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DETERMINATION OF THE TOXICITY OF DISPERSION COATINGS BY THE THERMAL DESTRUCTION METHOD

M. A. Kurbanova[1],
Rakhmatova N. Sh.[2],
Bekmuratova M. G[2].
[1]Tashkent medical akademy
PhD, associate professor, senior pr. departments
"Medical and biological chemistry",
The Republic of Uzbekistan,100095, Tashkent city
E-mail: mohira_1974@mail.ru
[2]Tashkent Institute of Chemical Technology,
Senior Lecturer, departments
"Inorganic, analytical, physical-colloid chemistry",
The Republic of Uzbekistan,100095, Tashkent city
E-mail: mohira_1974@mail.ru

Abstract
The authors propose a method for determining the toxicity of flame retardants obtained on the basis of colloid-emulsion compounds, as additives for water-dispersed paints used in residential premises, by the method of thermal destruction of building materials. Toxicity is determined by a method based on the study of volatility, smoke formation during combustion and thermal oxidation of building materials using differential thermogravimetric analysis.

Keywords: colloid-emulsion composition, flame retardant, toxicity, thermal degradation, combustibility, water-dispersion paint, building materials.

For a general assessment of the state of the environment and to determine the share of participation of individual sources in its pollution, as well as to comprehensively assess the safety of food and non-food products, sanitary-hygienic and toxicological research methods are used. However, in order to predict the results of the influence of unfavorable factors on both ecosystems and human health, it is necessary to take into account many indicators that characterize the response of individual organisms and the ecosystem as a whole to technogenic impact [1–3].
Toxicological assessment is carried out by determining the dermal and mucosal irritant effects (using laboratory animals) or by determining the general toxicity (using alternative in vitro biological models). Testing using laboratory animals is

labor-intensive, time-consuming, expensive, and typically requires the use of large numbers of different types of laboratory animals, including mammals, which is ethically difficult. Therefore, the development of alternative toxicological research methods is an important task of our time. [3, 4]. When studying the state of affairs in the development of alternative methods for studying toxicity, a tendency towards expansion and complexity of both test systems and methods for analyzing cellular, tissue, and organ toxic reactions was identified. Improving analytical methods involves both the creation of more sensitive analytical systems, instruments and computer programs for data processing, as well as the development of new laboratory methods of analysis [2, 3, 5, 6].

There are a number of methods for determining the toxicity control of samples of natural, drinking, household and household wastewater, treated wastewater, sewage, melted water, process waters using the express method using a device of the “biotester” series, but the determination of the toxicity of colloidal emulsion waters is little known to this day. systems based on water-dispersion paints for interior use for residential premises, especially fire retardants; there is also no specific GOST definition of the toxicity of water-dispersion systems [7]. Depending on the composition of the product, there is a whole arsenal of different methods for organizing various products that are used in everyday life and determine safety for human health [8].

The method we propose for determining toxicity establishes a method for determining the toxicity of colloidal emulsion flame retardants AP-12 for water-dispersion paints for interior use during decomposition by volatility and thermal destruction of toxic substances present in the composition of fire retardants using DTA and DSC devices. The method is carried out as follows. The method for determining the toxicity of colloidal-emulsion systems based on water-dispersion paints is based on the ability of test objects to undergo oxidation reactions by volatilization of toxic substances that pose a danger to human health when breathing in a room painted with fire-resistant water-dispersion paints, directed volatilization and smoke formation of these substances (oxidative reaction) , avoiding their harmful effects.

The necessary assessments of the effectiveness of thermal degradation and thermal destruction of fire-resistant coatings can be determined using thermal analysis methods: thermogravimetry (TG), differential thermogravimetry (DTG) and differential thermal analysis (DTA), which allow one to give a qualitative and quantitative characterization of these processes [9].

Thermal destruction of the binder, which can occur through a rather complex mechanism, including the elimination of side groups and breaks in the main polymer chain. According to differential thermogravimetric analysis (DTA), when a fire retardant (AP) is introduced into polyethylene and water-dispersion coatings, its resistance to elevated temperatures in the air increases.

The stability of colloidal emulsion flame retardants at high temperatures is evidenced by their non-volatility during flight time.

When studying polymers, the issues of dependence of the heat resistance and thermal stability of polymers on their structure are important. A derivatographic study of polymer compositions determines the effect of a fire retardant on the flammability of polymers, showing the temperature at which decomposition begins, and the mass loss of the substance during thermal destruction [10-12].

The proposed silicon-containing colloidal-emulsion flame retardants are more accessible, cheaper compared to flame retardants of organic oligomers, and many of them are non-volatile, forming low-toxic gases during decomposition. Catalysis of carbon formation reactions is carried out in the presence of substances that lead to the appearance in the system of strong acidic agents of dehydration, cyclization, cross-linking (phosphates, silicic acids) and the release of non-flammable gases: H_2O, CO_2, NH_3.

According to the state standard Republic of Uzbekistan 16363-98 "Fire retardant products for wood", fire retardant efficiency is characterized by the loss of mass of a wood sample treated with a protective composition during a fire test. To determine the fire resistance of AP-1 fire retardant, several experiments were carried out to determine the flammability group.

Methods have been identified to improve fire safety in order to obtaining fire-resistant and toxic colloidal emulsion systems based on water-dispersion paints, modified with new types of fire retardants based on local raw materials through the study of various methods for determining the volatility and fire resistance and flammability of various water-dispersion paints used to obtain fireproof (building materials) materials.

Figure 1 shows DSC curves with a given temperature program for five different modified water-dispersion paints. For the sample modified with oligomeric fire retardant AP-1, AP-2, AP-3, AP-4, AP-5, AP-6, a maximum peak is shown at 327-349 oC, corresponding to the high-temperature resistance of the polymers.

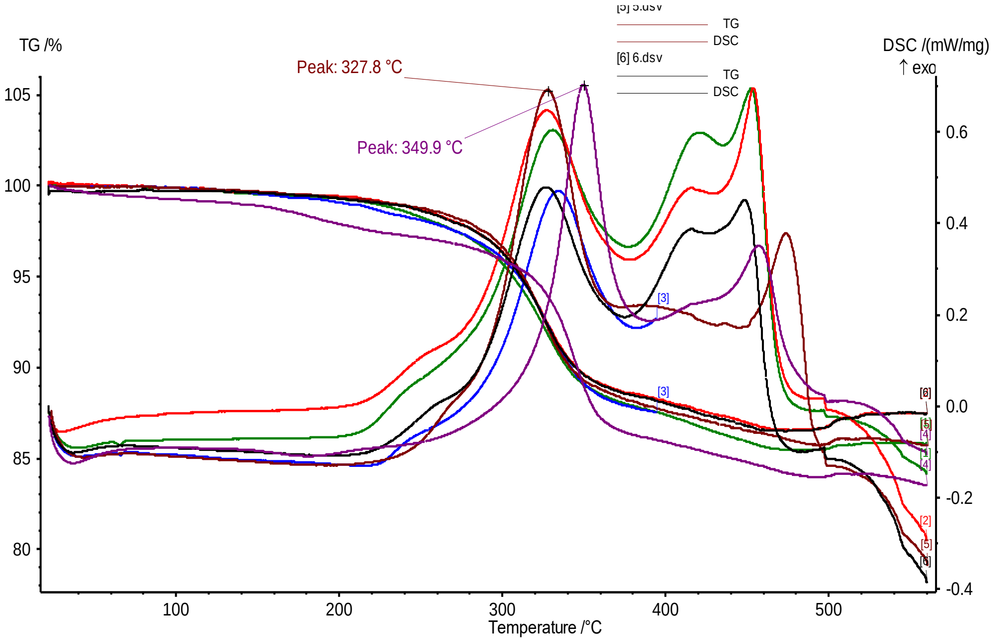

Fig.1. Comparison of thermal characteristics of samples (AP-1, AP-3, AP-4, AP-5, AP-6 and control sample) in water-dispersion paint; heating 5 K/min.

By integrating the peak area, the amount of heat required for melting can be calculated. The larger the peak area, the higher the degree of crystallinity. Samples or foreign components can be detected by DSC if they exhibit an intrinsic thermal effect in a temperature range different from that of the observed polymer.

Analysis of the volatilization of substances and thermal destruction of colloidal emulsion flame retardants in a water-dispersion system can be considered from the given indices that are used to characterize the thermal resistance of a number of polymers. They were obtained using dynamic thermogravimetric analysis, temperature (T) data corresponding to those used to characterize the thermal stability of polymers. They indicate weight loss points in different percentages (T_0-653K-, T_{10}-10%, -723K, T_{20}-20%-763K), (B) weight loss under isothermal conditions at one specific temperature: B_{673}. -3%, B_{783} - 34.0% [13].

Table 1 shows the values of the indices that are used to characterize the heat resistance of a number of polymers. They were obtained using dynamic thermogravimetric analysis.

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Table 1 Heat-resistant parameters of modified polymers according to dynamic thermogravimetric analysis

Polymer samples	Decomposition temperature, K				Weight loss at a certain temperature, %	
	T_0	T_{10}	T_{20}	T_{50}	B_{673}	B_{783}
LDPE-without stabilizer.	613	683	703	733	9	-
LDPE +AP-4 (0,5%)	643	703	733	753	6,8	37,9
LDPE +AP-4 (1%)	653	723	753	763	3,0	34,0
LDPE+AP-6 (2%)	633	693	733	783	4,1	38,2
LDPE +AP-5 (1%)	653	723	753	773	4,0	32,3

Note: kinetic parameters based on DTA data were calculated by the Freeman-Carroll method.

A methodology has been developed for a comprehensive study of fire technical characteristics of materials using standard methods for elucidating the characteristics of materials and the mechanism of action flame retardants, as well as for choosing a rational direction of work on creation of materials with reduced fire hazard by determining such fire-technical characteristics of materials as fire resistance, flammability, smoke generation, oxygen index and thermal oxidation stability of water-dispersion paints.

A selection of fire retardants available for use in the process of producing fireproof and non-toxic materials belonging to group I of fire-retardant efficiency is proposed by obtaining comparative characteristics of their fire hazard with the calculated values predicted based on the results of fire tests in laboratory installations. The introduction of the proposed flame retardants into PE, TM and water-dispersed coatings made it possible to slow down the process of thermal-oxidative destruction and increase heat resistance. The influence of flame retardants on the pattern of thermal-oxidative destruction of water-dispersion paints has been calculated [14].

The resulting new effective fire-retardant, heat-insulating paints and varnishes and fire retardants made it possible to transfer building materials from the flammability group (F4) to the low-flammability group (F1), as well as to scientifically prove the increase in the critical smoldering time of wood materials from 14 minutes to 18–19 minutes, i.e. . improvement by at least 1.1 times. The use of the results obtained in this work in a new composition of effective fire-retardant, heat-insulating paints and varnishes and fire retardants makes it possible to increase the strength of wood materials by 1.1%, heat resistance by 1.1–1.15%, and also scientifically prove the possibility of reducing the smoke generation coefficient to 1.2%, reduction in flame propagation speed by 1.2 times, which allows its use in the form of non-toxic materials [15].

Based on the conducted research, effective compositions that increase fire resistance and fire safety of buildings and structures by modifying water-dispersion paints used as coatings for building and cladding materials. It has been scientifically proven that this method of determining toxicity will make it possible to find ways of scientific solutions to reduce problems in the provision of fire safety and human health.

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