Simbirkina A. N.[1]***, Pogrebnaya E. A.***[1]***, Suchkov S. Yu.***[1]***, Potapov A. M.***[1]***, Sverdlikovskaya O. S.***[2]***,***
Chervakov D. O.[2]***, Chervakov O. V.***[2]

[1] **Yuzhnoye, State-owned Design Office named after M. K. Yangel. Ukraine, Dnipro**
[2] **State Higher Educational Institution "Ukrainian State University of Chemical Technology". Ukraine, Dnipro**

OPTIMIZATION OF THE PROCESSES OF FORMING HEAT-PROTECTIVE COATINGS BASED ON WATER POLYMER DISPERSIONS

Sprayed thermal protective coatings are used for short-term protection of the outer surfaces of aircraft from aerodynamic and other types of heating, as well as mechanical stresses. In the field of space technology, the task was set to create sprayable heat-protective materials with a density of 0.4–0.6 g/cm³ based on aqueous dispersions of polymers. These materials should be, first of all, non-combustible, not emit harmful substances during the manufacture of a liquid composition for application and directly from coatings based on them. [dx.doi.org/10.29010/89.5]

Keywords: *heat-shielding coating; aqueous dispersion of polymers; coating forming process.*

Introduction

Currently, testing of NTZP-U coating is being carried out under the production conditions of SE Yuzhnoye jointly with the State Higher Educational Institution Ukrainian State University of Chemical Technology (Dnipro).

NTZP-U is obtained by layering a liquid composition based on aqueous acrylic and urethane dispersions, glass and polymer microspheres, etc., onto the surface to be protected.

Water dispersions of polymers are characterized by the presence of two phases: solid — polymer particles (in our case, film former), and liquid — dispersion medium (water).

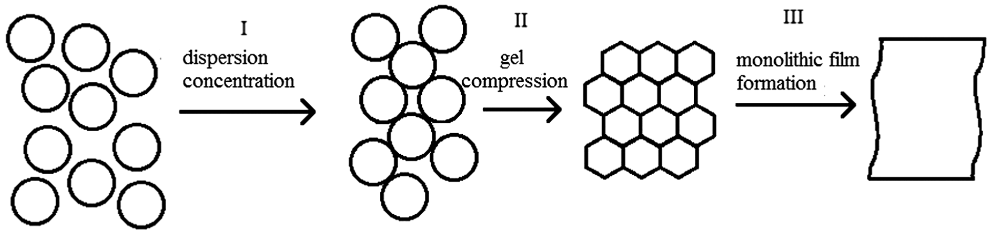

Fig. 1. Scheme of transformation of the polymer dispersion into a film during the evaporation of water

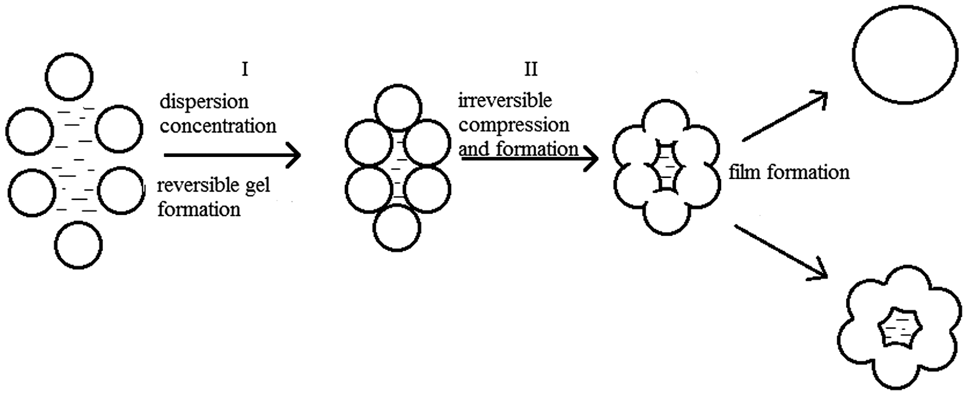

Fig. 2. Scheme of colloidal chemical transformations during the formation of films from dispersions

The ability of aqueous dispersions of polymers used as film-forming to form a film upon drying is the most important property. The process of formation of coating films from aqueous dispersions of polymers differs from that during the formation of films from organo-diluted systems. The film formation of systems based on aqueous dispersions of polymers is considered as a three-stage process. At the first stage, due to the removal of the dispersion medium — water, the solid phase (polymer particles) is concentrated, accompanied by gelation. At the second stage, the intermediate gel is compressed (contraction), which leads to the deformation of polymer particles.

Schematically, the processes occurring at stages 1 and 2 are presented, as shown in Figure 1, 2.

From the above diagram it follows that after the complete removal of water from the film, the last stage of film formation occurs, when the film acquires a characteristic structure and properties, a monolithic film is formed. The efficiency of the process of formation of a monolithic film with the participation of aqueous dispersions depends on the presence of coalescents in the last special additives, as well as on a temperature that should be higher than the minimum temperature of film formation (MTP) of the dispersion.

A feature of the studied NTZP-U liquid compositions for the production of heat-shielding coatings is their multicomponent nature; in addition, two aqueous dispersions are used as the film-forming one, one of which is capable of crosslinking, i.e. the formation of spatially crosslinked systems that contribute to the production of coatings with an increased complex of physical and mechanical properties.

From a technological point of view, it is very important to study the rate of moisture removal during the drying of formed coatings, both at room temperature and during heat treatment at temperatures of 40, 50 and 60°C. It should be noted that the process of water removal will be complicated when a set of up to 3–15 mm coating thickness.

To assess the rate of film formation, the kinetics of moisture evaporation was studied in the process of obtaining free films from aqueous dispersions of various types.

Figure 3 shows the curves characterizing the kinetics of moisture evaporation during the formation of films from dispersions 1, 2, and 3 at a temperature of 80°C, for the construction of which the water content W in the dispersion sample was determined depending on the time of heat treatment. Kinetic curves of moisture evaporation during film formation in the first stage of the process, when the concentration of the dispersed phase in the dispersion increases as a result of water evaporation

To estimate the rate of film formation, moisture evaporation was studied in the process of obtaining free films from various types of aqueous dispersions. Figure 3 shows the curves characterizing the kinetics of moisture evaporation during the formation of films from dispersions at a temperature regime for the construction of which the water content W in the image of the dispersions was determined depending on the time

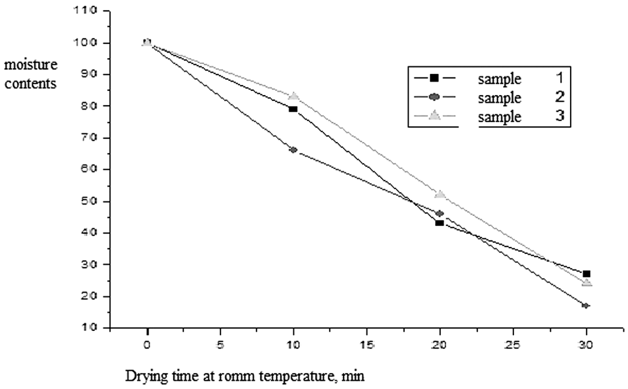

Fig. 3. Kinetic moisture evaporation curves during film formation from aqueous dispersions

of heat treatment. The kinetic curves of moisture evaporation during film formation at the first stage of the process, when the concentration of the dispersed phase in the dispersion increases as a result of water evaporation, are of the same nature. In the second stage of drying, it follows the concentration of the dispersion, the approach of the globules and gelation.

Determination of the optimal value of the dynamic viscosity of the liquid composition to obtain NTZP-U coating and its effect on the processability of application and the quality of the resulting NTZP-U coating. Dynamic viscosity was measured with a Brookfield viscometer.

In this study, we determined that the optimal dynamic viscosity is 1300 mPa · s, after the formation of the coating, a number of studies were carried out in the future and determined the characteristics for this viscosity presented in Table 1, 2. The results of the study comply with the requirements of TU 26.82.16.300-UGHTU-14308304-2014.

Accelerated climate tests taking into account the impact of operational factors. This study determines the possibility of using the NTZP-U outer heat-shielding coating in rocket and space technology after simulating impacts using the USP method, warehousing for 12 years and simulating being in the field for 5 years.

Table 1

Sample serial number	Densiby, g/cm³
Sample № 1	0,45
Sample № 2	0,47
Sample № 3	0,47
Sample № 4	0,46
Sample № 5	0,47
Sample № 6	0,47

Table 2

Sample serial number	Tear strength, MPa
Sample № 7	1,2
Sample № 8	1,0
Sample № 9	1,1
Sample № 10	1,2
Sample № 11	1,2
Sample № 12	1,2

To simulate storage in warehouse conditions, 12 test cycles were carried out, and aging was performed in each cycle, exposure in workshop conditions, exposure in a humidity chamber.

To simulate storage in the field, 5 test cycles, seasonal temperature differences were carried out. In each cycle, exposure to heat was performed, exposure to workshop conditions, and exposure to cold.

Aging was carried out at a temperature of 72°C for 6 days 10 hours.

10 cycles of moisture resistance tests were carried out.

After the work was carried out to determine the tensile strength. The results are presented in table 4. The results obtained are consistent.

Table 3

The moisture content in NTZP-U during hot drying

Layer number	The moisture content (%) during hot drying for 30		
	40°C	50°C	60°C
1-st layer	23	21	21
3-rd layer	54	52	49

Conclusions

Studies of the external heat-protective coating NTZP-U in full showed compliance with all requirements according to TU 26.82.16.300-UGHTU-14308304-2014. The data in the tables show stable composition results based on aqueous dispersions. Also, the coating is high-tech, allowing to apply coatings of various thicknesses, the formation of coatings is carried out both at ambient temperature and under conditions of slight heating (up to 70–80°C); It is also allowed on the NTZP-U formed coating to apply coatings of the type antistatic enamel HP-5237 black or ET-147 green.

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***Симбиркина А. Н.*[1]*, Погребная Е. А.*[1]*, Сучков С. Ю.*[1]*, Потапов А. М.*[1]*, Свердликовская О. С.*[2]*, Черваков Д. О.*[2]*, Черваков О. В.*[2]**

[1] **Государственное предприятие «Конструкторское бюро “Южное”» им. М. К. Янгеля. Украина, г. Днепр**
[2] **Государственное высшее учебное заведение «Украинский государственный химико-технологический университет». Украина, г. Днепр**

ОПТИМИЗАЦИЯ ПРОЦЕССОВ ФОРМОВАНИЯ ТЕПЛОЗАЩИТНЫХ ПОКРЫТИЙ НА ОСНОВЕ ВОДНЫХ ДИСПЕРСИЙ ПОЛИМЕРОВ

Напыляемые теплозащитные покрытия применяются для кратковременной защиты внешних поверхностей летательных аппаратов от аэродинамического и других видов нагрева, а также механических воздействий. В области космической техники было поставлено задание по созданию напыляемых теплозащитных материалов с плотностью 0,4–0,6 г/см³ на основе водных дисперсий полимеров. Данные материалы должны быть, в первую, негорючими, не выделять вредных веществ при изготовлении жидкой композиции для нанесения и непосредственно из полученных на их основе покрытий. [dx.doi.org/10.29010/89.5]

Ключевые слова: *теплозащитное покрытие; водная дисперсия полимеров; процесс формования покрытия.*

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