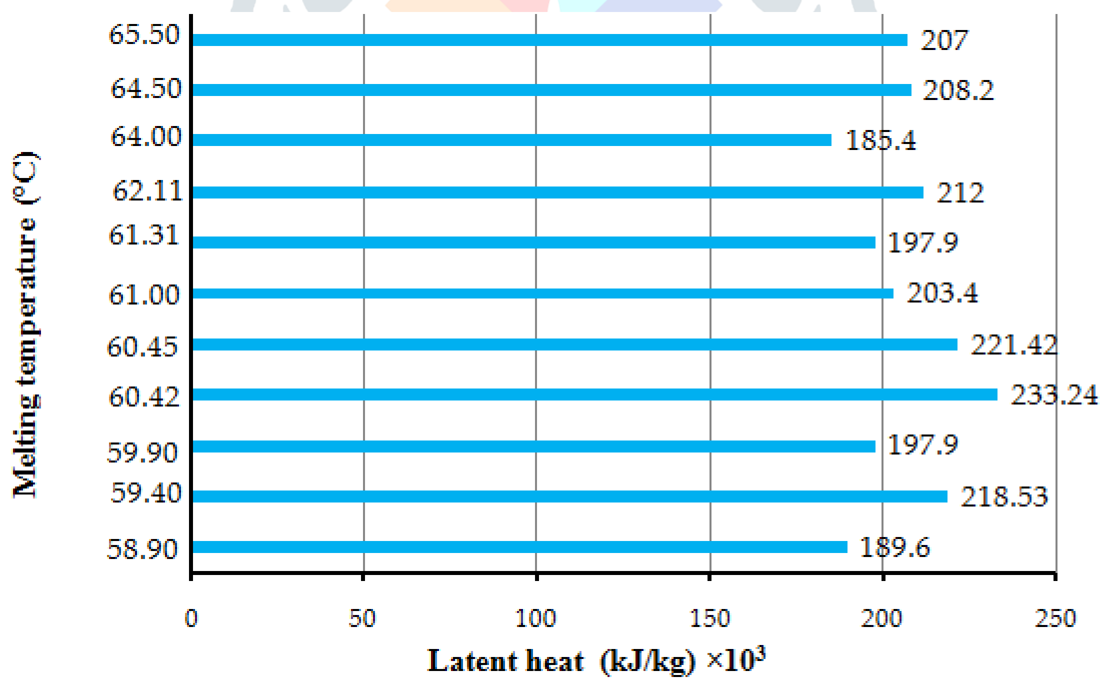

Figure 6 Melting temperature range with heat capacity for Palmitic acid [14][15][17][18][19][20][21][23][26][28][29][30]

Stearic acid($CH_3(CH_2)_{16}COOH$

Stearic acid is suitable for applications where heat absorption and release largely within range of 53.8°C to 70.9 °C. The melting temperature range and heat capacity are plotted in figure 7.

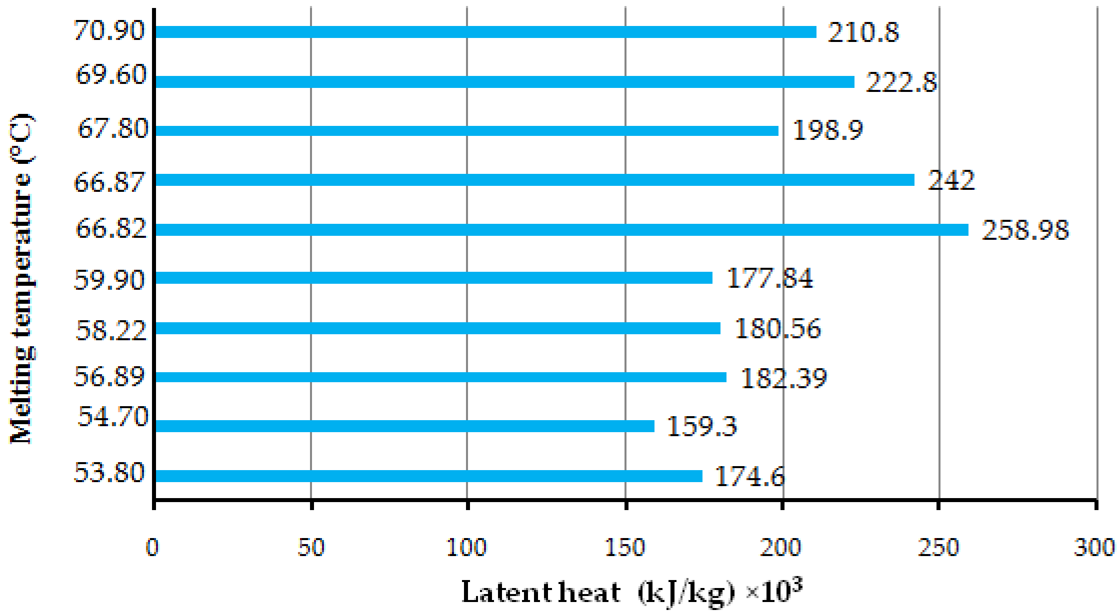

Figure 6 Melting temperature range with heat capacity for Stearic acid [14][15][16][18][19][20][21][23][26][31][32][33]

Conclusion

This article presented a review of pure fatty acid based phase change materials. The temperature range and heat capacity values shown fatty acids based PCMs are suitable in solar thermal storage, building applications etc. The continuous availability of fatty acid PCMs ensured as they are derived from vegetable and animal oils.

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