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Thermal Stability of Paraffin and Fatty Acid Mixtures

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Twenty kinds of paraffin mixtures and fatty acid mixtures were prepared. Phase change temperatures of mixtures are between 20 and 30 ºC and the phase change latent heats are bigger. The changes of phase change temperatures and latent heats of the phase change materials were tested by differential scanning calorimeter after multiple heat cycle. The results of the two kinds of mixtures were compared to discuss the thermal stability. The results showed that their thermal stabilities are good after 500 cycles and the phase change temperatures and latent heats have small fluctuations, but there is no obvious rule. The thermal stability of fatty acids mixtures is better than that of paraffin materials. Paraffin mixtures and fatty acid mixtures are ideal phase change material used for the wall to storage energy because of their good stability. The results can provide reference and basis for the application of paraffin and fatty acid in the field of building energy-saving.

Key Words: Paraffin, Fatty acid, Thermal stability.

INTRODUCTION

The application of phase change material in the wall was an effective method of improving indoor environment comfort, reducing energy consumption and decreasing negative effect to environment.

At present, studies of using phase change are gradually developing. The United States has carried out further studies in the preparation and performance of phase change material and the measures how to develop the materials' thermal performance[1]. Krichel and Schroeder studied phase change materials whose phase change temperatures are between -68 and 100 ºC[2,3]. Turkey mainly study the performance tests and heat transfer analysis of phase change boards. Sari and Kayqusuz studied the parameters such as transition times, temperature range and propagation of the solid-liquid interface as well as the effect of the heat flow rate on the phase change stability of stearic acid as a phase change material[4]. They also studied thermal stability of some fatty acids and their mixtures as phase change materials. The selected fatty acids were stearic acid, palmitic acid, myristic acid and lauric acid with melting temperatures between 40-63 ºC and industrial-grade with 90-95 % purity[5-7]. Sari[8] studied the thermal reliability of stearic acid, palmitic acid, myristic acid and lauric acid as latent heat energy storage materials with respect to various numbers of thermal cycles. Karaipekli *et al.*[9] evaluated the influence of expanded graphite and carbon fiber as heat diffusion promoters on thermal conductivity improvement of stearic acid. Expanded graphite and carbon fiber in different mass fractions (2, 4, 7 and 10 %) were added to stearic acid. Sari and Ahmet[10] prepared paraffin/high density polyethylene form-stable phase change materials and studied the thermal properties of solid-liquid phase change materials for thermal energy storage.

To find the more suitable phase change materials used in the wall, this paper prepared 20 kinds of paraffin mixtures and fatty acid mixtures with the phase change temperature of 20~30 ºC, so as to compare the thermal stability of two kinds of phase change materials. The changes of phase change temperatures and latent heats of the phase change materials were tested by differential scanning calorimeter after multiple heat cycle. The results of the two kinds of mixtures were compared to discuss the thermal stability.

EXPERIMENTAL

The DSC 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 60 mL/min and 20 mL/min respectively. In the experiment, the control temperature is from -150 ºC to 150 ºC. The increasing velocity of temperature is 8 ºC/min.

The materials *viz.*, 46# paraffin, liquid paraffin, capric acid, stearic acid, palmitic acid, lauric acid and myristic acid are purchased from Beijing Chemical Reagent Corporation.

Experimental samples are 20 kinds of mixtures and their compositions are shown in Table-1.

TABLE-1
EXPERIMENTAL SAMPLES

1	2
45 % 46# Paraffin-55% Liquid paraffin	50 % 46# Paraffin-50 % Liquid paraffin
3	4
55 % 46# paraffin- 45% Liquid paraffin	60 % 46# Paraffin-40 % Liquid paraffin
5	6
45 % 48# Paraffin-55% Liquid paraffin	55 % 48# Paraffin-45 % Liquid paraffin
7	8
60 % 48# Paraffin-40% Liquid paraffin	65 % 48# Paraffin-35 % Liquid paraffin
9	10
30 % Capric acid - 70% Stearic acid	60 % Capric acid - 40 % Stearic acid
11	12
90 % Capric acid - 10% Stearic acid	30 % Capric acid - 70 % Lauric acid
13	14
60 % Capric acid - 40% Lauric acid	90 % Capric acid - 10 % Lauric acid
15	16
30 % Capric acid - 70% Palmitic acid	60 % Capric acid – 40 % Palmitic acid
17	18
90 % Capric acid - 10% Palmitic acid	30 % Capric acid - 70 % Myristic acid
19	20
60 % Capric acid - 40% Myristic acid	90 % Capric acid - 10 % Myristic acid

RESULTS AND DISCUSSION

Twenty kinds of binary mixtures are prepared according to the determined mass proportion. Phase change materials were heated by infrared lamp and melted. They were cooled in the refrigerator. The process was performed repeatedly for 500 times. The phase change temperatures and latent heats of materials were tested by DSC every other 50 times. Each sample was tested by DSC in turn for three times and the average of experimental data was calculated.

The changes of phase change temperatures and latent heats of paraffin mixtures and fatty acid mixtures after thermal cycle for different times are shown in Figs. 1 to 8.

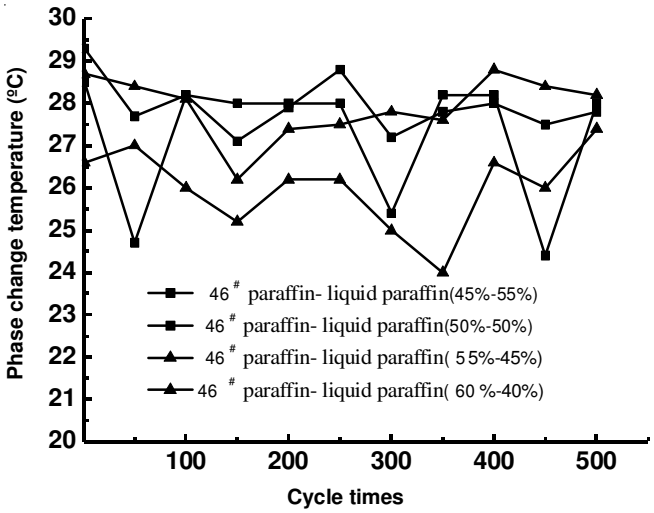

Fig. 1. Phase change temperatures of 46 # paraffin mixtures

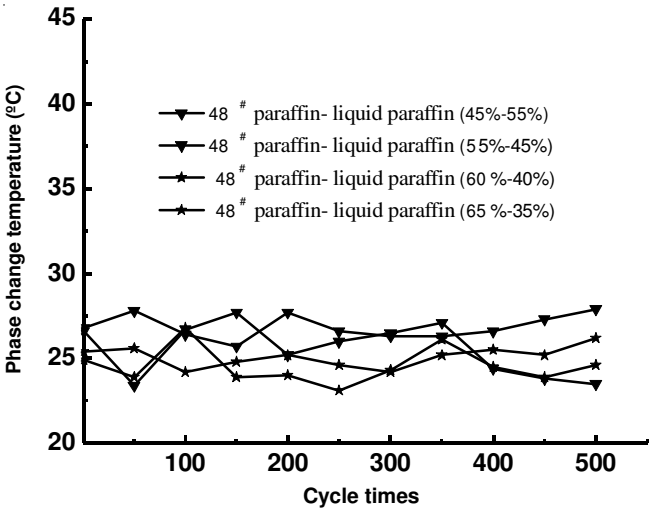

Fig. 2. Phase change temperatures of 48# paraffin mixtures

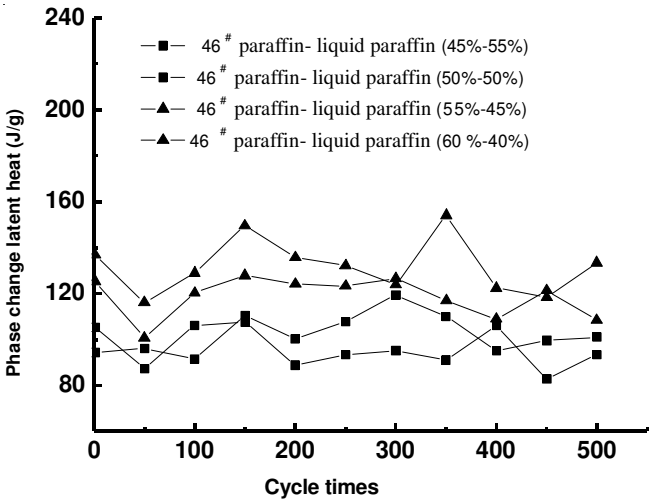

Fig. 3. Phase change latent heats of 46 # paraffin mixtures

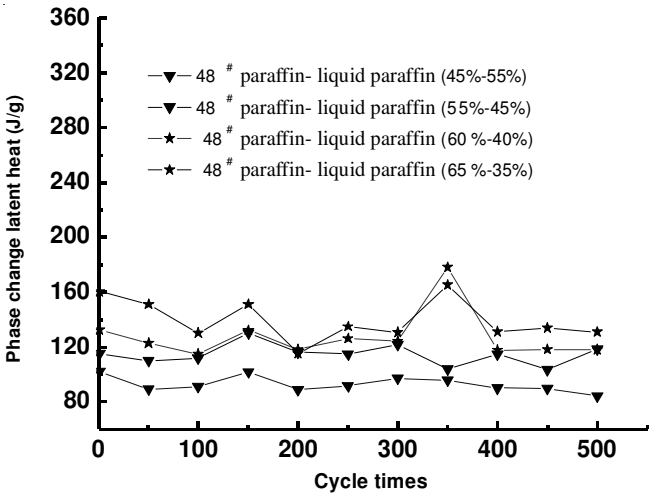

Fig. 4. Phase change latent heats of 48# paraffin mixtures

Figs. 1 and 2 show that the phase change temperatures of the paraffin mixtures fluctuate in a certain range, but there are no evident laws in the changes. The phase change temperatures of paraffin mixtures used in the experiment are between 24 and 30 ºC. The change in the phase change temperature of sample 5 is 1.34 ºC (5.3 %) and the highest among all paraffin

mixtures. The change in the phase change temperature of sample 2 is 0.46 ºC (1.7%) and the smallest among all paraffin mixtures. The temperature changes are small for all paraffin

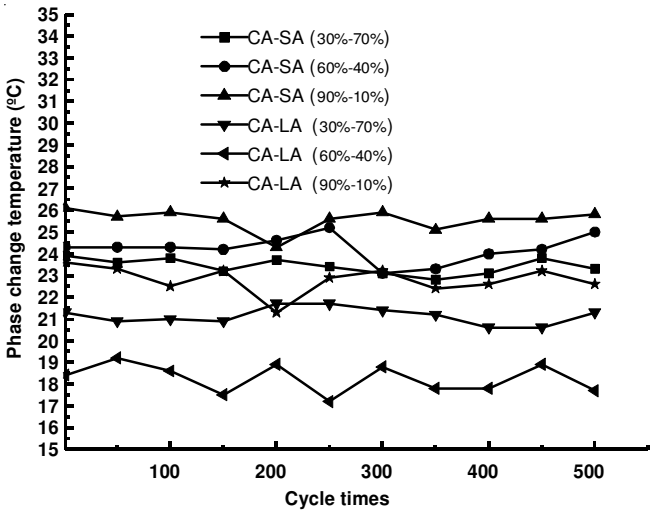

Fig. 5. Phase change temperatures of capric acid (CA)-stearic acid (SA) and capric acid-lauric acid (LA) mixtures

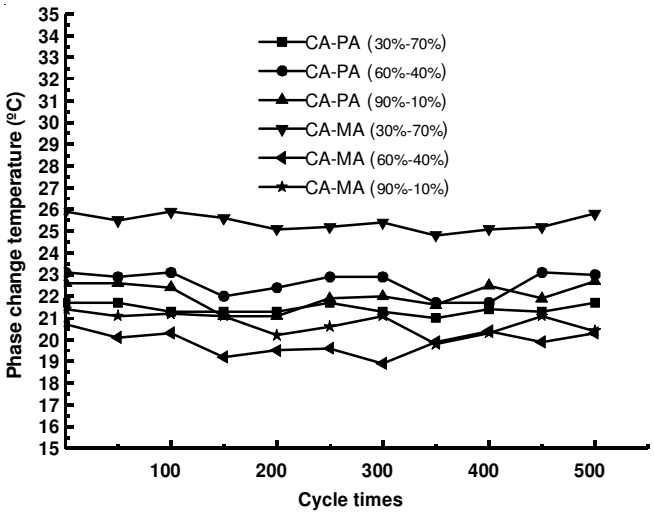

Fig. 6. Phase change temperature of capric acid-palmitic acid and capric acid-myristic acid mixtures

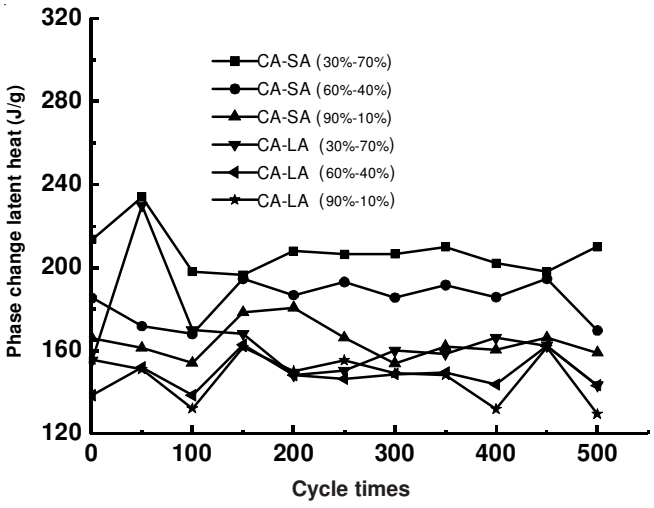

Fig. 7. Phase change latent heat of capric acid-SA and capric acid-LA mixtures

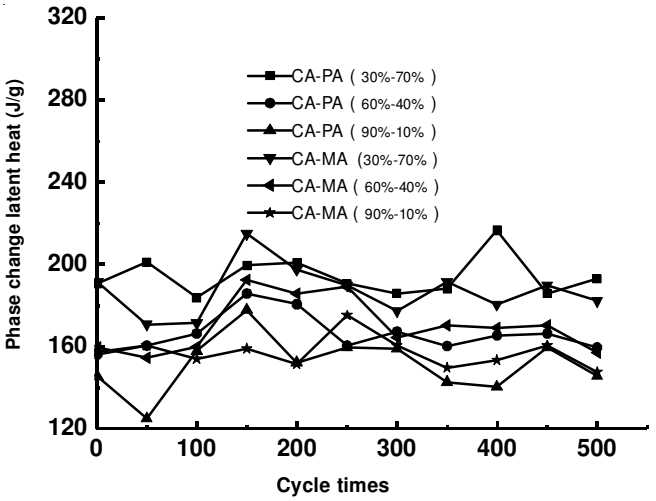

Fig. 8. Phase change latent heat of capric acid-palmitic acid and capric acid-myristic acid mixtures

mixtures and the paraffin mixtures are stable. Eight kinds of paraffin mixtures, by the temperature change rates, from small to large are sample 2, sample 7, sample 6, sample 3, sample 4, sample 8, sample 1, sample 5 and the average change rate is 2.9 %.

Figs. 3 and 4 show that the phase change latent heats of the paraffin mixtures are between 80 J/g and 160 J/g. The change rates of phase change latent heats are slightly larger than that of the phase change temperatures. The change rate of the phase change latent heat of sample 8 is 9.1 % and the biggest among all paraffin mixtures. The change rate of the phase change latent heat of sample 6 is 4.6 % and the smallest. Eight kinds of paraffin mixtures, by the change rates of latent heat, from small to large are sample 6, sample 5, sample 3, sample 2, sample 4, sample 1, sample 7, sample 8 and the average rate is 6.8 %.

Figs. 5 and 6 show that the phase change temperature changes of fatty acid mixtures are smaller than that of paraffin mixtures and the thermal stability of fatty acid mixtures is better than that of paraffin mixtures. The phase change temperatures of the fatty acid mixtures are between 20 ºC and 26 ºC. The change in the phase change temperature of sample 13 is 0.6 ºC (3.3 %) and the biggest among all fatty acid mixtures. The change in the phase change temperature of sample 15 is 0.2 ºC (0.9 %) and the smallest among all fatty acid mixtures. The temperature changes are very small for all fatty acid mixtures and the fatty acid mixtures have good thermal stability. Twelve kinds of paraffin mixtures, by the temperature change rates, from small to large are sample 15, sample 9, sample 18, sample 11, sample 12, sample 10, sample 19, sample 20, sample 14, sample 17, sample 16, sample 13 and the average change rate is 1.8 %.

Figs. 7 and 8 show that the phase change latent heat of the fatty acid mixtures are between 120 J/g and 40 J/g. The change rate of the phase change latent heat of sample 12 is 7.4 % and the biggest among all fatty acid mixtures. The change rate of the phase change latent heat of sample 9 is 3.3 % and the smallest. Eight kinds of paraffin mixtures, by the change rates of latent heat, from small to large are sample 9, sample 20, sample 11, sample 16, sample 15, sample 13, sample 10,

sample 18, sample 19, sample 14, sample 17, sample 12 and the average change rate is 4.9 %.

After thermal cycle for 500 times, the latent heat values of phase change materials are still large and do not affect the thermal storage.

Considering from thermal stability and phase change latent heat, sample 1, sample 2, sample 5, sample 13, sample 14, sample 17 are not suitable for thermal storage in the wall. Other samples are ideal phase change materials used in the wall.

DSC curves of several samples are shown in Figs. 9 to 14. DSC curves of paraffin mixtures have one peak and that of fatty acids have several peak. The areas surrounded by the curves of fatty acids are more than that of paraffin, so the latent heat of fatty acids are bigger than that of paraffin.

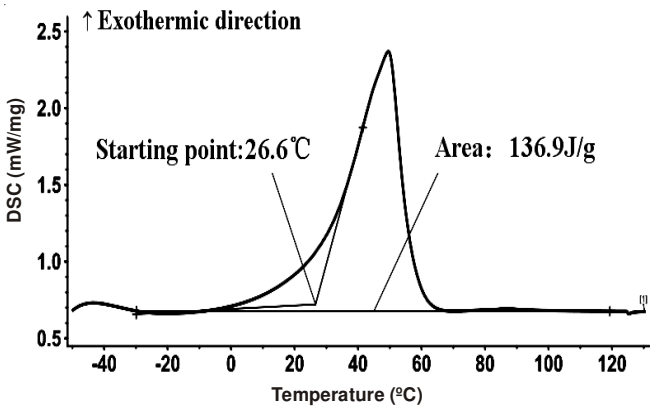

Fig. 9. 46# Paraffin- liquid paraffin (60 %-40 %)

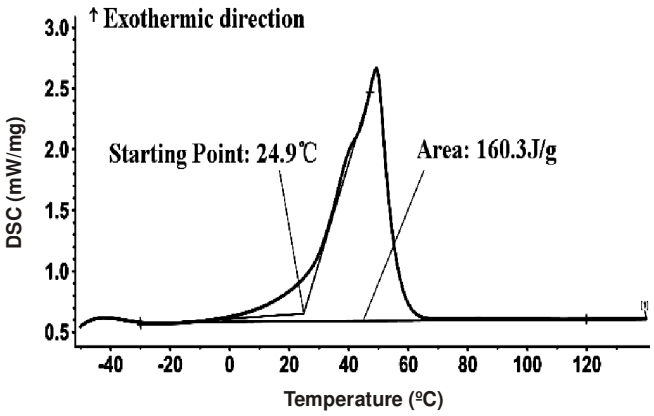

Fig. 10. 48# Paraffin- liquid paraffin (65 %-35 %)

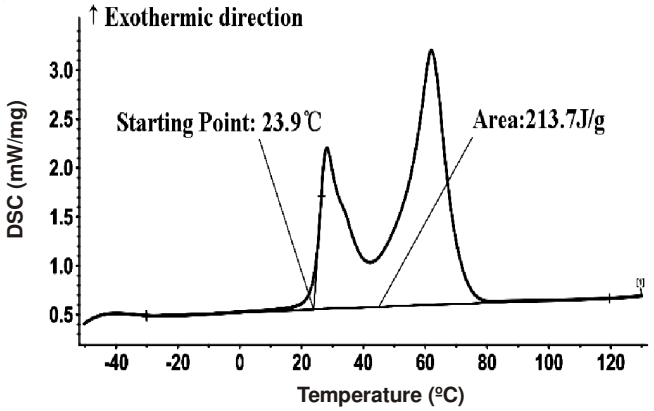

Fig. 11. Capric acid-stearic acid (30 %-70 %)

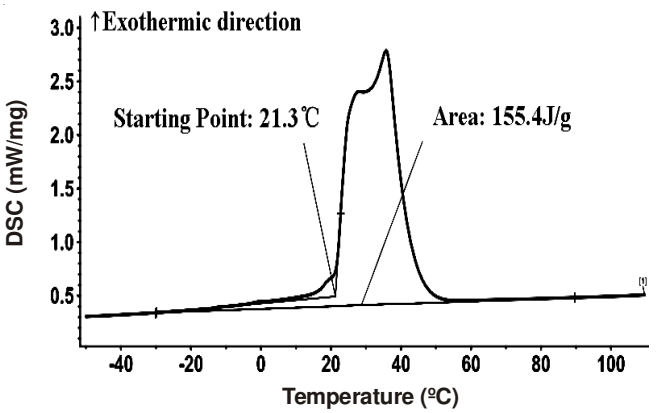

Fig. 12. Capric acid-lauric acid (30 %-70 %)

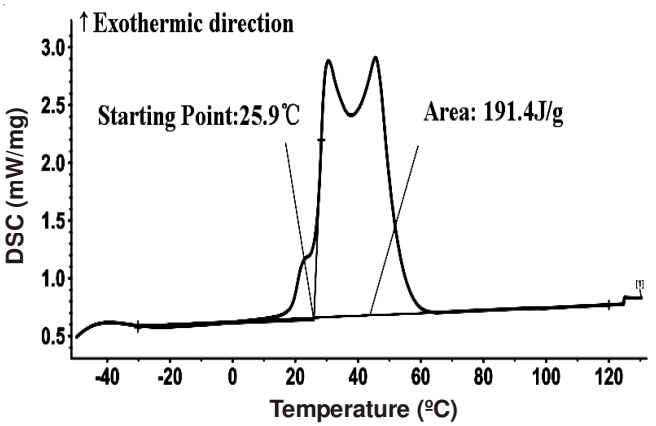

Fig. 13. Capric acid-palmitic acid (30 %-70 %)

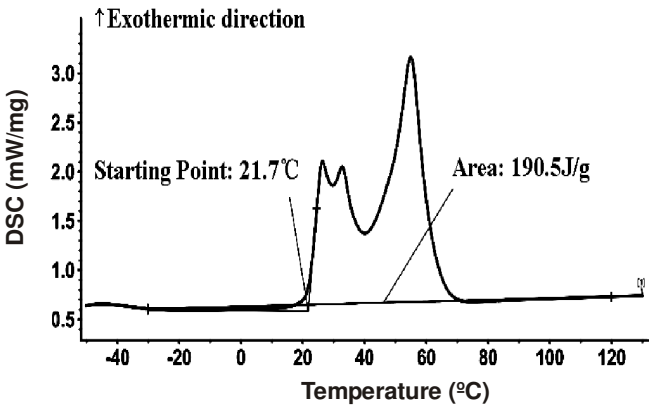

Fig. 14. Capric acid-myristic acid (30 %-70 %)

Conclusion

The phase change temperatures and latent heats of phase change materials studied in this paper have small fluctuations in the certain range, but there are no obvious laws. Thermal stabilities of the two kinds of mixtures are good after 500 thermal cycles. The average change rate of phase change temperatures of paraffin mixtures is 2.9 %. The average change rate of phase change latent heats of paraffin mixtures is 6.8 %. The average change rate of phase change temperatures of fatty acid mixtures is 1.8 %. The average change rate of phase change latent heats of fatty acid mixtures is 4.9 %. The change rates of fatty acid mixtures in the phase change temperatures and phase change latent heats are less than that of paraffin

mixtures. The fatty acid mixtures are more stable than paraffin mixtures. Paraffin mixtures and fatty acid mixtures in the paper have suitable phase change temperatures, large phase change latent heat and good thermal stability, so they are suitable phase change material used for the wall.

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REFERENCES

1. I.O. Anil and K. Sircar, Development of Phase Change Technology for Heating and Cooling of Residential Buildings and Other Applications. Proceedings of the 28th Intersociety Energy Conversion Engineering Conference, vol. 2, p. 134 (1993).
2. K.K. Latentwarmespeicher: Teil 1, Eigenshaften und Anwendungs Moglichkeiten von Latentwarmespeichern. Reprot BMVG-FBWT, 79-12, Institutfuer chemie der Treib-und-Explosivstoffe, Berghausen, FRG (1979).
3. K.K. Latentwarmespeicher: Teil 2, Speichermassen Bauformen und Werkstoffe Fuer Schmelzwarmespeicher. Reprot BMVG-FBWT, 79-13, Institutfuer chemie der Treib-und-Explosivstoffe, Berghausen, FRG (1979).
4. A. Sari and K. Kaygusuz, *Solar Energy*, **71**, 365 (2001).
5. A. Sari and K. Kaygusuz, *Renew. Energy*, **28**, 339 (2003).
6. A. Sari and K. Kaygusuz, *Renew. Energy*, **24**, 303 (2001).
7. A. Sari and K. Kaygusuz, *Solar Energy*, **72**, 493 (2002).
8. A. Sari, *Energy Conv. Manage.*, **44**, 2277 (2003).
9. A. Karaipekli, A. Sari and K. Kaygusuz, *Renew. Energy*, **32**, 2201 (2007).
10. A. Sari, *Energy Conv. Manage.*, **45**, 2033 (2004).