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STUDY OF IR AND THERMAL ANALYSIS OF MODIFIED POLYVINYL CHLORIDE

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Abstract
Fire retardants based on polyphosphate ammonium-containing metal oligomers have been obtained. When comparing the IR spectroscopic analysis of the sample under study with analogues, it was found that the characteristic relationships are close to each other.
Based on the results of DTA and TGA analysis, kinetic parameters were determined for various temperature ranges of the process. Its advantage is based on the experimental data obtained on the kinetics of processes in the temperature range from 100°C to 600°C; the properties of thermal-oxidative destruction of samples with 5-30% fire retardants have been studied.

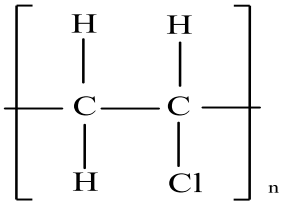
Keywords: cable, fire resistance, polymer, coating, oligomer, fire retardant, monomer, polyvinyl chloride, composition, heat resistance, melamine, polyphosphate, grade, analysis, thermal, mass.

Introduction

About 30% of fires occurring in the world in recent years are caused by short circuits in electrical cables; as a result of accidents, buildings and structures become unusable. Polyvinyl chloride polymers, which form the basis of electrical cables, are treated with fire retardants to increase their fire resistance. Such processing of cable materials based on polyvinyl chloride will increase by 5.7% in 2022. Much attention is paid to the production of oligomeric flame retardants to increase the fire resistance of electrical cables and polymer coatings, improve their rheological, physical and mechanical properties.
Scientific research is being conducted around the world to research and develop technologies for producing oligomeric flame retardants to reduce the flammability of cables based on polyvinyl chloride polymers. In this regard, to increase the fire resistance of polymer materials,

it is of particular importance to determine the optimal composition and physicochemical properties of oligomeric fire retardants containing metal and to study the mechanism of action of modifying fire retardants with polymers.

Polyvinyl chloride is a cheap and mechanically stable organic raw material, widely used in almost all areas of industry. Polyvinyl chloride is heat-resistant, actively decomposes with the release of hydrogen chloride and other compounds when exposed to high temperatures. Polyvinyl chloride is used in polymer formulations and in various mixtures that make the polymer practical for recycling. In the production of polyvinyl chloride, it is obtained by emulsion polymerization of vinyl chloride monomer [1].



(1.1)

Polyvinyl chloride compositions are intermediate products for the production of various types of products. Depending on their composition, they are divided into soft and hard. PVC-MP-Mg (polyvinyl chloride-melamine-polyphosphate-magnesium) compositions always contain thermal stabilizers and lubricants, as well as impact modifiers designed to absorb the impact energy of plastic deformation. They are most often used in the production of hoses, furniture and tiles [2].

In recent years, analysis of the global polyvinyl chloride market shows that consumption volumes are growing. According to experts, about 70% of produced polyvinyl chloride raw materials are consumed by the construction industry. The amount of consumption of this polymer depends on the area of the construction site (Fig. 1) [3].

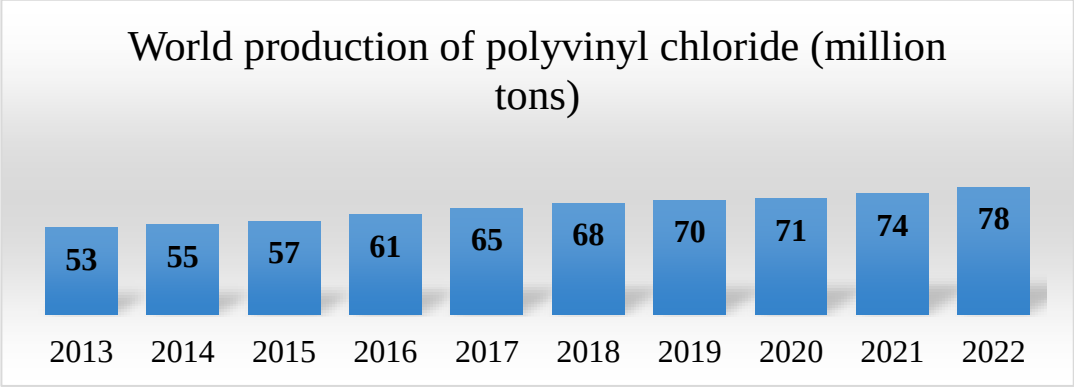


Figure 1. World production of polyvinyl chloride.

Globally produced polyvinyl chloride:

42% of raw materials are used for the production of pipes and fittings, 19% for profiles, 17% for sheets, 9% for cable production, 13% for general purposes.

It was estimated that 9% of the world's polyvinyl chloride production is used in the production of cable and wire coatings. In recent years, significant research has been carried out to further improve the properties of this polymer coating, resistance to high temperatures and fire resistance.

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The product obtained by suspension polymerization of polyvinyl chloride is mainly used in cable plastics. In this case, the monomers in the polymer are distributed according to the molecular weight distribution. Polyvinyl chloride, used in cable sheaths, has a molecular weight from 60,000 to 100,000. Polyvinyl chloride is a plastic and is used for insulation and protection of wires and cables operated in the temperature range from -60°C to +105°C [4-5-6].

Experimental part

In order to increase the heat resistance of polyvinyl chloride, a fire retardant PVC-MP-Mg based on melamine polyphosphate containing magnesium was obtained. Also, in order to study the existing composition of the PVC-MP-Mg fire retardant, the IR spectrum indicators were analyzed (Fig. 2).

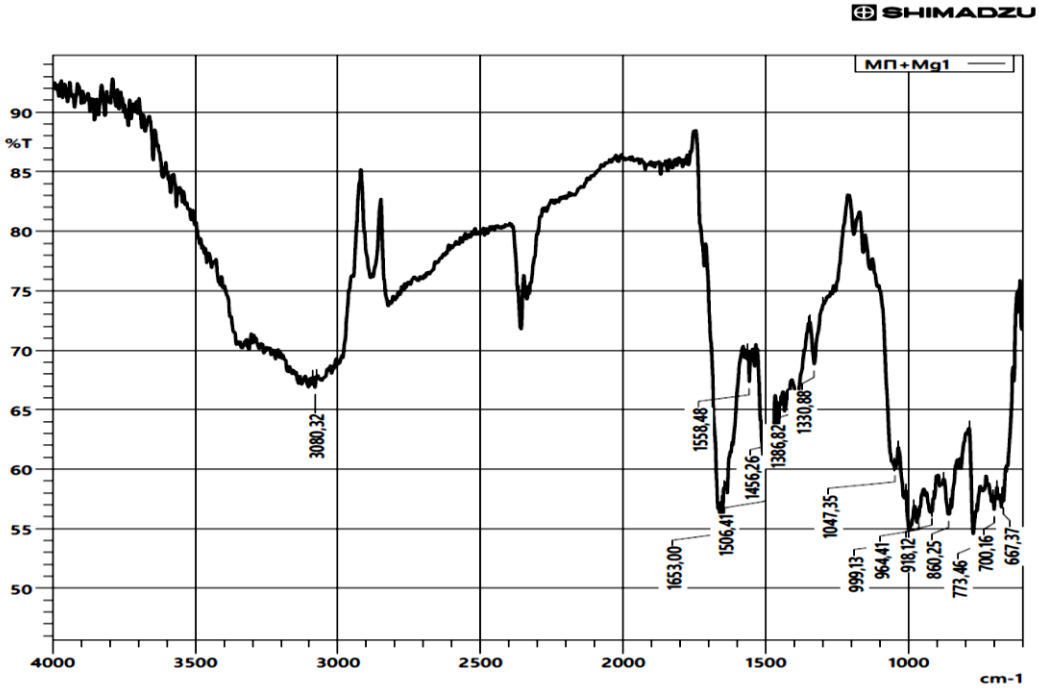

Figure 2. IR spectrum of the PVC-MP-Mg composite.

The main bonds characterizing, according to IR spectroscopy data, the fire retardant PVC-MP-Mg based on a melamine-polyphosphate-ammonium-magnesium compound are the following. With IR spectroscopy of melamine ammonium polyphosphate, it is possible to analyze bonds formed predominantly by phosphorus and nitrogen groups. You can analyze the presence of P=O bonds at 1100 – 1330 cm^{-1} and the presence of P-O- bonds at 999.13 – 1047 cm^{-1}. In this case, the analysis established the presence of P-O-P bonds in the fire retardant at 860-964 cm^{-1}. In addition, it was found that the groups characterizing bonds in melamine are C-H/NH_2 in the absorption regions of 773.13 - 860 cm^{-1}, and C=N bonds are present in the regions of 1500 - 1653 cm^{-1}. In addition, it was found that metal groups in the fire retardant contain absorption in the range of 667 – 700 cm^{-1}. In this way, fire retardants based on melamine-polyphosphate ammonium oligomers were obtained. When comparing the IR spectroscopic analysis of the sample under study with analogues, it was found that the characteristic relationships are close to each other.

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Results and its Discussion

In order to increase the fire resistance of plasticized PVC and propose its use as cables and cable coverings, modification with synthesized oligomeric fire retardants of the PVC-MP-Mg brand and their thermal stability were studied (Fig. 2).

DTA analysis revealed predominantly one endothermic lines: 286°C in PVC and 292°C in PVC-MP-Mg (5%), PVC-MP-Mg (10%), 296°C, PVC-MP-Mg (15%) 299°C, PVC , modified with flame retardants, -MP-Mg (20%) 308oC and PVC-MP-Mg (30%) 310oC were found during thermal analysis of polymers modified with fire retardants (DTA). Thus, the results of DTA analysis showed that the endothermic lines increase from 286°C to 310°C as the amount of fire retardants increases (Fig. 3).

Fire retardants of the PVC-MP-Mg brand, obtained as a result of modification of PVC by 5-30%, the degree of thermal decomposition under the influence of temperature increases with increasing amount of fire retardant. A temperature of 315°C was found to result in a 50% weight loss of PVC without flame retardants. Fire retardant material of the PVC-MP-Mg brand, modified with 5% PVC, had a weight loss of 50% at 350°C. Fire retardant material of the PVC-MP-Mg brand, modified with 10% PVC, has a weight loss of 50% at 400°C. The fire retardant composition of the PVC-MP-Mg brand, modified with 15% PVC, has a weight loss of 50% at 430°C. Fire retardant material of the PVC-MP-Mg brand, modified with 20% PVC, has a weight loss of 50% at 460°C. Fire retardant material PVC-MP-Mg modified with 30% PVC has a mass loss of 50% at 480°C.

It has been shown that when modifying PVC-MP-Mg PVC flame retardants in an amount of 5-30%, the thermal resistance of these polymer materials increases. In Fig. Figure 3 shows exothermic and endothermic processes at temperatures from 270°C to 330°C according to DTG. analysis. That is, after modifying PVC with flame retardants, it was analyzed that its decomposition temperature increases with increasing flame retardant content.

Based on the results of DTA and TGA analysis, kinetic parameters were determined for various temperature ranges of the process. Its advantage is based on the experimental data obtained on the kinetics of processes in the temperature range from 100°C to 600°C.

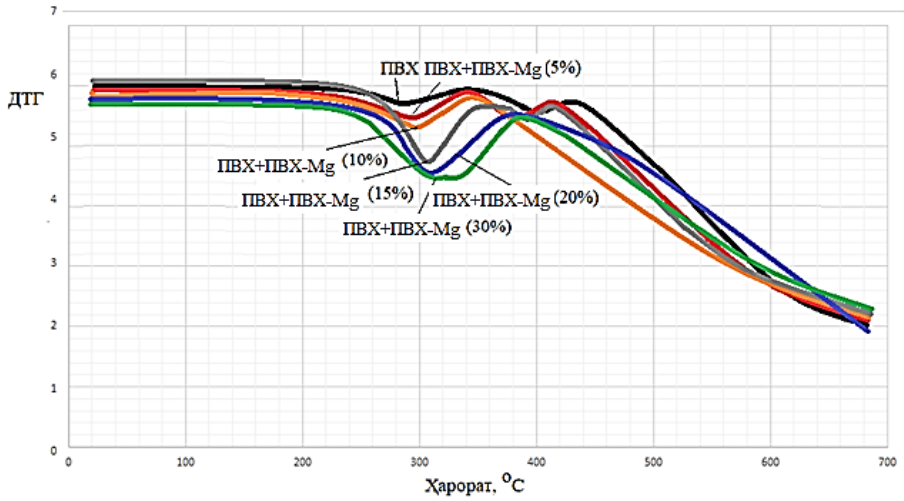

Figure - 3. Thermal analysis (DTA) of polymers modified with fire retardants of the brands PVC-MP-Mg (5%), PVC-MP-Mg (10%), PVC-MP-Mg (15%), PVC-MP-Mg (20 %) and PVC-MP-Mg (30%).

Fire retardants offered as part of various brands of fire-resistant PVC, which are in high demand among modern cable manufacturers, have a synergistic effect, are well modified by the polymer and do not have a negative effect on their properties.

Conclusions

In this way, fire retardants were obtained based on polyphosphate ammonium oligomers containing metal. When comparing the IR spectroscopic analysis of the sample under study with analogues, it was found that the characteristic relationships are close to each other.

It has been shown that when PVC is modified with fire retardants of the PVC-MP-Mg brand in an amount of 5-30%, the thermal stability of these polymer materials increases. DTG analysis shows exothermic and endothermic processes at temperatures from 270°C to 330°C. That is, after modifying PVC with flame retardants, it was analyzed that its decomposition temperature increases with increasing flame retardant content. Fire retardants offered as part of various brands of fire-resistant PVC, which are in high demand among modern cable manufacturers, have a synergistic effect, are well modified by the polymer and do not have a negative effect on their properties.

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