ANNOTATION

dissertation work on the topic:

«THERMAL INSULATION COATINGS BASED ON FINELY DISPERSED MINERAL GRANULAR SYSTEMS»

submitted for the degree of Doctor of Philosophy (PhD) in the specialty 6D071000 – "Material science and technology of new materials"

TASHMUKHANBETOVA INDIRA BERKINBAYEVNA

The purpose of the dissertation is to develop a new highly efficient liquid thermal insulation coating using finely dispersed mineral granular systems and to study the physico-chemical, mechanical properties of the coatings obtained by conducting climatic tests.

Research objectives:

- Obtaining a modified epoxy resin and determining its thermal conductivity coefficient by determining the effective grade of the hardener in the production of polymer liquid coatings;
- Determination of the color fastness of modified epoxy resin composites to the effects of natural climatic factors in order to determine the optimal grade of binder for obtaining a liquid coating;
- Determination of the optimal ratio of starting materials in the development of new polymer liquid thermal insulation coatings based on a finely dispersed mineral granular system – silica and binder – epoxy resin, as well as the study of the physico-chemical, mechanical properties of the resulting liquid thermal insulation material;
- Study of durability and economic and technological efficiency of polymer compositions based on silica and epoxy resin with thermal insulation properties.

Research methods

The main research and analysis methods used in the performance of the dissertation work include:

- An inverted metallographic optical microscope OLYMUSGX-71 and particle size analyzer ShimadzuSALD-3101 were used to evaluate the particle sizes of dispersed silica powders, their shape, color, and the presence of macropores and cracks;
- The study of the structure and chemical characteristics was carried out on a NICOLET 5700 FT-IR infrared Fourier spectrometer;
- A small-angle X-ray diffractometer "Hecus S3-MICRO X-Ray SAXS/SWAX System" was used to determine and evaluate the structural characteristics of filler powders;
- The viscosity of the obtained compositions was determined using a 4 mm diameter viscometer of the VZ-4 type;
- An AGS-X series testing machine with TRAPEZIUM X software was used for mechanical testing of polymer composites;
- Natural climatic tests were carried out using an automatic control station (ACS) of the N. P. Ogarev Mordovian State University (Saransk);

- The analysis of changes in decorative characteristics was revealed using a spectrophotometer SD–6834 Spectro-guide spliere gloss;

- The thermal properties of the coatings were investigated by thermogravimetric analysis on the device «Mettler Toledo TGA/SDTA 851»;

- Adhesive strength is carried out by the PSO MG4 adhesion meter;

- An electronic thermal conductivity meter ITS-1 was used to determine the thermal conductivity of materials;

- The gloss of the coatings was determined using a device for determining the degree of photoelectric gloss of the novo-Gloss series..

The main provisions recommended for protection (proven scientific hypotheses and other conclusions that are new knowledge):

1. 1. A technological method has been developed for the production of liquid coatings with the addition of the hardener Etal-1440N to epoxy resins ED-20 and Etal-247 modified with dibutyl phthalate, respectively, with an increase in tensile strength of 48,91 and 43,92 MPa, with an increase in viability by 112, 128 minutes, viscosity of 1,89 and 0,96 Pa·s.

2. Using ED-20 resin subjected to a natural climatic study of full color rendering for 10 months, it demonstrated minimal changes of only 0,5-0,7% and showed stability exceeding the indicators for 99 days, withstanding exposure to total solar radiation up to 6225 MJ/m^2, including 178 MJ/m^2 in the range A and 5300 MJ/m^2 in the B range, which confirms its high color fastness.

3. The developed method, which includes the addition of 20% microsilica to modified epoxy resin ED-20, demonstrates effectiveness in reducing the thermal conductivity coefficient by 0,081-0,088 W/(m·K) in the formation of a liquid thermal insulation coating.

4. The developed liquid thermal insulation coatings, when applied to metal, concrete, wood, brick and plaster surfaces, have optimal porosity (3-3,5%), low vapor permeability (0,001 mg/m·hour·Pa), high adhesive strength (1,3-2,2 MPa), low coefficient of thermal conductivity (0,08-0,1 W/m·K) and the degree of gloss of the coating in the range of 30-36.

Description of the main results of the study:

1. Etal-1440N was selected as a hardener added to epoxy resins ED-20 and Etal-247 in the production of polymer liquid coatings. The viability of the formulations at room temperature was 112 and 128 minutes, respectively, and the viscosity was 1,89 and 0,96, in addition, the tensile strength was 48,91 and 43,92 MPa. These results allow the use of Etal-1440H as a hardener in the production of liquid coatings of polymer composition.

2. With a natural climatic study of the complete color difference for 10 months, the instability and duration of Etal-247 resin compared to ED – 20 resin was 76 days, the total limit of solar radiation was 2100 MJ/m^2, the value of ranges A and B showed destruction after 76 MJ/m^2 and 1150 MJ/m^2, respectively. For comparison, ED-20 resin has undergone changes by only 0,5-0,7% over the entire exposure time and has stability for 99 days more than Etal-247 resin, total solar radiation up to 6225 MJ/m^2, in the

range A up to 178 MJ/m^2, in the range B up to 5300 MJ/m^2. The value was shown. These results showed that when obtaining polymer liquid coatings, it is preferable to use ED-20 resin as a binder.

3. The results of physico-chemical studies have shown that the optimal ratio of microsilica and epoxy resin for the development of thermal insulation materials is 20:80%, respectively. In the IR spectra of epoxy–microsilica composites, the formation of a new Si–O–C functional group was observed between the Si-OH microsilica functional group and the oxirane group of the epoxy resin. It was found that TGA thermograms of epoxy resin and epoxy-microsilica composite change the temperature of thermal decomposition of the composite to higher values compared with a sample of epoxy resin without microsilica. At a temperature of about 240 °C, a gradual decay began due to the cleavage of the ester bond. These studies have proved that the resin penetrates into the pores of silica microparticles, forming a mutual lattice that increases thermal stability, that is, heat resistance.

4. The operational and effective properties of liquid thermal insulation coatings when applied to metal, concrete, wooden, brick, plaster surfaces are determined – porosity, vapor permeability, adhesive strength, thermal conductivity coefficient, gloss values of the coating. The obtained values showed porosity – 3-3,5%, vapor permeability – 0,001 mg/m·h·Pa, thermal conductivity coefficient – 0,08-0,1 W/m·K, gloss level of coatings – 30-36, adhesive strength – 1,3-2,2 MPa. These values prove that the liquid thermal insulation coating complies with regulatory documents. In addition, the liquid thermal insulation coating showed a higher thermal conductivity of 0,123 W/(m·K) than the liquid coating without filler.

Substantiation of the novelty and importance of the results obtained

For the first time, a new liquid thermal insulation coating has been developed using local raw materials of the Republic of Kazakhstan as a filler with a complex of improved performance characteristics. For the first time, in the process of obtaining a liquid thermal insulation coating, full-scale climatic studies are carried out, this is a new direction for our country.

The proposed technology makes it possible for the first time to obtain liquid thermal insulation coatings based on modified epoxy resin with a thermal conductivity coefficient of 0,081–0,088 W/(m·K). This indicator is a popular task in the field of housing and construction complex - saving fuel and energy resources. The maximum performance characteristics of the created liquid thermal insulation coating have been established when applied to various surfaces in accordance with the standards.

The dissertation work has a high scientific value, which is confirmed by the author's scientific works and international reports containing published articles.

According to the results of the study, a protocol of experimental tests, an Act of introduction into the educational process of LLP "International Educational Corporation" and an Act of introduction (use) into the production of LLP "All Construction" were drawn up.

Compliance with the directions of scientific development or government programs

The topic of the dissertation corresponds to the scientific direction "Rational use of natural resources, including water resources, geology, processing, new materials and technologies, safe products and constructions".

The dissertation work was carried out jointly with the University of Mordovia in the research laboratory of Architecture and Construction of the non-profit joint stock company KazNITU named after K. I. Satpayev within the framework of the program "Grant financing of scientific and (or) scientific and technical projects for 2020-2022 with a duration of 27 months" AP08855714 within the framework of the program "Liquid thermal insulation coatings based on fine mineral granular systems". In addition, implementation continues within the framework of the target financing program BR21882292 – "Integrated development of a sustainable construction industry: innovative technologies, production optimization, efficient use of resources and creation of a technology park" for 2023-2025, funded by the Ministry of Science and Higher Education of the Republic of Kazakhstan.

The personal contribution of the author is to carry out experimental research outlined in the dissertation work, including methods of experimental research, conducting research, analyzing and formatting the results in the form of publications and scientific reports.

Description of the doctoral student's contribution to the preparation of each publication.

According to the results of the dissertation work published:

1. Zhumadilova Zh.O., Selyaev V.P., Nurlybayev R.E., Kuldeyev E.I., Sangulova I.B. Prediction of Durability of Thermal Insulating Epoxy Coatings with Regard to Climatic Ageing // Polymers 2022, Volume 14, Issue 9, 1650. E-ISSN:2073-4360.P.1-14 https://doi.org/10.3390/polym14091650.
2. Sangulova I.B., Selyaev V.P., Kuldeev E.I., Nurlybaev R.E., Orynbekov Ye.S., Assessment of the influence of the structural characteristics of granular systems of microsilicon on the properties of thermal insulation materials // Комплексное Использование Минерального Сырья. №1 (320), 2022 ISSN-L 2616-6445, ISSN 2224-5243. P. 5-14. DOI: 10.31643/2022/6445.01
3. Сангулова И.Б. Микрокремнеземнің құрылыста қолданылу аясының дамуы // Вестник КазНИТУ. ISSN 1680-9211, 2019. - №4(134)., С.344-348
4. Селяев В.П., Нурлыбаев Р.Е., Киселев Н.Н., Лияскин О.В., Сангулова И.Б. Оптимизация состава наполнителя вакуумных изоляционных панелей на основе Конасил-200 // Вестник КазГАСА. ISSN 1680-080X, 2019. - №2(72), С.169-175.
5. Селяев В. П., Нурлыбаев Р. Е., Сангулова И.Б., Лияскин О. В., Кечуткина Е.Л. Оптимизация технологических режимов синтеза диоксида кремния с размером частиц в нанометровом диапазоне // Вестник Поволжского государственного технологического университета. Серия: Материалы.

Конструкции. Технологии. № 4(12) (2019) – РИНЦ, ISSN 2542-114X. С.102-110. DOI: https://doi.org/10.25686/2542-114X.2019.4.102

6. Естигнеева В.М., Лазарев А.Л., Сангулова И.Б. Характер напряженно-деформированного состояния армированных изгибаемых клееных деревянных элементов // Огарёв-Online, № 3 (140), (2020) с.7. https://cyberleninka.ru/article/n/harakter-napryazhenno-deformirovannogo-sostoyaniya-armirovannyh-izgibaemyh-kleenyh-derevyannyh-elementov.

7. Селяев В.П., Нурлыбаев Р. Е., Кечуткина Е.Л., Сангулова И.Б. Оптимизация составов теплоизоляционных покрытий на основе водной дисперсии полимерных вяжущих // Научно-практический журнал «Эксперт: теория и практика», Тольятти. 2021, №4(13), С. 23-28.

8. Nurlybayev R.E., Zhuginisov M.T., Zhumadilova Zh.O., Orynbekov Ye.S., Khamza E.E., Sangulova I.B. Investigation of the effect of diatomite and bentonite clays on the properties of local loam-based products // Вестник КазНИТУ. 2021, №4 С.180-195 https://doi.org/10.51301/vest.su.2021.i4.23

9. Селяев В.П., Нурлыбаев Р.Е., Киселев Н.Н., Лияскин О.В., Сангулова И.Б. Диаграммы деформирования при сжатии и сдвиге вакуумных теплоизоляционных панелей // Труды Сатпаевских чтений. Инновационные технологии – ключ к успешному решению фундаментальных и прикладных задач в рудном и нефтегазовом секторах экономики РК. Том I. Алматы. 2019. С. 1038-1043

10. Orynbekov Ye.S., Zhumadilova Zh.O., Selyaev V.P., Sangulova I.B. The influence of climatic factors on the change in the elastic-strength indicators of epoxy polymers binders used in liquid thermal insulation coatings // Зарубежная конференция «The 2021 Southern brazilian journal of chemistry conference». Porto Alegre, RS. Brasil. March 18-19, 2022, E-ISSN 2764-5959, №30, С.44-53