

Preparation of Polyalcohols Mixtures and Experimental Research on the Thermal Performance

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Abstract: In this paper, the methods to prepare polyalcohols mixtures were discussed. The phase change temperatures and phase change heats of monobasic, binary and triatomic systems consisting of neopentylglycol(NPG), pentaerythritol(PE) and trihydroxy methyl-aminomethane(TAM) with different component were studied experimentally by differential scanning calorimeter(DSC). Feasibility of materials used in the building envelope was analyzed. Results can provide the basis for the application of solid-solid phase change materials in the building fields.

Keywords: polyalcohols, binary system, triatomic system, phase change temperature, thermal performance column

1. INTRODUCTION

Energy storage of phase change materials has become important in the fields of new energy application and energy-saving technology. Especially in the building fields, the application of thermal storage of phase change materials has been focus at home and abroad^{[1]-[4]}. It can save cooling load in the summer and heating load in the winter to add phase change materials into architectural materials by different methods. Phase change material building envelope can store cool or heat at night to bear part or all peak load in the daytime owing to the thermal property of phase change material, and decrease the indoor temperature fluctuation and raise the comfort degree

Phase change materials include solid-liquid phase change materials and solid-solid phase change materials. Solid-liquid phase change materials such as paraffin are traditional phase change materials used in the field of thermal storage. However, they must be loaded by the containers if they are used in the building so not as to leak. In order to avoid this phenomenon, shape-stabilized phase-change materials are used. Shape-stabilized phase-change material is made up of supporting material and phase change material^{[5]-[7]}.

Solid-solid phase change materials have some advantages such as small change in volume, leaklessness, no phase separation.

Solid-solid phase change materials have higher Supported by Beijing municipality key lab of heating, gas supply, ventilation and air-conditioning engineering (KF200310) phase change temperature in general, so they are suitable to thermal storage at the middle or high temperature. Mixing two or several kinds of polyalcohols to form alloy can decrease their phase change temperature, thus they can be used in the

lower temperature^{[8]-[10]}. Polyalcohols are more ideal phase change materials used in the building envelope if phase change temperature is suitable.

Phase change temperature and latent heat, stability and feasibility of phase change materials should be considered when choosing materials used in the building envelope. It is suitable that phase change temperature is between 20 and 40 centigrade according to different use^[11].

In this paper, preparation methods and thermal storage performance of polyalcohols mixture consisting of neopentylglycol, pentaerythritol and trihydroxy methyl-aminomethane were studied. Polyalcohols mixtures used in the building envelope were chosen by testing phase change temperature and heat.

2. EXPERIMENTAL EQUIPMENT AND MATERIALS

Experimental equipment include differential scanning calorimeter, analytic balance, beaker, heating furnace, infrared light, muller and so on. Differential scanning calorimeter was made in German Ntscz company, and its type is 200PC. The equipment is cooled by liquid nitrogen. Protective gas and purge gas are nitrogen with high purity degree. The velocities of flow of protective gas and purge gas are 65ml/min and 15 ml/min respectively.

Experimental materials are neopentylglycol, pentaerythritol, trihydroxy methyl-aminomethane and alcohol made in Beijing reagent company.

3. PREPARATION OF EXPERIMENTAL SAMPLES

Mix three kinds of polyalcohols by different mass proportion to form binary systems NPG/TAM, PE/NPG, TAM/PE and triatomic systems NPG/TAM/PE. Twenty-seven samples were prepared in the

experiment. They are showed in Table 1.

Table 1: Numbers and composition of samples

Sample number	1	2	3
Composition	NPG	TAM	PE
Sample number	4	5	6
Composition	90%NPG 10%PE	70%NPG 30%PE	50%NPG 50%PE
Sample number	7	8	9
Composition	30%NPG 70%PE	10%NPG 90%PE	90%NPG 10%TAM
Sample number	10	11	12
Composition	70%NPG 30%TAM	50%NPG 50%TAM	30%NPG 70%TAM
Sample number	13	14	15
Composition	10%NPG 90%TAM	90TAM 10%PE	70%TAM 30%PE
Sample number	16	17	18
Composition	50TAM 50%PE	30TAM 70%PE	10TAM 90%PE
Sample number	19	20	21
Composition	10%NPG 20%TAM 70%PE	20%NPG 70%TAM 10%PE	20%NPG 40%TAM 40%PE
Sample number	22	23	24
Composition	30%NPG 50%TAM 20%PE	30%NPG 20%TAM 50%PE	40%NPG 30%TAM 30%PE
Sample number	25	26	27
Composition	60%NPG 20%TAM 20%PE	80%NPG 10%TAM 10%PE	90%NPG 5%TAM 5%PE

Preparation of mixture used two methods. The first method is to mull and mix evenly sample, and heat it up to liquid in the electrical furnace, and then cool it in the air to solidify. The second method is to dissolve sample in the water or alcohol, and heat it by infrared light, and remove infrared light after water or alcohol evaporate.

Several samples were prepared by using the first method. Samples were weighted before and after melting. Results were shown in Table 2.

From the table, we can see that mass of most samples change evidently. Three kinds of Polyalcohols samples have different rate of weightlessness. Pentaerythritol has the biggest rate of weightlessness, and trihydroxy methyl-aminomethane has the smallest rate of weightlessness. The rates of weightlessness of binary systems are bigger when they contain more pentaerythritol or neopentylglycol. The first method is not suitable to preparing polyalcohols mixtures because three kinds of polyalcohols have different volatility. If the first method is used, the mass proportion of mixtures changes when heating and melting.

Table 2: Changes in mass of several samples.

Sample number	1	2	3
Mass before melting (mg)	17.5	27.6	15.1
Mass after melting (mg)	10.3	20.9	14.7
Rate of weightlessness(%)	41.1	24.3	2.6
Sample number	5	6	7
Mass before melting(mg)	8.2	7.3	15.8
Mass after melting(mg)	3.3	3.9	5.6
Rate of weightlessness(%)	59.8	46.6	64.6
Sample number	13	22	24
Mass before melting (mg)	25.1	10.6	11.1
Mass after melting (mg)	24.4	9.2	8.9
Rate of weightlessness(%)	2.8	13.2	19.8

In the experiment, we used the second method to make samples. Alcohol is used as dissolvent. The mass of sample has no weightlessness in the preparation.

4. RESULTS AND ANALYSIS

4.1 Thermal Storage Performance of Polyalcohols

The thermal analysis results of three kinds of polyalcohols were shown in Table 3.

Table 3: Phase change temperature and heat

Material		NPG	TAM	PE
Solid-solid change temperature (°C)		43	134.5	187.1
Solid-solid change heat (J/g)		110.4	285.3	289

From the table, we can see that the solid-solid phase change temperature of neopentylglycol is the lowest, and it can be used to store thermal energy in the lower temperature fields, such as phase change floor or solar storage. The solid-solid phase change temperatures of pentaerythritol and trihydroxy methyl-aminomethane are higher, and they can be used to store thermal energy in the higher temperature fields. The phase change heats of pentaerythritol and trihydroxy methyl-aminomethane are much higher than that of neopentylglycol.

4.2 Thermal Storage Performance of Polyalcohols Binary System

The testing results of binary systems were shown in the figure 1 to 4.

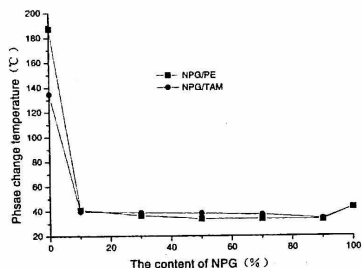


Figure 1: The relationship between phase change temperature and constituent of binary systems

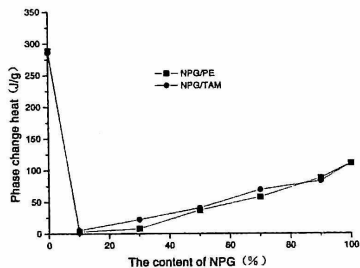


Figure 2: The relationship between phase change latent heat and constituent of binary systems

The phase change temperatures of binary system NPG/PE and TAM/NPG are much lower than that of single polyalcohols material. The difference of phase change temperatures of the two binary systems is small. The phase change temperatures of binary systems are all between 30 and 40 centigrade and have no relationship with the phase change temperatures of PE and TAM. The phase change temperatures of binary systems NPG/PE and TAM/NPG decrease to 41.1 and 39.7 centigrade respectively when the contents of NPG are up to 10 percent. The change in phase change temperature is not evident with the increasing of the contents of NPG. The phase change temperatures of binary systems NPG/PE and TAM/NPG are 33.2 and 34 centigrade respectively when the contents of NPG are up to 90 percent. In general, the bigger the contents of NPG are, the lower the phase change temperatures of binary systems.

The phase change heat of binary system NPG/PE and TAM/NPG are much lower than that of single polyalcohols material. The difference of phase change heats of the two binary systems is small. The phase change heats decrease rapidly when adding a little NPG into PE or TAM. But the phase change heat increases gradually with the increasing of the contents

of NPG.

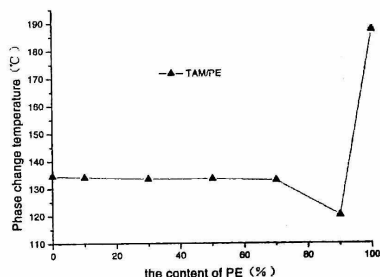


Figure 3: The relationship between phase change temperature and constituent of binary systems

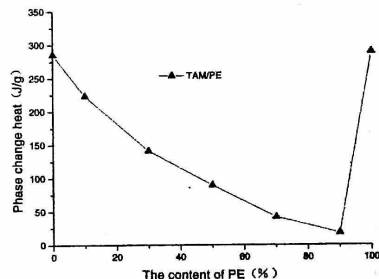


Figure 4: The relationship between phase change latent heat and constituent of binary systems

The phase change temperature of binary system PE/TAM is higher, and about 130 °C. The phase change temperature of the binary system consisting of PE and TAM decreases very small. The phase change heat of binary system PE/TAM is much lower than that of single polyalcohols material. The phase change temperature of PE/TAM has no evident changes and the phase change heat is lower, so this binary system has no value in the thermal storage fields.

4.3 Thermal Storage Performance of Polyalcohols Triatomic System

Experimental results of polyalcohols triatomic systems are shown in Table 4.

From the table, we can see that the phase change temperatures of triatomic systems NPG/PE/TAM is much lower than that of single polyalcohols material. The phase change temperature of triatomic systems in the experiment is between 23 centigrade and 38 centigrade, and lower than that of binary system. But the phase change heat of triatomic systems is lower. The phase change temperature of triatomic systems is lower and the phase change heat is higher when the

content of NPG is high in the triatomic systems. It is valuable to application in the thermal storage field.

Table 4: Experimental results of triatomic systems

Sample number	19	20	21
Phase change temperature (°C)	32.3	28.9	27.1
Phase change heat (J/g)	10.43	7.623	7.508
Sample number	22	23	24
Phase change temperature (°C)	37.8	31.1	27.8
Phase change heat (J/g)	15.26	4.69	17.9
Sample number	25	26	27
Phase change temperature (°C)	23.6	23.6	23.8
Phase change heat (J/g)	24.21	71.37	77.09

The phase change temperature of binary and triatomic systems with a certain constitution can change in the wider range. They are suitable to thermal storage in the building. The phase change temperatures of binary system NPG/PE and TAM/NPG are between 30 centigrade and 41 centigrade. The phase change heat of binary system is bigger when the content of NPG is 50 to 90 percent, and they can be used as thermal storage material. In our experiment, the phase change heats of triatomic systems such as sample 26 and sample 27 are higher, and others are lower and not suitable to thermal storage.

5. CONCLUSIONS

- 1) Polyalcohols is volatile in the high temperature and the rate of weightlessness is higher. The method to prepare polyalcohols mixtures by heating and melting is not suitable because the constitution of polyalcohols mixture changes evidently with the temperature and time. Samples have not weightlessness if they are prepared by the method of melting and crystallization of dissolvent.
- 2) Solid-solid phase change temperature and heat of NPG, TAM and PE are bigger, so it is suitable to thermal storage in the high or middle temperature.
- 3) The phase change temperatures and heats of binary system NPG/PE and TAM/NPG are much lower than that of single polyalcohols material. The phase change temperatures of binary system NPG/PE and TAM/NPG are between 30 centigrade and 41 centigrade. The phase change heat of binary system is bigger when the content of NPG is 50 to 90 percent, and they can be used as thermal storage material.
- 4) The phase change temperature of binary system PE/TAM is higher and about 130°C, and the phase change heat is lower. Therefore, it has no significant to thermal storage.
- 5) Triatomic polyalcohols system NPG/PE/TAM has

lower phase change temperature and heat. The phase change heat is above 70J/g when the content of NPG is up to 80% to 90%, and it has value in the thermal storage.

- 6) The binary and triatomic polyalcohols systems with a certain constitution are ideal materials used in the building in the phase change storage fields.

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