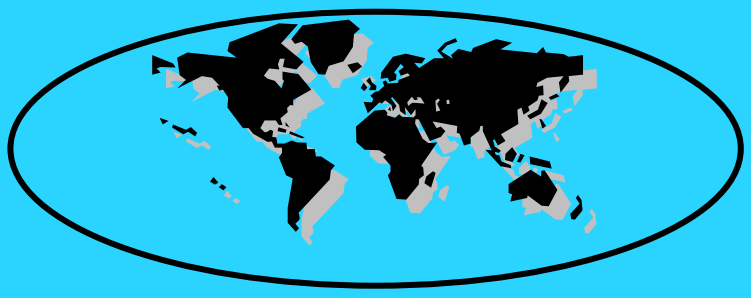

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ЭНЕРГИЯ ВА РЕСУРС ТЕЖАШ МУАММОЛАРИ

ПРОБЛЕМЫ ЭНЕРГО- И РЕСУРСОСБЕРЕЖЕНИЯ

PROBLEMS OF ENERGY AND SOURCES SAVING

Махсус сон (№85) **2024**

Энергия ресурсларидан фойдаланиш самарадорлигини ошириш учун мамлакатимиз энергетика тизимини ислоҳ қилишимиз, бу борада аниқ стратегия ишлаб чиқишимиз лозим.

Ш.М.Мирзиёев

Для повышения эффективности использования энергоресурсов нам необходимо реформировать энергетическую отрасль страны, разработать в этом направлении конкретную стратегию.

Ш.М.Мирзиёев

In order to increase the efficiency of energy resources, we need to reform the energy system of our country and develop a clear strategy in this regard.

Sh.Mirziyoyev

ЎЗБЕКИСТОН РЕСПУБЛИКАСИ ЭНЕРГЕТИКА ВАЗИРЛИГИ

ЎЗБЕКИСТОН РЕСПУБЛИКАСИ ОЛИЙ ТАЪЛИМ, ФАН ВА ИННОВАЦИЯЛАР ВАЗИРЛИГИ

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DETERMINATION OF THERMAL PROPERTIES OF VARIOUS MIXED PARAFFINS BY THE "T-HISTORY" METHOD

L.I. Ochilov, B.Sh. Ganiev, M.S. Mirzaev, K.A. Samiev

Ushbu ishda turli qotish haroratidagi va solishtirma issiqlik sig'imli materiallarni izlab topish maqsadida parafinni kimyoviy aralashtirishlar yo'li bilan aralashmalar sintez qilingan. Kimyoviy toza holadagi stearin kislota, palmitin kislota va sianur kislota namunalari parafinning fazaviy o'zgaruvchi material (FO'M) sifatida foydalanishida qo`llash uchun turli nisbatlarda aralashtirilib, olingan namunalar T-histori usulida tadqiqotlar laboratoriya sharoitida o'tkazilgan. O'tkazilgan tadqiqotlardan quyidagi natijalari kiritilgan. Unga ko'ra eng katta issiqlik sig'imiga va issiqlik o'tkazuvchanlik koeffisiyenti, ega bo'lgan 2 namuna $c_{p,s}$=8400 J/(kg °C) va k_s=0.217 watt/(m °C), eng katta sintez issiqligi 3 namuna H_m=4328.9·10^3 J/kg, eng ko'p vaqtda qotadigan 4 namuna t_f =29 minutni tashkil qildi.

Kalit so'zlar: *fazaviy o'zgaruvchi material (FO'M), paraffin, stearin kislota, palmitin kislota, sianur kislota, solishtirma issiqlik sig'imi, sintez issiqligi, issiqlik o'tkazuvchanlik koeffisiyenti.*

В данной работе для поиска материалов с различными температурами затвердевания и удельной теплоемкостью были синтезированы смеси методом химического смешения парафинов. Химически чистые образцы стеариновой кислоты, пальмитиновой кислоты и циануровой кислоты были смешаны в различных пропорциях для использования парафина в качестве материала фазового перехода (МФП) и полученные образцы исследованы методом Т-истории в лабораторных условиях. Приведены следующие результаты проведенных исследований. Согласно ему у 2 образцов с наибольшей теплоемкостью и коэффициентом теплопередачи $c_{p,s}$=8400 Дж/(кг·°С) и k_s=0,217 Вт/(м·°С) наибольшая теплота синтеза 3 образцов H_m= 4328,9·103 Дж/кг, 4 образца, которые затвердевали дольше всего, составили t_f =29 минут.

Ключевые слова: *Материала фазового перехода (МФП), парафин, стеариновая кислота, пальмитиновая кислота, циануровая кислота, удельная теплоемкость, теплота плавления, коэффициент теплоотдачи.*

*In this work, in order to find materials with different solidification temperatures and specific heat capacity, mixtures were synthesized by chemical mixing of paraffin**.** Chemically pure samples of stearic acid, palmitic acid and cyanuric acid were mixed in different proportions for the use of paraffin as a phase change material (PCM), and the obtained samples were studied by the T-history method in laboratory conditions. The following results of the conducted research are included. According to the results obtained on the basis of the conducted research, the largest heat capacity and heat transfer coefficient were established*

in sample 2: $c_{p,s}$=8400 J/(kg °C) and k_s=0.217 W/(m °C). The largest fusion heat was H_m=4328.9·103 J/kg in sample 3, and the longest solidification time was t_f =29 minutes in sample 4.

Key words: *phase change material (PCM), paraffin, stearic acid, palmitic acid, cyanuric acid, specific heat capacity, heat of fusion, heat transfer coefficient.*

Introduction. In 2020, global energy consumption and CO_2 emissions are expected to increase by 41% and 35%, respectively, over the last 20 years [1]. The Paris Agreement created an international framework for reducing greenhouse gas emissions, and each country agreed to achieve carbon neutrality by 2050, further reducing CO2 emissions [2].

Considering that the energy consumption of the construction sector is 36% of the total energy consumption worldwide and the CO_2 emission is 37% of the total emission, attention is paid to the use of solar thermal devices [3].

In recent years, increasing the efficiency of solar thermal devices by using phase change materials, using heat accumulators in ensuring the continuity of energy consumption has become important. [4]. Currently, differential scanning calorimetry (DSC) and differential thermal analysis (DTA) are among the most popular methods for rapid analysis of thermal properties of PCMs. The small size of the sample used in these devices reduces the possibility of obtaining complete information about the thermal properties of the substance over the entire volume [5]. "T-history" method is one of the methods that provides complete information about the thermal properties of PCMs and does not require a lot of money from a relatively economical point of view [6].

When PCM is formed using chemical mixtures, the following requirements should be considered, in which the substance has a melting temperature, high heat capacity, high latent heat capacity in a small volume range, solid and liquid in loading and transporting heat energy the phases should have good thermal conductivity, less chemical and physical changes during the phase change, and the substance should be unchanged during melting and solidification cycles of PCM [3].

The T-history method is a method that determines the thermal parameters of PCM by comparing the temperature graphs of PCM and water at the same temperature and the same volume as the temperature of the PCM is completely solidified [4]. Time dependence graphs of PCM and water temperatures are presented in Fig.1 and 2 [3].

Surfaces A_1, A_2, A_3, A_1', A_2' in the graphs in the pictures are the multiplication of temperature change over time. These surfaces can be determined using the following integral expressions [4].

$$A_1 = \int_{t_0}^{t_1}(T_0 - T_a)dt \quad (1)$$

T_0 -initial temperature, T_a -ambient temperature.

$$A_2 = \int_{t_1}^{t_2}(T_m - T_a)dt \quad (2)$$

T_m - temperature at which the solidification process of PCM begins.

$$A_3 = \int_{t_2}^{t_3}(T_s - T_a)dt \quad (3)$$

T_s - temperature at which PCM is fully solidified.

$$A_1' = \int_{t_0}^{t_1'} (T_0 - T_a)dt \quad (4)$$

$$A_2' = \int_{t_1'}^{t_2'} (T_s - T_a)dt \quad (5)$$

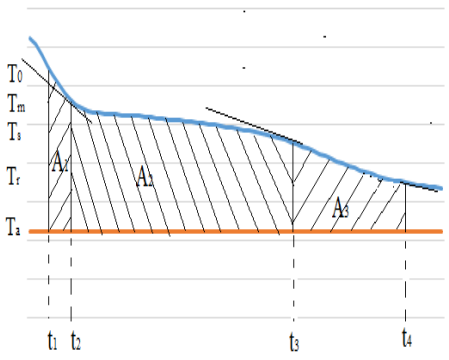

Fig.1. Time dependence graph of PCM temperature

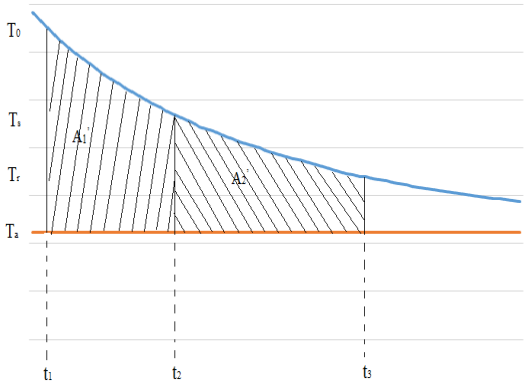

Fig.2. Time dependence graph of water temperature

The specific heat capacity of PCM during solidification is determined using the following equation.

$$c_{p,s} = \frac{m_t c_{p,t} + m_w c_{p,w}}{m_p} \frac{A_3}{A_2'} - \frac{m_t}{m_p} c_{p,t} \quad (6)$$

where, m_t and m_p- are the masses of the test tube and the PCM, respectively, m_w and $c_{p,w}$ mass and specific heat capacity of water, respectively, $c_{p,t}$- specific heat capacity of the test tube.

Its specific heat capacity in the liquid state is determined using the following equation.

$$c_{p,l} = \frac{m_t c_{p,t} + m_w c_{p,w}}{m_p} \frac{A_1}{A_1'} - \frac{m_t}{m_p} c_{p,t} \quad (7)$$

The heat of fusion of PCM is defined as follows.

$$H_m = \frac{m_t c_{p,t} + m_w c_{p,w}}{m_p} \frac{A_2}{A_1'} (T_0 - T_s) - \frac{m_t c_{p,t} (T_{m1} - T_{m2})}{m_p} \quad (8)$$

We can determine the heat transfer coefficient of PCM [6; 7].

$$k_s = \frac{\left[1 + \frac{c_{p,s}(T_m - T_a)}{H_m}\right]}{4\left(\frac{t_f (T_m - T_a)}{\rho_p R^2 H_m} - \frac{1}{h_m R}\right)} \quad (9)$$

where, k_s- heat transfer coefficient of PCM in solid state, ρ_p- density of PCM, t_f- complete solidification time of PCM, R-the radius of the cylinder of the test tube, h_m- the height of the part where the material sample is placed in the test tube.

In order to find materials with different solidification temperatures and specific heat capacity, mixtures were synthesized by chemical mixing of paraffin. The mixture was synthesized as follows:

Chemically pure samples of stearic acid, palmitic acid and cyanuric acid were mixed in different proportions for use in the use of paraffin as PCM. The synthesis or preparation methodology of the 5 samples to be prepared was carried out in the following order [6].

Sample 1: 10 g of paraffin was measured, 1.5 g of stearic acid and palmitic acid were added, and it was first mixed in a water bath with a magnetic stirrer at 50 °C. Then, increasing the temperature to 70 ºC, the synthesis was carried out for 2 hours until the mixture became a homogeneous system. The prepared sample was slowly cooled to room temperature and stored in a sealed container for further analysis.

Sample 2: To prepare the second sample, 10 g of paraffin was measured, 0.7 g of stearic acid and palmitic acid, and 0.6 g of cyanuric acid were added to it and slowly crushed in a porcelain lime. The mixture was first stirred in a water bath with a magnetic stirrer at 70 °C. Then, increasing the temperature to 90 °C, synthesis was carried out for 2 hours until the mixture became a homogeneous system. The prepared sample was slowly cooled to room temperature and stored in a sealed container for further analysis.

Table 1

Thermal properties of various mixtures

Specific heat capacity in sample 1 $c_{p,s}$=2715 J/(kg °C), heat of fusion H_m=258.5·10^3

Name of material	Specific heat capacity in the solid state $c_{p,s}$ J/(kg °C)	Specific heat capacity in the liquid state $c_{p,l}$ J/(kg °C)	Heat of synthesis H_m, 10^3 J/kg	Heat transfer coefficient k_s, W/(m °C)	Melting-solidification temperature range (°C)	Melting time (min)
Ordinary paraffin	5288	3545	256.172	0.168	45-54	22
Sample 1: Paraffin-77% Stearic acid-11.5% Palmitic acid-11.5	2715	3108.2	258.5	0.102	38-51	28
Sample 2: Paraffin-83% Stearic acid-6% Palmitic acid-6% Cyanuric acid-5%	8400	3401.7	163.8	0.217	42-53	20
3 - sample: Paraffin-83% Stearic acid-17%	3655	4328.9	394	0.138	40-54	28
4 - sample: Paraffin-83% Palmitic acid-17%	2855.5	3173.9	341.5	0.111	38-53	29
5 - sample: Paraffin-83% Cyanuric acid-17%	4538.98	2754	163.56	0.163	39-53.5	19

Sample 3: 10 g of paraffin and 2 g of stearic acid were measured and mixed together during this synthesis. The prepared mixture was first stirred in a water bath with a magnetic stirrer at 50 ºC. Then, increasing the temperature to 70 °C, the synthesis was carried out for

2 hours until the mixture became a homogeneous system. The prepared sample was slowly cooled to room temperature and stored in a sealed container for further analysis.

Example 4: This synthesis was also carried out according to the procedure of Example 3, and a sample was prepared by taking 2 g of palmitic acid.

Example 5. In contrast to the above syntheses, in this synthesis, 2 g of cyanuric acid was first liquefied in an electric heater at a temperature of 90-100 ºC. The resulting liquid was kept in a water bath with a magnetic stirrer at a temperature of 80-90 °C, adding 10 g of paraffin little by little, and the process was continued for 4 hours until the mixture became homogeneous. At the end of the synthesis, the sample was slowly cooled to room temperature and stored in a sealed beaker for further analysis.

The results of determining the thermal properties of the synthesized mixtures are shown in Table 1.

J/kg, heat transfer coefficient k_s=0.102 W/(m °C), melting time t_f=28 min, the melting-solidification temperature range was 38-51°C.

Specific heat capacity in sample 2 $c_{p,s}$=8400 J/(kg °C), heat of fusion H_m=3401.7·10^3 J/kg, heat transfer coefficient k_s=0.217 W/(m °C), melting time t_f =20 min, the melting-solidification temperature range was 42-53°C.

Specific heat capacity in sample 3 $c_{p,s}$=3655 J/(kg °C), heat of fusion H_m=4328.9·10^3 J/kg, heat transfer coefficient k_s=0.138 W/(m °C), melting time t_f =28 min, the melting-solidification temperature range was 40-54°C.

Specific heat capacity in sample 4 $c_{p,s}$=2855.5 J/(kg °C), heat of fusion H_m=3173.9·10^3 J/kg, heat transfer coefficient k_s=0.111 W/(m °C), melting time t_f =29 min, the melting-solidification temperature range was 38-53°C.

Specific heat capacity in sample 5 $c_{p,s}$=4538.98 J/(kg °C), heat of fusion H_m=2754 J/kg, heat transfer coefficient k_s=0.163 W/(m °C), melting time t_f =19 min, the melting-solidification temperature range was 39-53.5 °C.

Conclusions. By adding various acids to paraffin, it was possible to partially lower its melting point. At the same time, in some samples, the melting time increased significantly. The largest heat capacity and heat transfer coefficient were established in sample 2: $c_{p,s}$=8400 J/(kg °C) and k_s=0.217 W/(m °C), the largest fusion heat was H_m=4328.9·103 J/kg in sample 3, and the longest solidification time was t_f =29 minutes in sample 4.

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БУДУЩЕЕ «ЗЕЛЁНОЙ» ЭНЕРГЕТИКИ РЕСПУБЛИКИ УЗБЕКИСТАН

ГОДОВОЙ ТЕХНИЧЕСКИЙ ПОТЕНЦИАЛ ВОЗОБНОВЛЯЕМЫХ ИСТОЧНИКОВ ЭНЕРГИИ РЕСПУБЛИКИ УЗБЕКИСТАН

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