ANNOTATION

for the dissertation of Yerzhan Ormanbekovich Dzhakipbekov on the topic: “Development of technology for the production of polymer composites and their use to increase the fire resistance of structures and transportation of biological products”, submitted for the degree of Doctor of Philosophy (PhD) in specialty 6D072100 - “Chemical technology of organic substances”.

Relevance of the research topic. This dissertation is devoted to the study of multifunctional coatings that increase the fire resistance of wood and metal coatings.

Currently, fire-retardant coatings are widely used as a means of increasing the degree of fire resistance of buildings and structures, as they have high fire-retardant efficiency and productivity. At the same time, under the influence of elevated temperatures, the paint swells, does not burn, increases many times in volume and forms a porous layer endowed with thermal insulation properties.

The fire resistance of wooden structures can be increased chemically by adding a polymer reagent to the coating composition.

Chemical fire retardants make fire extinguishing easier, preventing the development of fire, and also eliminate the possibility of a fire.

The study examines various methods of fire protection of wooden structures, studies the influence of these compositions on some properties of the materials used, and examines the operating and storage conditions of fire-resistant structures.

Currently, scientists and researchers are developing fire-retardant paints and coatings, which include fire-resistant fillers, organic and inorganic binders. Work on the production and development of fire-retardant coatings “Pyro - TechLS” (England), “Barrier-87” (Italy), “MS” (Russia), etc. is widely known. These compositions have standard properties during operation, but their main disadvantage is the need to adapt to modern fire safety requirements and high cost.

Research into the production of domestic fire-retardant coatings has not been carried out thoroughly and systematically. In general, the work was purely technological and descriptive in nature and was limited to a number of studies commissioned by specific manufacturers. In this dissertation, it is proposed that instead of imported polymer reagents, we use polymers synthesized at the Department of «Oil Refining and Petrochemistry» of M. Auezov SKU as additives. The dissertation author received 2 patents for coating compositions (No. 4873 12/10/2019 and No. 2020/1072.2 dated 11/30/2020).

Another important area of application of polymer reagents is the production of antibacterial compositions. The polymer reagent acts as a carrier for transporting antibiotics. The paper presents the results of studies of the physicochemical properties of water-soluble polymer reagents and their compatibility with antibiotics. The production of new polymer drugs, from synthesis in laboratory conditions to their use and release by industry, as soft carriers (ointments), is a relatively expensive and time-consuming process. Therefore, the most promising

and justified is to expand the range of polymer reagents by modifying known basic samples. The polymers MPAA-PV (modified polyacrylamide - hydrogen peroxide), MPAA-MEA (modified polyacrylamide - monoethanolamine), MPAA-TEA (modified polyacrylamide - triethanolamine) was studied. The synthesized polymers were proposed as soft carriers for transporting drugs.

Purpose of the work. The purpose of the research is to develop a technology for producing polymer composites and their use to increase the fire resistance of structures and materials (paint) and for transporting biological products.

Research objectives. To achieve this goal, the following research objectives were identified:

– generalization of known information about the current state of the theory and technology of producing fire-retardant coatings, technological solutions for processing wooden and steel structures with fire-retardant paints;

– synthesis of polymer reagents to add them to coatings and determination of optimal conditions for their production;

– study of the properties of polymer carriers in combination with antibacterial compounds;

– increasing antibacterial activity using polymer reagents;

– mathematical planning of the experiment;

– technology for producing multifunctional coating (paint) and antibacterial compounds.

Research methods. To solve the problems posed in the work, experimental physicochemical and analytical research methods were chosen: electron microscopy, IR spectroscopy, elemental analysis, spectroturbodimetry, viscometry, potentiometry, thermogravimetry, sedimentation analysis, microphotography, agar diffusion method, as well as a number of methods mathematical analysis (statistical analysis, experimental planning).

Object of study: the objects of study of this doctoral dissertation are: polymer reagent MPAA, a number of fire-retardant coatings (paint), samples of wooden bars and samples of metal plates, antibacterial compounds.

Subject of research: the process of obtaining fire-retardant intumescent compositions (paints), the process of obtaining soft polymer carriers (ointments) for medicines.

Main provisions submitted for defense:

– new methods for producing polymer reagents based on the hydrolysis of polyacrylamide with the addition of modifiers;

- conditions for obtaining new polymer reagents have been developed, the optimal synthesis time is 2-3 hours, the optimal synthesis temperature is 348-368 K, the functional composition of the polymers has been established;

– new methods for producing multifunctional coatings (paints). Impregnation composition: technical ammonium phosphate (GOST 8515-57) or ammophos, which is a mixture of ammonium salts of phosphoric acid (diammonium phosphate and monoammonium phosphate). Ammophos contains on average 75% of the total amount of these salts, patent RK No. 4873 dated December 10, 2019;

– technology for producing antibacterial compositions using polymer reagents; it has been shown that the use of polymer reagents as antibacterial compositions increases the antimicrobial activity of drugs;

- results of pilot tests of the coatings obtained and the economic efficiency of the developed technology.

Main results of the study:

- generalized known information about the current state of the theory and technology for producing fire-retardant coatings, about known technological solutions for treating wooden and steel structures with fire-retardant paints to increase fire resistance;

- generalized known information about the current state of the theory and technology of obtaining and using polymer reagents for transporting soft dosage forms (ointments);

- the properties of the polymer reagent MPAA and their aqueous solutions were studied.

The optimal ratio of the components of the reagent MPAA-PAA:NaOH:H_2O_2 is 1:0.4:0.2; the optimal synthesis time is 2-3 hours, the optimal synthesis temperature is 348-368 K, the functional composition of the polymers has been established (Appendix B).

The stability of the resulting polymers to thermal-oxidative effects was studied.

It has been shown that MPAA can be classified as a thermostable polymer.

The physico-chemical properties of aqueous solutions of modified acrylic polyampholytes MPAA were studied using viscometry, spectroturbodimetry, colorimetry, conductometry, pH-metry - the values of specific and relative viscosity (η_{sp}=1.1, ηrel=2.1.), surface tension (σ= 51.6·103N/m^2) and adsorption (G=10.5 C/g˙10^{-7}), specific electrical conductivity (χ=79 $Ohm^{-1}\times cm^{-1}$) and equivalent electrical conductivity (λ=16.5), pH values of aqueous solutions of polymers.

The properties of wood and metal coatings treated with paint (BC) and antibacterial compositions with the addition of the polymer reagent MPAA were studied.

It has been shown that a wooden coating treated with fire-retardant paint with the MPAA polymer reagent allows wood to be transferred from the group of combustible materials to group G1 - low-flammable materials. In this case, the weight loss of the samples after testing averages 3-5% wt. Accordingly, with a coating thickness of 2 mm and 1.3 (3 and 2 layers).

It has been shown that treating metal structures with fire-resistant paint with a polymer reagent increases the fire resistance of structures and increases the stability time of the structure.

It has been shown that the use of polymer reagents as antibacterial compositions increases the antimicrobial activity of drugs. A technology for producing antibacterial compounds has been developed.

It has been shown that impregnating solutions increase the effectiveness of the paint we offer as a result of a combined (fire-retardant and anti-rot) effect.

Wooden structures become resistant not only to fire, but also resistance to destruction and rotting.

Mathematical planning of the experiment was carried out. The transition between the main mechanisms of increased flame retardancy and antimicrobial activity was modeled. The transition between regimes is shown to occur more abruptly than previously thought.

A technology for producing a multifunctional coating (paint) has been developed and a 1 mm thick coating has been studied, which shows fire-retardant effectiveness. These tests were carried out by the testing center of «Malika» LLP in Shymkent.

The economic efficiency of using multifunctional coatings (paints) using polymer reagents has been determined. The advantage of the proposed technology over analogues is the use of cheap local raw materials, which reduces the cost of products. It is shown that the break-even point of production is at the level of 20 million tenge of profit, with a production capacity load of 25 %.

Justification of the novelty and importance of the obtained results:

– a new composition was established, based on IR spectroscopy data, polymer reagents, the presence of main reactive groups was revealed;

– a new qualitative assessment of the thermal stability of polymer additives was obtained, the weight loss is 32.1%, 1.5 times less than the base polymer;

– it has been shown that the electrical conductivity of aqueous solutions of polyelectrolytes increases with increasing concentration: polymers in an aqueous solution can be represented as a giant polyion; with an increase in the concentration of ions per unit volume, the ionic strength of solutions increases, and, consequently, the specific electrical conductivity;

– it has been established that the optical density of aqueous solutions of polyelectrolytes increases slowly with increasing concentration, which can be explained by conformational transformations of macromolecules;

– it is shown that the change in viscosity at constant ionic strength created by electrolyte additives, which suppresses the ionization of functional groups and, accordingly, changes the conformational state of macromolecular coils, provides a linear dependence of the reduced viscosity on concentration;

– it has been established that the new polymer reagents are water-soluble polyelectrolytes with ampholytic properties;

Theoretical and practical significance of the work.

Theoretical significance of the work:

– the mechanism of action of polymer additives on the composition of fire-retardant paint is proposed;

- it has been shown that a coating treated with fire-retardant paint with a new polymer reagent allows wood to be transferred from the group of combustible materials to the group of low-flammable materials;

– it is shown that the fire resistance limit of a metal structure with paint containing a new polymer reagent (180 minutes) increases compared to the fire resistance limit of a metal structure without paint (7 minutes);

– the compatibility of new polymer reagents with antibacterial drugs was established and antimicrobial activity was revealed, the optimal ratio of polymer and distilled water was 1:5.

The practical significance of the work lies in the development of technology for producing a fire-retardant intumescent composition (paint) (patent RK No. 4873 dated December 10, 2019) and antibacterial compositions with additives of the MPAA polymer reagent and its use at industrial facilities in the region.

The synthesis of the MPAA polymer reagent and the production of paint samples were carried out at the university department, studies of the fire resistance of wooden and metal structures in the laboratory of the fire service department of the South Kazakhstan region, part of the research work was carried out during an internship at the department of "Oil Refining Technology" of the Faculty of "Chemical Technology and Ecology" St. -Petersburg Technical University (Russia), under the leadership of the head of the department, candidate of chemical sciences, associate professor Antipov A. and doctor of technical sciences professor Dmitrievsky B.A. from 15.05. – 06/15/2019.

Research on polymer reagents as antibacterial compositions was carried out jointly with B.O. Tarlanova, associate professor of the department of “Pharmaceutical Production Technology” of SKGFA.

Compliance with directions of scientific development or government programs.

The dissertation work was carried out in accordance with the theme of state budgetary works of the department “Technology of inorganic and petrochemical production” of M. Auezov SKU on the topic: Research B-22-03-05: “Development of methods and technologies for producing highly effective multifunctional gelling polyelectrolytes, surfactants, composite polymers materials, high-tech rubber compounds and ingredients for the rubber industry."

The principle of reliability. The reliability of the results of the work is determined by the use of modern physical and chemical research methods, the generalization and introduction into scientific circulation of new theoretical and empirical materials, and the use of the most accurate methods of analysis. When working on the dissertation research, domestic and foreign sources of scientific literature were reviewed and analyzed. The information obtained on the basis of the available results is supplemented by the results obtained during the work.

Publication of research results. Based on the dissertation materials, 20 works were published, including 2 articles in International publications included in the Scopus database, 4 articles in journals recommended by Committee for Quality Assurance in the Field of Science and Higher Education, 12 articles in collections of International and Republican conferences, 2 patents were received.

Personal contribution of the doctoral student to the preparation of each publication:

1. Article “The study of physical and chemical properties of water soluble polymer reagents and their application as an ointment” in the Oriental Journal of Chemistry - preparation of a review and data analysis, obtaining and processing of results.
2. Article “Physico-chemical investigation of aqueous solutions and their application as soft medicinal forms” in the Oriental Journal of Chemistry – preparation of a review and analysis of literature data, obtaining and processing of results.
3. Article “The study of physical and chemical properties of the water-soluble polymer reagents and their compatibility with antibiotics” in the Rasayan Journal Chemistry - obtaining and discussing experimental data.
4. Article “The investagion of study of physical and chemical properties of the water solutions of polymers and their application in combination with drugs” in the Rasayan Journal Chemistry - obtaining and discussing experimental data.
5. Patent of the Republic of Kazakhstan “Fire-retardant intumescent composition for structural coatings” - search and analysis of analogues and prototypes, obtaining experimental data.
6. Patent of the Republic of Kazakhstan “Fire-retardant intumescent composition for coatings” - search and analysis of analogues and prototypes, obtaining experimental data.
7. Article “Physical – chemical and colloid-mechanical methods of research of modified polymer reagents of the M-PAA series and their application for obtaining ointment” in the journal News of the academy of sciences of the republic of Kazakhstan JSC “D.V. Sokolsky institute of fuel, catalysis and electrochemistry" Series Chemistry and technology - obtaining and discussing experimental data.

Structure and scope of the dissertation. The dissertation consists of 4 chapters, including introduction, literature review, experimental part, conclusion, list of sources used. The work is presented on 103 pages of computer text, includes 25 figures, 17 tables and 106 cited literature sources, 2 appendices.