Study on Thermal Storage Performance of Industrial Paraffin and Fatty Acid Binary Mixture

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Abstract. Taking the industrial paraffin and fatty acid binary mixture as the research object, the phase change temperature, latent heat of phase change and supercooling degree were studied by differential scanning calorimeter, aiming at reducing the application cost of simple fatty acid as phase change material, broadening the range of phase transition and increasing the amount of latent heat value of phase change. The results show that the paraffin-tannic acid and paraffin-lauric acid binary mixture reduces the phase transition temperature and increases the latent heat of phase change compared with the single fatty acid, which is suitable for the energy storage of the envelope structure. The phase transition temperature of paraffin-myristic acid, paraffin-stearic acid, paraffin-palmitic acid mixture is lower than 40 °C. Although it is lower than the phase transition temperature of single fatty acid under certain mixing ratio conditions, which is not suitable for application. In the energy storage of the structure, it can be used in other energy-saving systems such as phase change heat exchangers for waste heat recovery. Paraffin-tannic acid and paraffin-lauric acid binary mixtures are less subcooled and are ideal for energy storage in envelope structures.

1. Introduction

The unique superiority of phase change material energy storage technology in the field of energy storage has made phase change materials more and more attention as a new energy storage material. The phase change material energy storage technology absorbs/releases a large amount of heat through an approximately isothermal phase change process to achieve thermal energy conversion while ensuring thermal comfort.

The application of phase change material energy storage technology in the field of energy conservation has been relatively mature, and experts and scholars at home and abroad have conducted in-depth research on this. Sharma[1] tested the phase transition parameters and thermal storage properties of paraffin, stearic acid and acetamide. Keles[2] prepared a composite phase change material using lauric acid-myristic acid as a phase change material, and applied it to the thermal storage system of a vertical coaxial casing, and studied its heat storage performance and application feasibility. Sari[3] mixed lauric acid, stearic acid, myristic acid and palmitic acid to test the phase transition temperature and latent heat of phase change of the binary complex fatty acid. Hou Jingpeng et al[4] tested the temperature control effect of paraffin phase change temperature control concrete and the thermal conductivity of paraffin phase change temperature control mortar. The research results show that the temperature control effect of paraffin phase change temperature control concrete is obvious, and the paraffin phase change temperature control The thermal conductivity of the mortar is significantly improved. Wu Qisheng et al[5] prepared a binary organic eutectic (C citric acid CA and cetyl alcohol H) / expanded graphite
composite phase change energy storage material, and studied its structure and thermal properties, found that expanded graphite to CA-H. The physical adsorption effect reaches 80%, and the composite phase change energy storage material has better thermal stability. Yan Quanying et al[6] studied the phase transition temperature and phase change latent heat of two binary mixtures consisting of 48# paraffin and liquid paraffin, tannic acid and stearic acid, respectively, using a differential scanning calorimeter. The thermal stability of the mixture is good, and the thermal stability of the fatty acid mixture is superior to the paraffin mixture. Li Lisha[7] studied the stability of paraffin-like and fatty acid phase change materials, and found that fatty acids have better heat storage properties and thermal stability than paraffin, and are more suitable for building energy conservation. Zhang Lin[8] formulated a variety of fatty acid phase change materials and selected fatty acid composite phase change materials suitable for wall applications. After repeated cycles experiments, the fatty acid phase change materials prepared have good stability. Zhang Yi[9] formulated a dibasic fatty acid composite phase change material of tannic acid-lauric acid, and tested its thermal properties by differential scanning calorimetry (DSC), using porous diatomaceous earth to adsorb fatty acid phase change materials, and The heat storage performance and thermal conductivity of the diatomaceous earth/fatty acid composite phase change material were tested. Huang Xue[10] selected 10 kinds of ternary eutectic fatty acid composite phase change materials with five kinds of single fatty acids, such as tannic acid, lauric acid, myristic acid, stearic acid and palmatic acid, and studied their thermal properties by DSC. A fatty acid composite phase change material with excellent performance. In this study, binary mixtures of low-cost industrial paraffin and high-priced fatty acids were used to study the range and regularity of the phase transition temperature and latent heat of phase change. Paraffin and fatty acid are used as low-temperature energy storage phase change materials. According to the phase change temperature that can be achieved by the formulated mixture, it can be applied to building envelopes such as walls and floors, and can also be used for phase change energy storage heat transfer of waste heat recovery heating systems.

2. Material and Methods

2.1. Materials and instruments
Industrial paraffin, citric acid, lauric acid, palmitic acid, stearic acid, nutmeg. Sinopharm Chemical Reagent Co., Ltd. The heat storage performance data of the experimental paraffin and fatty acid phase change materials are shown in Table 1. Differential Scanning Calorimeter (DSC, Model 200 PC) is made by Germany’s NETZSCH; Electronic Balance (AR1530/C) is made by House International Trading Co., Ltd.

Table 1. Thermal storage performance data of experimental paraffin and fatty acid phase change materials

| Phase change material | Phase transition temperature/°C | Phase change latent heat/(J·g⁻¹) |
|-----------------------|---------------------------------|---------------------------------|
| Industrial paraffin (P) | 66.0                            | 180.2                           |
| Tannic acid (CA)      | 30.5                            | 151.1                           |
| Lauric acid (LA)      | 42.8                            | 222.3                           |
| Palmitic acid (PA)    | 61.0                            | 241.0                           |
| Stearic acid (SA)     | 67.4                            | 239.9                           |
| Myristic acid (MA)    | 52.7                            | 217.6                           |

2.2. Preparation of samples
The industrial paraffin and five kinds of fatty acids were weighed according to the preset mass ratio, and the electronic balance (AR1530/C type, House International Trading Co., Ltd.) was weighed and placed in a beaker, and the beaker was placed on an alcohol lamp to heat it. The mixture of paraffin and fatty acid is completely melted, stirred with a glass rod until the material is evenly mixed, and naturally cooled.
and solidified in the air. This process was repeated 3 times, and finally 46 kinds of paraffin and fatty acid binary mixture samples were separately prepared.

2.3. Test of samples
Forty-six samples were tested by differential scanning calorimeter (DSC, Model 200PC, Nexus, Germany) and their test results were analyzed.

3. Results
Organize and summarize the measured data and draw the following graphics. Among them, the paraffin-tannic acid mixture phase transition temperature and phase change latent heat curve are shown in Figure 1. The phase transition temperature and phase transition latent heat curve of the paraffin-palmitic acid mixture are shown in Figure 2.

![Figure 1. Phase transition temperature and phase change latent heat curve of paraffin-decanoic acid mixture.](image1)

![Figure 2. Phase transition temperature and phase change latent heat curve of paraffin-palmitic acid mixture.](image2)

![Figure 3. Phase transition temperature and phase change latent heat curve of paraffin-stearic acid mixture.](image3)

![Figure 4. Phase transition temperature and phase change latent heat curve of paraffin-myristic acid mixture.](image4)

The phase transition temperature and phase transition latent heat curve of the paraffin-stearic acid mixture are shown in Figure 3. The phase transition temperature and phase change latent heat curve of the paraffin-myristic acid mixture are shown in Figure 4. The phase transition temperature and phase
transition latent heat curve of the paraffin-lauric acid mixture are shown in Figure 5. The subcooling curve of paraffin and 5 fatty acids under different mixing ratios is shown in Figure 6.

4. Discussion

4.1. Analysis of phase transition temperature and latent heat of phase change of paraffin-citric acid mixture

It can be seen from Figure 1 that the phase transition temperature of the binary mixture of industrial paraffin and tannic acid fluctuates between 27.3 and 60.0 °C. As the amount of paraffin increases, the phase of the binary mixture of paraffin and tannic acid The temperature is lowered first, then the situation is raised. Under the condition of 40% paraffin (wt, mass fraction, the same below), the mixture reaches a low in-melt state, the phase transition temperature reaches a minimum value; the paraffin amount is <40%. Under the condition that the phase transition temperature of the mixture fluctuates between 27.3 and 29.7 °C, it is suitable for the energy storage of passive phase change wall; the phase transition temperature of the mixture is between 50% and 60% of paraffin. Between 30 and 40 °C, it is suitable for use in active phase change wall and phase change floor. Under the condition of paraffin dosage >60%, the phase transition temperature of the mixture increases rapidly and is higher than 40 °C, which is not suitable for the envelope structure. The low-temperature energy storage application can be used as the energy storage material for the phase change heat recovery of waste heat recovery; in addition, the latent heat of phase change of paraffin-citric acid mixture increases with the increase of paraffin consumption . Latent heat between 168.6 ~ 209.2 J / g change, capric acid itself is large relative to the latent heat. As the amount of paraffin increases, the latent heat value is greater than the phase change latent heat of the two single components.

4.2. Analysis of phase transition temperature and latent heat of phase change of paraffin-palmitic acid mixture

It can be seen from Figure 2 that the phase transition temperature of the paraffin-palmitic acid binary mixture decreases rapidly with the increase of the amount of paraffin, and then rapidly increases the situation. The mass ratio of paraffin to palmitic acid is 5:5. The phase transition temperature and the latent heat of phase change are the minimum values, the phase transition temperature is 46.7 °C, the latent heat of phase change is 201.9 J / g, which is lower than the melting point of palmitic acid and
paraffin, and has high latent heat. The paraffin-palmitic acid phase transition temperature is high and is suitable for use in waste heat recovery phase heat exchangers.

4.3. Phase transition temperature and latent heat of phase change of paraffin-stearic acid mixture

It can be seen from Figure 3 that as the amount of paraffin increases, the phase transition temperature of paraffin-stearic acid is always reduced, and the minimum is 45.3 °C, which is lower than the melting point of paraffin and stearic acid single substance; The latent heat of phase change of stearic acid mixture increases slowly and then decreases rapidly with the increase of paraffin dosage. The minimum value of latent heat value is 174.8 J/g, which is lower than that of paraffin and stearic acid. Change the latent heat.

4.4. Phase transition temperature and latent heat of phase change of paraffin-myristic acid mixture

It can be seen from Figure 4 that the phase transition temperature of paraffin-myristic acid increases slowly with the increase of paraffin dosage. Under the condition of 40% paraffin, the phase transition temperature of paraffin-myristic acid is 57.38°C, the latent heat of phase change is 213.97 J/g. Under the condition of paraffin dosage >40%, the phase transition temperature decreases rapidly. Under the condition of paraffin dosage of 60%-90%, the phase transition temperature is lower than paraffin and myristic acid. The melting point of any single substance can achieve the purpose of lowering the phase transition temperature by mixing; however, the latent heat of phase change has no obvious change law, and the whole fluctuates between the latent heat values of the two substances. By mixing, the latent heat of phase change of paraffin-myristic acid was not significantly improved.

4.5. Phase change temperature and latent heat of phase change of paraffin-lauric acid mixture

It can be seen from Figure 5 that as the amount of paraffin increases, the phase transition temperature of the paraffin-lauric acid mixture decreases first and then increases. The latent heat of phase change increases first and then decreases, and the amount of paraffin is 20%-50. Under the condition of %, the phase transition temperature varies between 30 and 40 °C. Under the condition of 50% paraffin, the phase transition temperature of the paraffin-lauric acid mixture reaches the minimum value of 37.1 °C, and the latent heat of phase change is 207.1 J/g, very close to the maximum. This combination ratio is suitable for use in the field of energy storage for active enclosures.

4.6. Undercooling analysis

In the process of phase transition from liquid to solid, the temperature at which the phase transition actually occurs is lower than the theoretical transition temperature. This temperature difference is called subcooling. A large number of studies have shown that organic phase change materials have the advantage of less subcooling than inorganic phase change materials, but the specific values of subcooling of different kinds of organic phase change materials are large and small, the phase transition temperature is suitable, and the latent heat is better. Large and subcooled phase change materials are more suitable for phase change energy storage applications. The subcooling curve of paraffin and 5 fatty acids under different mixing ratios is shown in Figure 6. It can be seen from the figure that the binary mixture of paraffin-myristic acid and paraffin-stearic acid has a higher degree of subcooling, and the subcooling ratio of the paraffin-nonanoic acid binary mixture and the paraffin-lauric acid binary mixture is higher. The subcooling degree of small, paraffin-myristic acid gradually decreased with the increase of paraffin dosage. The subcooling degree of the mixture under different mixing ratios varied greatly from 13.1 °C to 5.6 °C; - The degree of subcooling of stearic acid mixture decreases first and then increases with the increase of paraffin amount, and the degree of supercooling fluctuates between 6 and 9 °C; paraffin-antimonic acid binary mixture, paraffin-lauric acid binary The supercooling degree of the mixture and the paraffin-palmitic acid binary mixture increased slowly with the increase of the amount of paraffin in the mixture; the subcooling degree of the paraffin-antimonic acid binary mixture and the paraffin-lauric acid binary mixture were all compared. Small, between 1 and 3.5 °C, the degree of
subcooling varies little with the mixing ratio, and the smaller degree of subcooling provides a broader space for the application of the binary mixture.

5. Conclusions
(1) The phase transition temperature of the paraffin-niobate binary mixture decreases slowly and then increases rapidly with the increase of paraffin dosage. Under the condition of paraffin dosage less than 60%, the phase transition temperature of the mixture is 20.0. Between 40.0 °C fluctuation, the latent heat of phase change is greater than the latent heat of phase change of single component, broadening the range of phase transition temperature, and increasing the latent heat of phase change. It can be used for active or passive enclosure under different mix ratio conditions. Structure energy storage field.

(2) The phase transition temperature of paraffin-lauric acid binary mixture decreases first and then increases with the increase of paraffin dosage. The latent heat of phase change increases first and then decreases, and the mass ratio of paraffin to lauric acid increases. Under the condition of 5:5, the phase transition temperature is the lowest, 37.1 °C, and the latent heat of phase change is 207.2 J / g, which is close to the maximum value, which is suitable for energy storage in the active wall or floor area.

(3) The phase transition temperature of the paraffin-myristate binary mixture, the paraffin-stearic acid binary mixture, the paraffin-palmitic acid binary mixture, although in some mixing ratios, is higher due to the higher phase transition temperature of the industrial paraffin itself. Under the condition, the phase transition temperature of the single fatty acid is lower than that of the single fatty acid, but it is still above 40 °C. It is not suitable for the active wall energy storage field. Some mix ratios can be applied to the active wall or floor energy storage field, or phase change storage. Can be in the field of heat exchangers.

(4) The subcooling degree of the binary mixture formed by paraffin wax and different kinds of fatty acids is different, the binary mixture of paraffin-myristate and the paraffin-stearic acid binary mixture has a large degree of supercooling, and the paraffin-nonanoic acid binary mixture The degree of subcooling is at least between 1.0 and 3.5 °C.

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