INVESTIGATION OF FIRE-RESISTANT METAL COATINGS

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Abstract. *Analysis of the available data shows that the amount of material damage increases as a secondary factor due to damage to metal structures of buildings and structures in man-made emergencies related to fire. The treatment of metal structures of buildings and structures with fire-resistant coatings is one of the urgent measures to reduce the amount of damage observed in such cases.*

Keywords: *flame retardant coating, acrylic copolymer, water-dispersion acrylic copolymers.*

Introduction. In the foreign literature, it stated that research is underway on the synthesis of high temperature resistant acrylic copolymers based on the derived characteristics of film-forming copolymers of acrylic acid. In this research work, practical experiments carried out to obtain a dispersion copolymer based on an acrylic monomer for use in fire-resistant metal structures of buildings and structures. Special attention paid to the physicochemical properties of organic monomers obtained for the experiment [1-2].

Methods and materials. In this research work, the synthesis of the acrylic-urethane copolymer carried out during practical experiments on the synthesis of an adhesive-specific flame-retardant coating with the participation of an acrylic monomer [3].

In the method of obtaining a copolymer of acrylic-styrene-urethane dispersion, distilled water, acrylic (acrylic acid and butyl acrylate ether), styrene monomers, and a urethane oligomer applied to a flask with three necks and the copolymerization process carried out for 8 hours at a temperature of 75°C, in a nitrogen medium. During the reaction, an initiator, a catalyst and a surfactant added to the mixture.

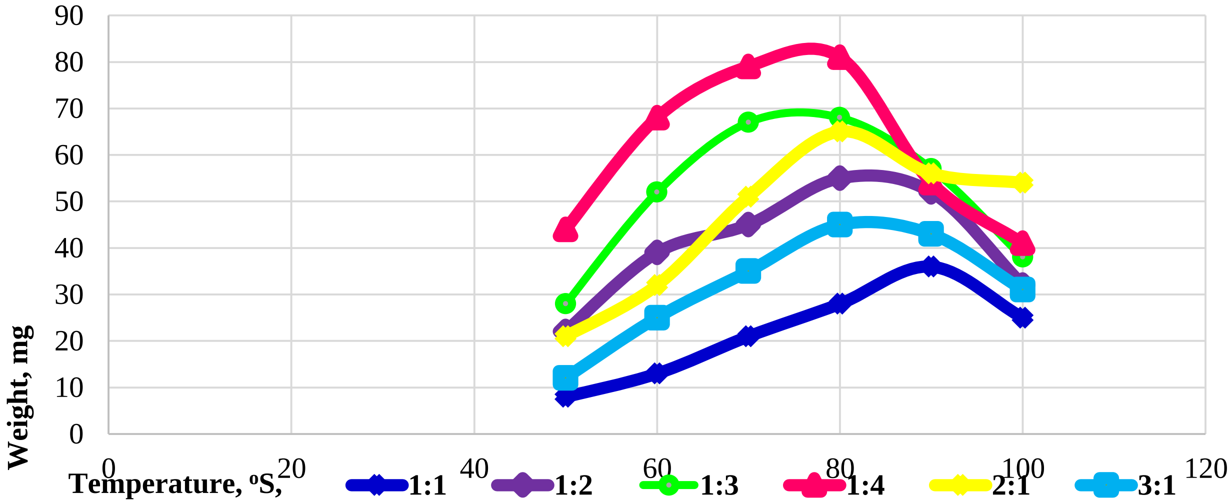


Figure 1. Influence of temperature and mass ratios on the reaction product.

During a practical experiment, the resulting copolymer shaken in methanol and dried in a vacuum oven for 6 hours. The properties of the finished acrylic-urethane copolymer dried in the furnace have been studied using modern methods. When analyzing the results of the reaction of acrylic monomers and urethane oligomers in various proportions and temperatures, at a temperature of 75-80°C, the mass ratios of the starting substances show high results in a ratio of 4:1 (fig. 1).

In the course of practical experiments, a copolymer of acrylic-styrene with urethane, having a characteristic coating, obtained. In the course of this study, optimal conditions for the synthesis of the acrylic-styrene-urethane copolymer were determined.

Results and discussion. To analyze the position of carbon bonds in the main chain of a dispersed acrylic-styrene-urethane copolymer synthesized during this practical experiment, the parameters of the nuclear magnetic resonance of the copolymer were analyzed when it was dissolved in the solvent dimethyl sulfoxide [4]. In experiments, the composition and functional groups of the acrylic-styrene-urethane copolymer were studied by proton signals in the nuclear magnetic resonance spectra (fig. 2).

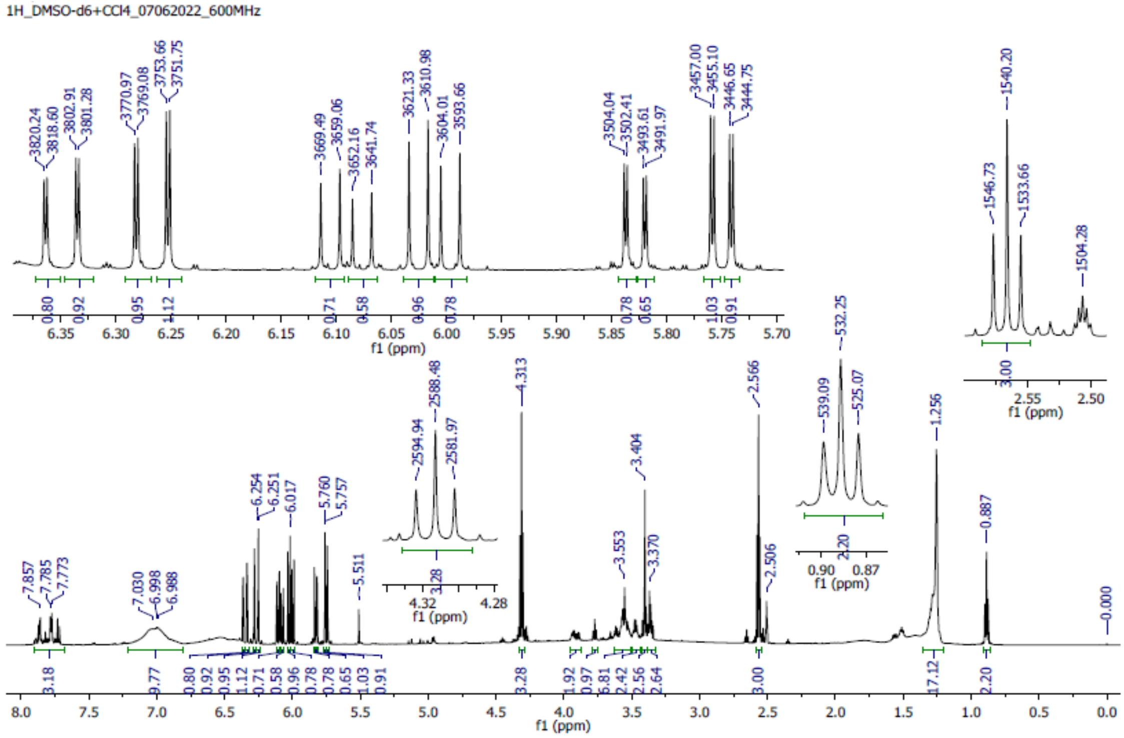


Figure 2. NMR spectrum of acrylic-styrene-urethane copolymer.

Nuclear magnetic resonance (NMR) spectroscopy makes it possible to characterize the sequence and distribution of monomers in the copolymer structure. In particular, resonant absorption of methyl (-CH) protons about δ 0.887-1.256 ppm and strong absorption of methylene ($-CH_2$) protons in the band about δ 2.506-2.566 ppm were observed in these NMR spectrum indicators.

The protons of the aromatic ring of the styrene monomer show two broad bands, one of which belongs to orthoprotons about δ 3.404 ppm, and the other to meta and para protons, which are in the range δ 7.753-7.857 ppm. The acrylic monomer in the copolymer (OSN_2) proton is about δ 4,313-ppm, and the protons α-CH_2, β-CH_2 and $-CH_3$ observed in the spectrum δ 2,581-2.594 and 5,757-5,760 ppm. In addition, resonant signals near δ 1,256-2,506 and 3,370-3,404 ppm are manifested by methylene protons C-3 and C-2.

Protons of acrylic-styrene-urethane copolymer –($OHCO_2$) were observed in the form of a triplet about δ 6,988-7,030 ppm. Attribute the wide signal of about δ 7,773-7,857 ppm to the protons α-CH and β-CH2 of styrene and acrylic monomers.

The analysis of the NMR spectrum of the acrylic-styrene-urethane copolymer obtained during practical experiments indicates that the acrylic-styrene monomers and urethane oligomers that have entered into the copolymerization reaction have entered into grafted copolymerization

In the course of practical experiments, the resulting acrylic-styrene-urethane copolymer studied based on established norms for its physico-mechanical properties (particle size, density, viscosity and kinematic viscosity). A comparative analysis of the identified indicators of the copolymer coating in relation to analogues also carried out (table 1).

In accordance with this table, it was determined that the kinematic viscosity of the acrylic-styrene-urethane copolymer is 1600 MPa*s, which is revealed to be more than the indicator for the acrylic-styrene coating and less than the indicator for the acrylic-urethane coating. When comparing the density indicators of these coatings, it found that acrylic-styrene-urethane has a higher density compared to analogues of copolymer coatings. It was also found that the adhesion characteristics of the polymer coatings obtained during the study were positive compared to their analogues in a coating containing acrylic-styrene-urethane.

Table 1.

Comparative analysis of physical and mechanical parameters of acrylic-styrene-urethane copolymer in relation to anologs

№	**Coatings**	**Coating grades**	**Particle size** (microns)	**Density 20-23°C** (g/cm^3)	**Adhesion** (point)	**Kinematic viscosity** (MPa*s)
1	Acrylic-styrene-urethane	ASU	0.02	1.45	2	1600
2	Acrylic-styrene	BS-24	0.15	1.04	1-2	1500
3	Acrylic - urethane	AC-PU	0.075	1,37	2	3000

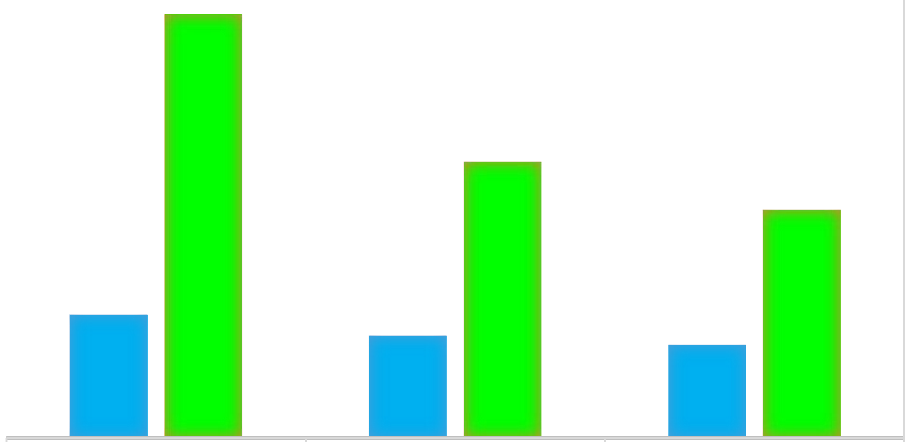
In order to study the flame-retardant properties of this dispersed acrylic-urethane copolymer, the oxygen index of the copolymer studied using test experiments.

For this purpose, a sample of a copolymer film with a size of 50:25 mm was prepared in accordance with GOST 12.1.044-2018 and placed in a device for determining the oxygen index (Limited Oxygen Index Tester). Before burning the sample, the oxygen index was set at 18%. At each stage of the practical experiment, the oxygen index increased by 1% during the combustion of the sample [5-6].

In the process, when the oxygen index reached 41%, the burning state of the film observed. It found that a 50:25 mm coating film sample burns for 2 minutes and 21 seconds at an oxygen index of 41%. In the course of a practical experiment, it proved that the average value of the oxygen index of the dispersion acrylic-styrene-urethane copolymer, which is a coating based on an acrylic monomer, is 41.

In the course of research experiments, oxygen indices of analogues of acrylic-styrene-urethane copolymers, i.e. acrylic-urethane and acrylic-styrene dispersion copolymers, were determined using the above method. A comparative analysis of the flammability of these dispersion copolymers also carried out (fig. 3).

According to the results of determining the oxygen index of copolymers and a comparative analysis of their indicators, it was found that the oxygen index of acrylic-styrene-urethane copolymer on an acrylic basis obtained during research experiments is higher than that of its analogues.



	Acrylic-styrene-urethane	Acrylic-urethane	Acrylic-styrene
Oxygen index (%)	41	34	31
Burning time (sek.)	141	92	76

Figure 3. Acrylic based oxygen index values

Thus, in the course of this study, the expediency of using a dispersion acrylic-styrene-urethane copolymer as a coating to increase the fire resistance of metal structures of buildings and structures was scientifically considered.

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