Experimental Study on Phase Change Energy-storing Material

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ABSTRACT: *This study had chose the half water gypsum board and diatomite as the main raw material, and added lime and mullite fiber preparation of ordinary gypsum board; and chose the capric acid and dodecanoic acid as phrase change materials, then mixed both based on a certain mass weight ratio, then chose plaster board carrier, and made phase change energy-storing gypsum board by impregnation method; Finally, this study analyzed and discussed the quality of the relationship between prepared phase change energy-storing gypsum board and the dipping time, the content of phase change material in phase change energy-storing gypsum board, the durability and water-absorption performance of phase change energy-storing gypsum board, etc.*

Keywords: Phase Change Materials, Phase Change Energy-storing Gypsum Board, Performance

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1. Introduction

Environment pollution and energy shortage in today's society had become an important problem we were all facing. The development and utilization of renewable energy had an important realistic significance to environmental protection and energy saving[1]. Phase change energy-storing technology achieved the purpose of energy storage through the phase change materials absorbing and releasing a lot of calories. Phase change process was an isothermal or approximate isothermal process, often with the releasing and absorbing in the process of phase transition or absorption. In this part, the changes in energy was called phase change latent heat, many phase change energy-storing materials had been developed through this features of phase change process. PCM was the material could absorb the amount of heat (cold) in the environment, and release to the environment in their hot (cold) in the process of phase change of its own, so as to achieve the aim of controlling ambient temperature of the material. For energy development and rational utilization, the phase change energy-storing material was very significant. Phase change latent heat of phase change materials was used to realize the energy storage, solve the contradiction between supply and demand in time and space, effectively improve the energy efficiency, and achieve the goal of energy conservation and emissions reduction [2].

According to the phase transition form and the phase change process, phase change energy storage material were divided into solid-liquid phase and solid-solid phase change energy storage material. According to the phase transition temperature, these were divided into low, medium and high temperature energy storage material. Usually it was made up of multicomponent phase change energy storage material, mainly included the main reservoir agent, extreme cold prevention agent, phase change point adjusting agent, anti-separation agent and phase change promoter, etc. Current research available for phase change material was solid-liquid phase change material, which used the solid-liquid phase change process to store thermal energy materials. Gypsum board had nearly half of the volume of air hole, and the hole structure was the carrier of phase change materials ideal.

2. Experiment

2.1 Experimental Drugs and Instruments

Capric acid and dodecanoic acid (AR, produced by SINOPHARM); Polyvinyl alcohol(PVA, AR, produced by Shanghai crystal pure reagent biochemical technology co., LTD); bassanite (CaSO4.1/2H2O, AR, produced by Tianjin regent chemicals co., LTD); diatomaceous earth(AR, produced by Tianjin regent chemicals co., LTD); lime(AR, produced by Tianjin bo di chemical co., LTD); Mullite polycrystalline fibres (PFM-1600, produced by Shanghai crystal pure reagent biochemical technology co., LTD); differential scanning calorimetric apparatus (model: DSC204F1, from Germany NETESCH Co.)

2.2 Experimental Process

2.2.1 The preparation of General Gypsum Board

This study took the bassanite and diatomaceous earth as the main raw material for making the plasterboard, and added the lime, mullite polycrystalline fibres and water, and mixed gypsum slurry [3], then pulled into a mold (length 20 mm, width 200mm, height 13mm) for molding, then removed the mold after half an hour, and then took it into oven for drying. The preparation process was as follows: Raw material weight counting, mixing and making material pulp, grouting mold, mold removal and dry, products got. Table 1 was the formula of composition preparation of ordinary plasterboard in this study.

Parameter Content (Wt %)	Raw material name			
	Bassanite	Diatomaceous earth	Lime	Mullite polycrystalline fibres
	45	40	5	10

Table 1. Formula of ordinary plasterboard

According to above special technical prescription and processes, took raw materials, mixed and added some water into mullite fiber, evenly dispersed, and added the mullite fiber into raw material evenly, then added water, and made gypsum slurry. Ensuring liquidity, if water content was less, the more density and more Strong of product, the less pore within, and pulled the gypsum slurry into the mold and shaking, remove the mold after 30 minutes, then naturally dry the plasterboard [4]. and the water content is less, the better, products more compact, less porosity, add the gypsum slurry into the template vibration close-grained, 30 min after parting molding, made from natural drying plasterboard [4].

2.2.2 Making Phase change Energy-storing Gypsum Board by Impregnation Method

Took the above plasterboard into oven in 120^0C for drying, and took capric acid and dodecanoic acid based on mass ratio of 66%:34%, and completely molten in 60^0C in water, then binded the gypsum board with cord then added into the molten liquid, Observed the whole impregnation process, and recorded the weight of gypsum board based on dipping time, till fully impregnation. Then took out and added into dry oven 2 hours in 120^0C, and then took out and calculated the weight.

3. Performance Analysis of Phase Change Energy-storing Gypsum Board

3.1 The Change of Weight and Content of Gypsum Board with Time

Under normal pressure, took capric acid and dodecanoic acid based on the mass ratio of 66:34, and mixed it. Then melted it in to 60^0C water bath, and made sure dipping plasterboard was completely in the phase change material, recorded the weight of gypsum board as the impregnating time variation, seen as follows:

From the diagram, as the extension of dipping time, the plasterboard weight increased first, then basically remained unchanged.

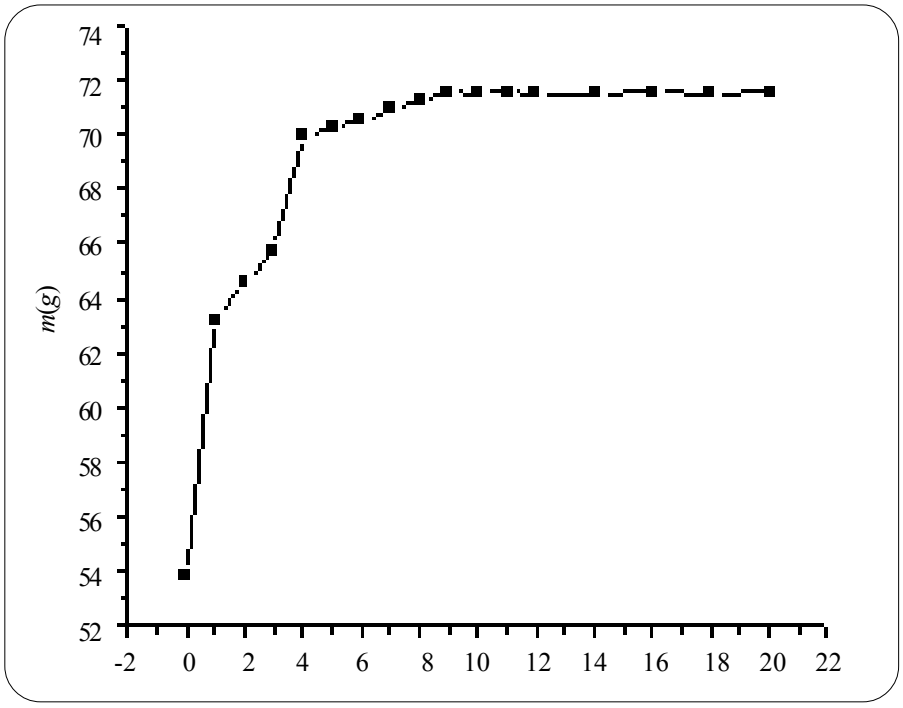

Figure 1. Plasterboard weight change under different soaking time

In the first 4 minutes, the weight of the plasterboard increased rapidly, which indicated that plaster change material was easy to immerse in plasterboard when the dipping started. Due to larger pore in the plasterboard, the weight of gypsum board rose slowly over time, after 10 minutes of dipping, the weight of gypsum board basically did not change. The phase change materials had reached its maximum in the plasterboard, dipping experiment had finalized.

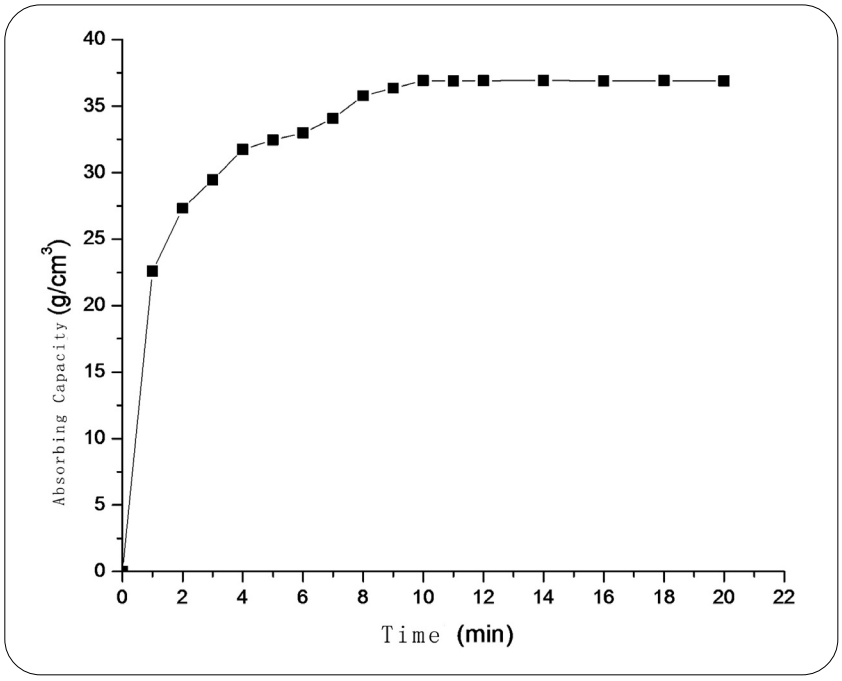

Figure 2. Plasterboard adsorbing capacity under different immersion time

From the diagram, as the extension of dipping time, absorbing capacity of phase change materials was obvious, then basically remained unchanged. At the beginning of immersing, the increased amount of absorbing capacity was very obvious; with the extension of time, the absorbing capacity rose slowly. When the dipping time was more than 10 minutes, plasterboard absorbing capacity basically remain unchanged, the saturated absorbing capacity was 36.92 g/cm^3.

3.2 DSC Analysis of Phase change Energy-storing Gypsum Board

Plasterboard was prepared in order to study the impregnation method of heat reservoir performance, through the DSC analysis, result was listed in table 2.

Sample Name	Thermal performance coefficient	
	Phase transition temperature (^0C)	Phase change enthalpy (J/g)
Capric acid and dodecanoic acid	21.25	145.68
Phase change plasterboard	23.26	45.87

Table 2. Thermal performance coefficient of phase change materials and phase change energy-storing gypsum board

Table 2 showed capric acid and dodecanoic acid mixture phase transition temperature of 23.26^0C, the phase transition temperature of phase change materials was lower than phase change energy-storing gypsum board, the difference was not very obvious, the phase transition enthalpy of phase change energy-storing gypsum board was 45.87 *J/g*, capric acid and dodecanoic acid system of phase change latent heat of phase change materials was basically equal to the weight ratio of phase change latent heat and phase change plasterboard.

3.3 Durability Analysis of Phase Change Energy-storing Gypsum Board

In the process of phase change energy storage materials [5], stored phase change material in porous media constantly solidification-melting thermal cycling. The phase change energy-storing gypsum board sample was set for experimental, lab environment temperature was 15^0C, and prepared a cooling box reserve. Took the plasterboard into oven temperature of 50^0C. After 20 minutes, took the phase change energy-storing gypsum board sample to the cooling box, after 20 minutes, took out. This was one time had finished. Then redo the same, totally was 100 times. For samples after thermal cycle of weighing, compared with that without overheating loop samples, the measured weight was loss, thus to measure the durability of the product [6].

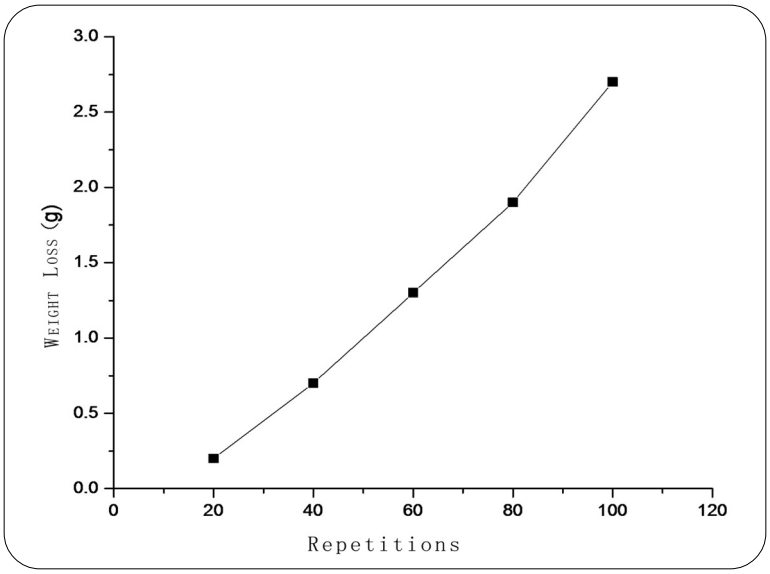

Figure 3. Phase change energy-storing gypsum board quality loss after thermal cycling

From the figure 3, after 100 times thermal cycling, weight loss of phase change energy-storing gypsum board reached 2.7g. And along with the increasing of cycling, weight loss was more, it showed that the durability of the plasterboard was not promising, phase change materials was easy to leak. It needed to take measures to packaging, etc.

3.4 The Analysis of the Phase Change Energy-storing Gypsum Board Water Absorption Performance

Plasterboard was environmental protection, no radiation and had respiratory function. When the humidity was less in the air, it could release moisture; when the humidity was more in the air, it could absorb the moisture. It kept the indoor space comfortable to live. Although the plasterboard had many advantages, its water absorption characteristics limited its application scope [7], such as air damp places, external wall, etc., so it need to test the water absorption properties of the phase change energy-storing gypsum board. Bibulous rate was the ratio of the weight of absorbed phase change energy-storing gypsum and weight of the dry material. This experiment adopted this method to check the phase change energy-storing gypsum bibulous rate .

4. Results

Phase change materials storing and releasing energy was in a very narrow temperature range, so the application to the building materials would greatly improve the comfort of living environment. This article used the impregnation method for phase change energy-storing gypsum board, and analyzed the performance of the plasterboard preparation [10].

This experiment chose bassanite and diatomite as the main raw material, then added mullite fiber and lime to make normal. In which, the application of diatomite plasterboard has more pore [11], so as to provide space for the phase change material, while, if added mullite fiber and lime which could enhanced the function. Study found that on the premise of guaranteed liquidity of the gypsum slurry, the less water added, the pore less, the stronger the plasterboard [12]. The impregnation method was applied to form the phase change energy-storing gypsum board, as the extension of dipping time, the quality of gypsum board was increased then basically remain unchanged; When dipping time was more than 10 minutes, the quality of the phase change energy-storing gypsum board was basically remain unchanged; when the dipping time was up to 12 minutes, the content rate of phase change material in plasterboard pore had reached its maximum, the measured figure was 36.92g/cm^3.

The further analysis research on durability and absorbent capacity of the prepared phase change energy-storing gypsum board found that the absorbent capacity of phase change energy-storing gypsum was half the average plasterboard, the phase change energy-storing gypsum board could be used in damp environment.

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