Study on Energy-Storing Building Materials Made of Paraffin/Montmorillonite Composites

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Abstract. Phase change materials (PCM) are promising in the application for reducing building energy consumptions and increasing thermal comfort. However, PCM have not been used as building materials extensively. A major technical hindrance for the applications of PCM in building materials is the packaging of PCM. The strategies for the packaging of PCM in building materials reported in the previous studies were mostly unsatisfactory because of the disadvantages such as complex processes, high cost or poor packing effectiveness, etc. This study presented a novel simple and low-cost way to make energy-saving building materials with PCM. In this study, a composite containing PCM was developed with montmorillonite (MMT) and paraffin via a simple and low-cost route. Through the selection of appropriate raw materials and with the vigorously mixing using a high-shear mixer, the PCM/MMT composites were prepared simply. The thermal properties of the PCM/MMT composites were investigated by differential scanning calorimetry (DSC). Based on the thermal properties and packing effectiveness the weight ratio of PCM: MMT =5:4 was determined as the appropriate composition of the PCM/MMT composites. As compared with the PCM composites made of organically modified MMT, the PCM/MMT composites prepared in this study exhibited higher compression strength. The thermal conductive performance of the wallboards made of the PCM/MMT composites and the ordinary wallboards was simulated through numerical simulation. The experimental systems were also set up for testing the energy-saving characteristic of the building materials containing the PCM/MMT composites under both laboratorial conditions and natural outdoor conditions. The numerical simulation as well as the experimental results indicated that the wallboard made of the PCM/MMT composite could effectively reduce the temperature fluctuation and would be favorable for keeping room in a comfortable temperature range. Hence the PCM/MMT composites might be promising for developing high-performance thermal regulating building materials with low-cost.

1. Introduction
The fast economic growth and high standards of living imposed the world to consume large amount of conventional energy resources (fossil fuels) that drive environmental pollutions and climate changes. In addition, the dependency towards conventional energy resources will empties the sources more rapidly. Therefore, the effectiveness utilization of energy becomes a main issue recently. Nowadays, the phase change materials (PCMs) have drawn extensive interests from both academia and industry for their various applications in many fields, especially the application for energy-storing materials. A phase change material (PCM) can absorb or release a great deal of latent heat changing from solid state to liquid state or vice versa [1-4]. Incorporating PCMs into building materials and taking advantage of the circular energy-storing ability of PCMs can effectively reduce the electricity consumption of air conditioning systems [5-7]. Meanwhile, it also enables the refrigeration or heating
system to use the night electricity, reducing the operational costs and relieving the short supply of electricity [8, 9].

These materials make use of the latent heat between the solid and liquid phase change, and must be encapsulated or stabilized for a technical use in any building systems, either active or passive. Thus can be achieved using a direct inclusion in the wall [10], by impregnation in a porous material as gypsum [11], by using microencapsulation techniques [12], using a shape-stabilization or slurries of PCM suspended on a thermal fluid [13]. The encapsulation is a key issue for the implementation of these technologies in the buildings and must be designed to avoid leakage and corrosion.

In the application of PCMs for energy-storing building materials, immersing conventional wallboards in molten PCMs or encapsulating PCMs in polymeric films in advance has ever been employed [14-17]. Although immersing wallboards with PCMs is simple and low-cost, the liquid PCMs are inclined to migrate outside to the surface of the wallboard, especially after the PCMs experienced several heating–cooling cycles. The encapsulation method consists of macro-encapsulation and micro-encapsulation [14, 15, 18]. It has been proved that the macro-encapsulation failed in developing energy-storing building materials with PCMs due to the poor conductivity of the phase change material. When it regains the heat from the liquid phase, the PCM solidifies around the edges and prevented efficient heat transfer. In contrast, of PCMs can be avoided. But the micro-encapsulating PCMs suffered from complicated polymerization processes, resulting in higher cost of the energy-storing building materials micro-encapsulation can effectively avoid the problem since the dimensions of the micro-encapsulation of PCMs are so small that the problem caused by lower thermal conductivity thermal conductivity and thus deteriorate the heat transfer rate of the PCM. Therefore a simple and low-cost way, in which the aforementioned problems can be overcome, is much desired for developing energy-storing building materials with PCMs.

Montmorillonite (MMT) is a sort of layered silicate mineral and naturally hydrophilic. Recently, intercalation compounding was employed in preparing composite PCMs with organically modified MMT which is abbreviated as OMMT afterwards in this paper. Fang and coworkers prepared OMMT in advance and then incorporate OMMT into PCMs to fabricate PCM composites [18, 19]. The layered particles can play the role of carriers of PCMs which enable the containing of PCMs and prevent from the leakage of PCMs in storage. However, this method needs to modify the MMT with organic chemicals prior to intercalation compounding, which is much time-consuming and water-wasting.

This study presents a simple and low-cost way for preparing energy-storing building materials with PCM and MMT. Herein, the PCM/MMT dispersions were fabricated by vigorously mixing MMT dispersions and melt paraffin using a high-shear mixer. After drying at room temperature, the PCM/MMT composites were prepared. The thermal properties and structure of the PCM/MMT composites were studied with differential scanning calorimetry (DSC) and X-ray diffraction (XRD). The computational and experimental results showed that the wallboards made of the PCM/MMT composites could reduce temperature fluctuation as compared with the ordinary wallboards. This strategy for making PCM/MMT composites is simple and low-cost and might be promising for developing energy-storing building materials.

2. Experimental

2.1. Materials
The sodium containing MMT was supplied by Nanhai Non-Metallic Mines Corp., China. The solid paraffin with melting temperature of 48°C and the liquid paraffin were provided by PetroChina Co Ltd Dalian Petrochemical Branch.

2.2. Preparation of PCM/MMT Composites and PCM/OMMT Composites
For saving cost, the industrial cheap solid paraffin with melting temperature of 48°C was mixed with the liquid paraffin. The phase change temperature of the PCM material can be readily adjusted by changing the mass ratios of the two kinds of paraffin. In this study, the mixed paraffin was prepared by blending the melt solid paraffin with the liquid paraffin at the mass ratio of 3:1. After being cooled down to room temperature, the solid mixed paraffin was achieved, serving as the PCM material. The
MMT dispersion was prepared by mixing 400 g deionized water with 100 g MMT in a 1000 ml beaker under vigorous stirring with a high-shear mixer for 30 min. After being heated to melting state, the different amount of mixed paraffin was added into the MMT dispersion under the blending by the high-shear mixer. After vigorous stirring for 20 min, the PCM/MMT water dispersions with different compositions were thus prepared. The PCM/MMT water dispersions were paste-like and could be stored steadily at room temperature for more than one year. Some PCM/MMT water dispersions were coated on a glass plate and were dried completely at room temperature. The mixtures were ground again to obtain the PCM/MMT composite. For comparison, the OMMT were prepared by treating Na-MMT with hexadecyltrimethyl ammonium bromide as described in the previous works. The PCM/OMMT composite samples were also produced in a way similar to the previous reports [18, 19], but replacing the RT20 PCM with our mixed paraffin.

2.3. Fabrication of Wallboards
By mixing the PCM/MMT water dispersion, river sand, cement, water and water reducer, a well dispersed slurry, in which the PCM/MMT composite accounted for 10% in weight, was prepared. Then, the slurry was placed in a stainless steel mold (300mmx50mmx300mm). After vibrating for a few minutes, the mold was placed at room temperature for 3 days. The mold was then removed and the PCM/MMT composite wallboard was dried at room temperature before use. By changing the weight ratios of the raw materials the PCM/MMT composite wallboards with different compositions were prepared. Heating the PCM to melting state, a series of wallboards were prepared by replacing PCM/MMT with PCM at the same weight percentages. The ordinary wallboard was also fabricated via the same route in absence of the PCM/MMT water dispersions.

2.4. Making Chambers with and without PCM/MMT Composites
For evaluating the thermal regulating performance of the PCM/MMT composites a chamber was fabricated with the PCM/MMT composite wallboards, which is denoted as PCM/MMT chamber. The chamber was in cubic shape with length of 300mm and with thickness of 50mm. For comparison, a reference chamber was made with the ordinary wallboards in the same shape and with the same sizes. Each chamber was equipped with 5 thermocouples used to record the internal air temperature of the chamber. In a laboratory, the PCM/MMT chamber was placed into an oven set at 42°C. When the internal air temperature of the chamber reached to 36.5°C, the chamber was taken outside and allowed to cool freely at room temperature. The reference chamber was also heated and cooled in the same way. By comparing the variations of the internal air temperature of the chambers changing with time the thermal regulating performance of the PCM/MMT chamber was examined. In addition, the thermal regulating performance of the PCM/MMT composite was tested during day and night. Hence, the chambers were placed outside the laboratory and exposed to the natural outdoor conditions including day time natural solar heating and night time natural cooling processes. The two chambers were located on the top of a building in the Guangzhou SUPE chemical Ltd., Co. between the 25 July and the 28 July, 2015 under the same natural environment conditions. The internal air temperature changes of the two chambers during the period were thus recorded.

2.5. Measurements
The tests of the storage stability of the PCM/MMT composites were conducted in an oven at 40°C for 12 days. The differential scanning calorimetry (DSC) measurements of the PCM/MMT composites were performed using Differential Scanning Calorimeter DSC-204 F1 Phoenix (NETZSCH Group, Germany). The DSC tests were carried out with nitrogen purging at a heating rate of 5°C/min. The compression strength of the wallboards was measured with a YAW-100 concrete mortar compressor (Jinan Kai Rui Mechanical Equipment Co., Ltd., Jinan, China) according to the standard JG170-90. The thermal conductivity and the specific heat capacity of the wallboards with or without PCM/MMT composites were tested with the DRM thermal conductivity tester (Xiangtan Xiangyi apparatus Co., Ltd) via a quasi-steady-state method according to the standards JG151-2002, JG158-2004 and JG/T283-2010. The measurements were carried out at 22°C with the relative humidity of 65%. The density of the wallboards was tested according the standard GB/T4111-2013.
3. Numerical Simulation
In a building wallboard made of PCM/MMT composites, the PCM composite particles were randomly distributed in the concrete matrix, which is difficult to depict with a mathematical model. It is assumed that the height of the building wallboard is much larger than its thickness and the heat transfer caused by the MMT slices can be neglected, the building wallboard made of PCM/MMT composites can be described by a simplified model, in which the interior layer and the exterior layer represent ordinary building materials while the middle layer stands for PCM (see Fig. 1).

![Figure 1. Schematic diagram of the simplified model of the wallboard containing PCM composites](image)

Because the PCM particles are much smaller as compared with the concrete matrix the convection heat transfer caused by the melting or freezing of the PCM particles can be neglected. Hence only heat transfer is considered in this model. The following two equations govern the temperature distribution of the interior layer and the exterior layer of the model during the heat transfer:

\[
\frac{\partial t_1}{\partial \tau} = \alpha_1 \frac{\partial^2 t_1}{\partial x^2} \quad 0 < x < L_1 \tag{1}
\]

\[
\frac{\partial t_2}{\partial \tau} = \alpha_2 \frac{\partial^2 t_2}{\partial x^2} \quad L_2 < x < L_3 \tag{2}
\]

Where \( t_1 \) and \( t_2 \) stand for the temperature of the exterior layer and the interior layer respectively of the model, \( \alpha_1 \) and \( \alpha_2 \) represent the thermal diffusivity of the exterior layer and the interior layer respectively, while \( \tau \) is time. The structure in the zone \( L_2 < x < L_3 \) is composed of the PCM/MMT composites wherein there are solid phase and liquid phase. The solid-liquid interface of the two phases is denoted by the function \( S(\tau) \) which represents the distance from the solid-liquid interface to the origin of coordinate at a certain time \( \tau \). Thereby the solid-liquid interface can be described by the following two equations:

\[
t_s = t_1 = t_p \tag{3}
\]

\[
\lambda_s \frac{\partial t_s}{\partial x} - \lambda_l \frac{\partial t_l}{\partial x} = \rho L \frac{dS(\tau)}{d\tau} \tag{4}
\]

Where \( t_s \), \( t_l \) and \( t_p \) stand for the solid phase temperature, the liquid phase temperature and the phase transition temperature respectively, \( \lambda_s \) and \( \lambda_l \) are denoted as the thermal conductivity of the solid phase and the liquid phase respectively, \( \rho \) stands for the density of PCM/MMT, \( L \) is the phase transition latent heat. Accordingly, the following equations governing the solid phase and the liquid phase can be expressed as:

\[
\text{Liquid phase zone:} \quad \frac{\partial t_l}{\partial \tau} = \alpha_1 \frac{\partial^2 t_l}{\partial x^2} \quad L_1 < x < S(\tau) \tag{5}
\]
Solid phase zone: \( \frac{\partial t_s}{\partial t} = \alpha_s \frac{\partial^2 t_s}{\partial x^2} \quad S(\tau) < x < L_2 \) \hfill (6)

Where \( \alpha_l \) and \( \alpha_s \) represent the thermal diffusivity of the liquid phase and the solid phase respectively.

For an air-conditioned building, the indoor temperature (\( t_{\text{Ind}} \)) can be considered as a constant. In addition, the outdoor temperature, the interior surface temperature and the exterior surface temperature of the wallboard in the model are designated as \( t_{\text{Out}} \), \( t_{\text{Int}} \) and \( t_{\text{Ex}} \) respectively. If the influence of humidity is ignored, the temperature distribution of the wallboard in the model relies on the heat radiation from the indoor matters and the indoor atmosphere and the heat radiation from the outdoor factors such as sunlight and the outdoor atmosphere. Hence the following boundary conditions of the model can be expressed as:

\[
q = h(t_{\text{Out}} - t_{\text{Ex}}) \quad x = 0 \hfill (7)
\]

\[
q = h(t_{\text{Int}} - t_{\text{Ind}}) \quad x = L_3 \hfill (8)
\]

where \( q \) is denoted as the heat flux density exchanging at the surfaces of the wallboard, while \( h \) stands for the specific enthalpy. The other boundary conditions includes:

\[
q = -\lambda_l \frac{\partial t_l}{\partial x} \quad x = 0 \hfill (9)
\]

\[
t_1 = t_l \quad x = L_1 \hfill (10)
\]

\[
\lambda_l \frac{\partial t_1}{\partial x} = \lambda_s \frac{\partial t_s}{\partial x} \hfill (11)
\]
\[ t_s = t_2 \quad x = L_2 \]  

\[ \lambda_s \frac{\partial t_s}{\partial x} = \lambda_2 \frac{\partial t_2}{\partial x} \]  

(12) \hspace{1cm} (13)

The initial conditions of the model is:

\[ t_1 = t_2 = t_s = t_1 = t_{ind} < t_p \quad \tau = 0 \]  

(14)

The equations (1)-(14) govern the heat conductive behaviors of the wallboard containing PCM/MMT composite. Based on this model, the finite element analysis software ANSYS was employed in this study to simulate the transient temperature distribution changing of the wallboards.

4. Results of Experiments and Mathematic Simulation

4.1. Formation Mechanism of the PCM/MMT Composites

Sodium based MMT (Na-MMT) can easily dissolve in water. This is ascribed to the hydration of the interlayer cations and the expansion effect when the water penetrates into MMT interlayer. In principle, the 5% pure Na-MMT sol can be dispersed into individual MMT layers under high-speed stirring in deionized water. As the concentration of MMT increases (e.g. 20%), the separated MMT layers can overlap with each other to form dispersions (see Fig.2a). When the melt PCM is added into the MMT dispersion using high-shear mixer, the PCM is dispersed into small droplets. These small droplets are separated by the MMT silicate layers and the PCM/MMT water dispersion comes into being (see Fig. 2b). During the dying of the PCM/MMT water dispersion, the distances among the MMT layers decrease gradually as the water evaporates. The PCM is finally enclosed in the cages formed by the MMT slices wherein the liquid PCM hardly migrates out. Then the stable PCM package system is thus established and the PCM/MMT composite is achieved (see Fig.2c).

4.2. Storage Stability of PCM/MMT Composites

Serving as the energy storing building materials, the PCM/MMT composites definitely experience multiple cycles of heating and cooling. At low temperature, the PCM/MMT composites as well as the PCM/MMT water dispersions can be steadily stored more than one year. But at higher temperature the PCM melts and the liquid paraffin can leak outside of the package formed by the MMT cages. Hence the storage stability the of PCM/MMT composites was tested at 40°C in an oven. Every two days, the PCM/MMT composites were taken out for observation and the results are shown in Table 1. As can be seen, the composites with lower content of PCM be stored steadily at 40°C during 12 days. For the sample with the composition PCM:MMT =2:1, it was observed that the liquid paraffin migrated outside after 12 days. With the increase of PCM content, the sample with the composition PCM:MMT =3:1 even could not keep stable after 2 days. Hence, the composites with the composition PCM:MMT =5:4 and those with lower PCM content are considered relatively stable and suitable for making energy-storing building materials because the composites could withstand the high temperature continuously for 12 days whereas the building materials usually experience heating and cooling cycle every 24h.
Table 1. Storage stability the of PCM/MMT composites at 40°C

| Samples           | Time of storage (days) |
|------------------|------------------------|
|                  | 2  | 4  | 6  | 8  | 10 | 12 |
| PCM:MMT =1:4     | Stable | Stable | Stable | Stable | Stable | Stable |
| PCM:MMT =3:4     | Stable | Stable | Stable | Stable | Stable | Stable |
| PCM:MMT =1:1     | Stable | Stable | Stable | Stable | Stable | Stable |
| PCM:MMT =5:4     | Stable | Stable | Stable | Stable | Stable | Stable |
| PCM:MMT =2:1     | Stable | Stable | Stable | Stable | Stable | Stable |
| PCM:MMT =3:1     | Migrated out | Migrated out | Migrated out | Migrated out | Migrated out | Migrated out |

4.3. DSC Analysis

The DSC thermograms of PCM and PCM/MMT composites with different weight ratios are presented in Fig.3 and the testing results are summarized in Table 2. The peak temperature of the melting of the mixed paraffin PCM is 40.1°C and the melting enthalpy is 188.6J/g. In contrast, the peak temperatures of PCM/MMT composites were lower than that of PCM by 4-7°C while the melting enthalpies of the composites showed dramatic decrease as compared with that of the PCM. This is ascribed to the decrease of the content of PCM in the composites. In addition, the presence of MMT in the composites influenced the crystallization of paraffin and gave rise to the decrease of the melting temperature of the PCM. Fang et. al. prepared PCM composite with OMMT via intercalation compounding. It was found that the melting transition enthalpy of the PCM/OMMT composite was 79.25J/g, which is apparently less than some of the PCM/MMT composites in our study. This means that the newly developed PCM/MMT composite possesses a good capacity of thermal storage. The DSC tests proved that the composite with the composition PCM: MMT =5:4 is suitable for developing energy-storing building materials.

Figure 3. The DSC thermograms of PCM and PCM/MMT composites with different weight ratios.

Table 2. Summary of the DSC tests of PCM and PCM/MMT composites

|                      | Transition temperature (°C) | Peak temperature (°C) | Melting enthalpy (J/g) |
|----------------------|----------------------------|-----------------------|------------------------|
| PCM                  | 35.4                       | 40.1                  | 188.6                  |
| PCM:MMT =5:4         | 31.9                       | 36.6                  | 128.4                  |
| PCM:MMT =1:1         | 31.8                       | 36.3                  | 120.5                  |
| PCM:MMT =3:4         | 31.7                       | 35.8                  | 111.1                  |
| PCM:MMT =1:4         | 31.9                       | 33.5                  | 66.3                   |

4.4. Compression Strength of Wallboards

The influences of the content of PCM and PCM composites on the compression strength of the wallboards is shown in Fig.4. As can be seen, the compression strength of the wallboards decreased as the increase of the content of PCM or PCM composite. This is because the matrix of wallboard is...
cement which is totally inorganic in nature which is incompatible with the organic PCM. Hence more content of organic chemicals resulted in more depression of the compression strength of the wallboards. Moreover, it is found that the wallboards containing pure PCM exhibited the lowest compression strength for a given content of PCM or PCM composite. In addition, the wallboards containing PCM/MMT composite exhibited the higher compression strength as compared with those made of PCM/OMMT composites. This is because that the PCM/MMT composites are more compatible with concrete than the PCM/OMMT composites and thus have little impact on the strength of the wallboards. Fang and coworkers modified MMT with hexadecyltrimethyl ammonium bromide improved that compatibility of MMT and PCM but decreased the compatibility of concrete and PCM/OMMT composites [14, 15].

Figure 4. Influences of the content of PCM and PCM composites on the compression strength of the wallboards.

4.5. Numerical Simulation
In the simulation, the indoor air convection heat transfer coefficient and the outdoor air convection heat transfer coefficient are set as 10 W/(m²·°C) and 20 W/(m²·°C) respectively while the indoor temperature $t_{\text{Ind}}$ of the air-conditioned building is set as 20°C. The outdoor temperature $t_{\text{Out}}$ can be approximated by the outdoor hourly comprehensive temperature of summer ($t_{\text{sh}}$). In Guangzhou of China, $t_{\text{sh}}$ can be expressed as [16]:

$$t_{\text{sh}} = t_{\text{wp}} + \beta \frac{(t_{\text{wg}} - t_{\text{wp}})}{0.52}$$

(15)

Where $t_{\text{wp}}$ stands for the outdoor mean daily temperature for summer air conditioning, $t_{\text{wg}}$ represents the outdoor dry-bulb temperature for summer air conditioning, $\beta$ is denoted as the outdoor temperature hourly variation coefficient of summer, which hourly changes with time in a day. In addition, for simulating the thermal behavior of the wallboards, thermal conductivity, specific heat and density of the ordinary wallboards and the wallboards containing PCM/MMT composites were experimentally measured and the results are summarized in Table 3.

| Properties                  | Ordinary wallboard | Wallboard containing PCM/MMT composite |
|-----------------------------|--------------------|---------------------------------------|
| Thermal conductivity(W·m⁻¹·°C⁻¹) | 0.76               | 0.35                                  |
| Specific heat(J·kg⁻¹·°C⁻¹)   | 836                | 880                                   |
| Density (kg·m⁻³)            | 1700               | 1009                                  |

After 15h from the starting of simulation, the temperature distributions of the ordinary wallboard and the PCM/MMT containing wallboard are shown in Fig.5. It can be seen that the temperature on
the interior surface of the PCM/MMT composite material is lower than that on the ordinary material by $1.5^\circ C$.

\[ \text{Figure 5.} \] The transient temperature distributions of the wallboards at 15h after the beginning of simulation: (a) ordinary wallboard; (b) PCM/MMT containing wallboard

4.6. Testing for Energy-Storing Performance

The variations of the internal air temperature changing with time for the chamber are shown in Fig. 6. It can be clearly seen that, the internal air temperature of the reference chamber made of ordinary wallboards increased rapidly whereas the increment in the temperature of the PCM/MMT chamber was apparently slower. The internal air temperature of the PCM/MMT chamber took 4.1h to reach 36.5°C while the reference chamber took only 1.4h to get to the same temperature. The PCM/MMT chamber took longer time to be heated up to 36.5°C because of heat storage by the PCM. The longer heating time suggests that the prepared building wallboards made of the PCM/MMT composites has a good energy-storing and thermal regulating property. It also can be seen in Fig. 6 that in the cooling period, the internal air temperature of the PCM/MMT chamber decreased slower than that of the reference chamber due to discharging of heat stored by PCM (seen Fig. 6). The cooling times from 36.5°C to room temperature 25.8°C for the reference chambers and the PCM/MMT chamber were determined as 13.5h and 20.7h, respectively. This result indicates that the PCM/MMT composite played an important role in controlling of the indoor temperature of the PCM/MMT chamber during the cooling process. Therefore it can be imagined that indoor temperature of the buildings made of the PCM/MMT building materials will be effectively regulated and controlled in a comfortable temperature range both in hot summer and in cold winter, thus reducing air conditioning consumption and effectively achieving building energy efficiency.

\[ \text{Figure 6.} \] Variations of the internal air temperature changing with time of the chambers under laboratory conditions
Fig. 7 shows the temperature variations of the reference chamber made of ordinary wallboards and the PCM/MMT chamber containing PCM/MMT composites in 3 days. It can be seen that under the same environmental conditions the temperature fluctuation of PCM/MMT chamber was less than that of reference chamber by 1-2°C. The tests experimentally proved that the wallboards made of the PCM/MMT composites could decrease the temperature fluctuation and be favorable for keeping room comfort. It thus can be drawn that incorporating the PCM/MMT composites into wallboards made it possible for buildings to capture solar energy directly and store thermal energy.

![Temperature Variation Graph](image.png)

Figure 7. Variations of the internal air temperature changing with time of the chambers under natural outdoor conditions

5. Conclusions
PCM are promising in the application for energy saving of buildings. The packaging of PCM is a key issue for the implementation of these technologies in the buildings. The methods for the packaging of PCM in building materials developed in the previous studies were mostly unsatisfactory because of the disadvantages such as complex processes, high cost or poor packing effectiveness. This is an important factor for hindering the industrialization of the energy-storing building materials. This study presented a simple and low-cost way to develop energy-storing building materials by making PCM/MMT composites. The PCM/MMT composites were developed with paraffin and Na-MMT through the vigorously mixing using a high-shear mixer. The storage stability of the composites with varying compositions were examined at 40°C for 12 days. The DSC tests proved that the PCM/MMT composites have relatively higher latent heat as compared the PCM composites made of the OMMT reported previously. It was found that the PCM/MMT composites exhibited higher compression strength as compared with the PCM/OMMT composites. The simulation as well as the experiments manifested that the wallboard made of the PCM/MMT composite could reduce the temperature fluctuation and might be favorable for keeping room in a comfortable temperature range. The study may render a promising strategy for developing high-performance energy-storing building materials with low-cost.

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