Properties of capric acid - myristic acid as the core material of microcapsule phase change materials

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Abstract

The eutectic composition of fatty acid binary mixtures $C_{10:0}$-$C_{14:0}$, the thermal properties (e.g., melting and crystallizing points and phase change enthalpy), and the capacity of heat storage and heat release are observed by binary phase diagram, DSC, and heat storage and temperature regulating performance test. The study shows that the eutectic composition of $C_{10:0}$-$C_{14:0}$ is $C_{10:0}$74.73$C_{14:0}$25.27. The melting points and phase-change enthalpy, the crystallizing points and phase-change enthalpy are 21.80°C and 177.1J/g, 18.24°C and 172.6J/g, respectively. $C_{10:0}$-$C_{14:0}$ has suitable phase change temperature and higher phase-change enthalpy. So, $C_{10:0}$-$C_{14:0}$ can be used as the core material of microcapsule phase change energy storage material for building.

Keywords

Phase change material, Microcapsule, Capric acid, Myristic acid.

1. Introduction

The ideal phase change energy storage material for building must have the following features: appropriate phase change temperature, high latent heat, low cost, non-toxicity, non-flammability, uniform phase change characteristics, such as no undercooling or phase separation [1]. Fatty acids are widely used organic phase change material (PCM) in thermal energy storage systems because they are superior in renewable, suitable phase change temperature, high latent heat, inconspicuous volume change, no phase segregation, little supercooling degree, nontoxicity and good thermal reliability. [2-4]. However some drawbacks limit the application of the fatty acids to a large extent, such as the leakage of melted fatty acids and the fixed phase change temperatures.[3,5] The use of phase change microcapsules and eutectic mixture can help to solve the problems. In this paper, PCM is developed based on fatty acid eutectics by microencapsulation, and be aiming to solve the suitable phase change temperature of fatty acid and prevent the leakage of fatty acid eutectics, make it suitable to be incorporated in building materials. The fatty acid eutectics are prepared from Capric acid ($C_{10:0}$) and myristic acid ($C_{14:0}$). Various mass ratios are investigated to achieve the suitable phase change temperature. The thermal properties (e.g., melting and crystallizing points and phase change enthalpy), heat storage and temperature regulating performance of $C_{10:0}$-$C_{14:0}$ are also measured.

2. Experimental

2.1 Materials

Capric acid (C10:0) and myristic acid (C14:0) are purchased from Sinopharm Chemical Reagent Co., Ltd.

2.2 Thermal properties

The thermal properties of $C_{10:0}$-$C_{14:0}$ (e.g., melting and crystallizing points and phase change enthalpy) are measured through the DSC technique using a DSC Q2000 (TA Instruments, USA). 5–15mg of samples is added to aluminum sample pans under N_2 flow of 80ml/min. Temperature program is started at -20 °C, staying at this temperature for 3 min, heated to 80 °C at 5 °C /min, staying at this temperature for 3 min, then cooled to -20°C at 5 °C /min.

2.3 Heat storage and temperature regulating performance

The self-designed indoor heat storage and temperature regulating performance test setup consisted of components, Fig. 1.

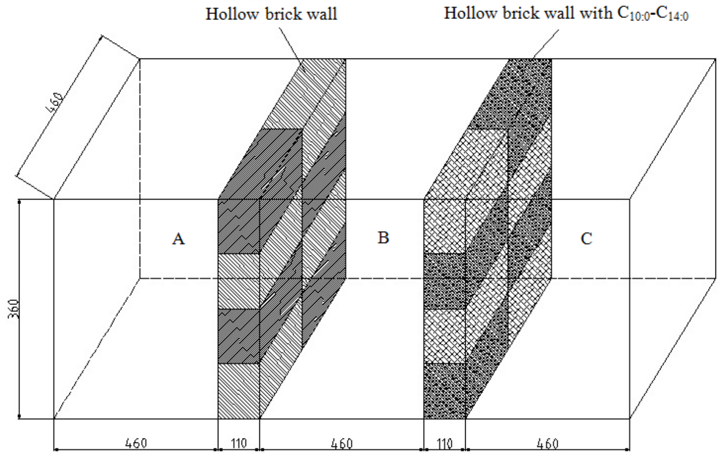


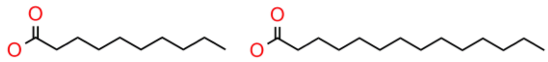
Fig. 1 Schematic of a small test room model

For this test, the region A and C is heated from 0 – 5 °C for 9 h at region B being maintained at 70 – 80 °C, and the region A and C is cooled from 70 – 80 °C for 7 h at region B being maintained at 0 – 5 °C.

3. Results and discussion

3.1 Molecular structure

The molecular structure of $C_{10:0}$ and $C_{14:0}$ are shown in Fig. 2. They are aliphatic, Zigzag structure of straight chain, monocarboxylic acids.



(a) $C_{10:0}$ (b) $C_{14:0}$

Fig. 2 The molecular structure

3.2 Thermal properties

Binary phase diagram of $C_{10:0}$ and $C_{14:0}$ is illustrated in Fig. 3. The eutectic composition of $C_{10:0}$-$C_{14:0}$ is 74.73w% ($C_{10:0}$). The eutectic temperature T_{eu} of $C_{10:0}$-$C_{14:0}$ is 23.61°C. The phase transition enthalpy is 154.06 J/g.

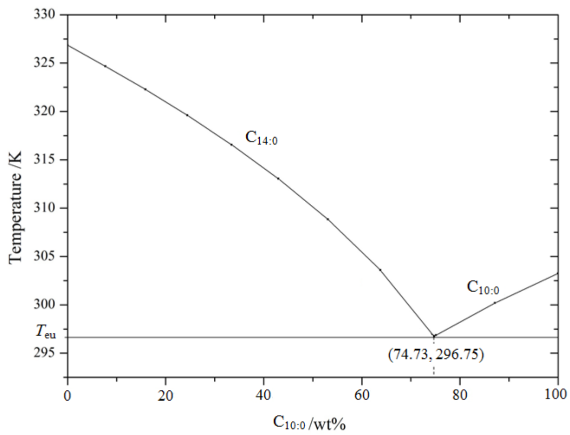


Fig.3 Binary phase diagram of $C_{10:0}$-$C_{14:0}$

The DSC of $C_{10:0}$-$C_{14:0}$ is shown in Fig.4. From Fig. 4, the melting and crystallizing points are 21.80 and 18.24°C respectively, and phase-change enthalpy is 177.1 and 172.6J/g. So $C_{10:0}$-$C_{14:0}$ can be used as a phase change energy storage material for building.

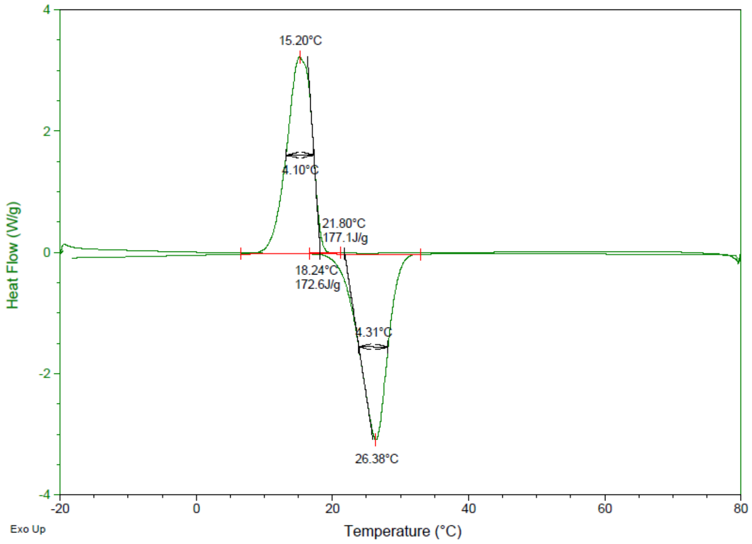


Fig.4 The DSC curves of $C_{10:0}$-$C_{14:0}$

3.3 Heat storage and temperature regulating performance

The heating and cool processes are shown in Fig.5 and Fig.6.

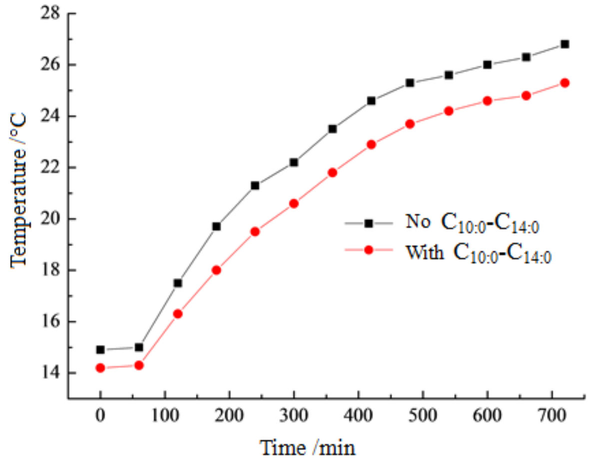


Fig.5 The heating process

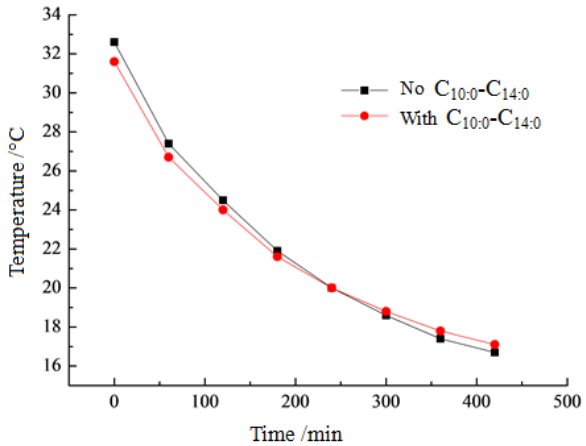


Fig. 6 The cooling process

As shown in Fig.5 and Fig.6, the temperature rise of region C (with $C_{10:0}$-$C_{14:0}$) is lower than that of region A (no $C_{10:0}$-$C_{14:0}$), and the temperature drop of region C (with $C_{10:0}$-$C_{14:0}$) is also lower than that of region A (no $C_{10:0}$-$C_{14:0}$). So it can be noted that binary mixtures fatty acid $C_{10:0}$-$C_{14:0}$ has a certain capacity of heat storage and heat release. It is in reliable level to apply as the core material of microcapsule PCMs for building.

4. Conclusion

Based on the results of this study, we conclude that:

Novel phase-change composite $C_{10:0}$-$C_{14:0}$ as the core material of microcapsule PCMs for building is designed. The melting points and phase-change enthalpy, the crystallizing points and phase-change enthalpy are determined by DSC analysis to be 21.80°C and 177.1J/g，18.24°C and 172.6J/g, respectively.

From heat storage and temperature regulating performance test on thermal energy storage $C_{10:0}$-$C_{14:0}$, it is found that $C_{10:0}$-$C_{14:0}$ has a certain capacity of heat storage and heat release. The performance of $C_{10:0}$-$C_{14:0}$ in adjusting the room temperature is optimized. Therefore, $C_{10:0}$-$C_{14:0}$ microcapsule PCMs can improve the thermal performance of building.

Acknowledgements

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