ABSTRACT

of dissertation of Turakulov Bakhriddin Bakhodurovich on the theme
"Development of technological bases of chromite pigments production from technogenic wastes for the printing on cotton and mixed fabrics"
for the degree of Doctor of Philosophy (PhD) in the specialty
6D072000 – Chemical Technology of Inorganic Substabces

The relevance of the theme. In modern real conditions of depletion and limited natural resources, the development of domestic competitive chemical industries, including production for rational processing of natural raw materials and technogenic wastes, is one of the priority areas provided for in the Strategy "Kazakhstan 2050".

Inorganic pigments and filler pigments derived from various materials are components of a wide range of materials used in a number of industries. Being part of the printing paste, when applying a printed pattern on the surface of cotton and mixed fabrics, pigments perform a decorative coloristic function. Most pigments are used in the production of pigment dyes for textile products. In the world market of producers of pigment dyes for the textile industry, the leading positions are occupied by the European companies "Bayer AG" (Germany), "Arcroma" and "SNT/BEZEMA" (Switzerland).

In the Republic of Kazakhstan, there is no production of pigments for dyeing and printing on textile products, although they are widely used at textile enterprises of our republic – JSC "Azala Textiles" (Shymkent), Almaty branch of LLP "Sewing and Knitting Factory "Saule" (Almaty), LLP "Nimex Textiles" (Ust-Kamenogorsk). To meet the needs of enterprises in the republic, pigments are supplied mainly from Europe, Türkiye, India and China, and therefore they are imported products, causing their high cost, and as a result, this affects the cost and competitiveness of products of domestic enterprises. At the same time, the Republic of Kazakhstan has an extensive raw material base for production of chromite pigments: tens of thousands of tons of various technogenic wastes containing chromite are generated annually at mining and processing plants and metallurgical enterprises. Currently, these wastes are removed and stored at specially designated landfills or on enterprise sites. According to General Director of RSE "Information and Analytical Center for Environmental Protection" under the Ministry of Ecology, Geology and Natural Resources of the Republic of Kazakhstan "... The real figure of radioactive wastes, technogenic mineral formations and so-called overburden rocks accumulated by Kazakhstan as a result of extraction of natural resources is more than 30 billion tons! Landfills are a ticking time bomb. This is a source of danger that threatens the life of all biological species". The environment is polluted, and together with melt and storm waters they enter reservoirs and drains, thus becoming involved in biological cycles. Maintenance and operation of landfills requires significant economic costs. Currently, in the world practice of producing pigments for the textile industry, many methods are known for their production based on chromium compounds, but the use of technogenic wastes in the form of internal overburden rocks of coal mining, "tailings" of chromite ore enrichment, dust from aspiration systems and after water

classification of sludges has not been sufficiently studied. A systematic approach to chromite wastes as a raw material for production of pigments containing surface-active modifiers and used for printing on cotton and mixed fabrics has not been developed.

Thus, the presence of a large amount of wastes from coal mining and enrichment of chromite ores, their lack of knowledge and the lack of available technological solutions for practical application in the textile industry, create conditions for the need to conduct research, methods of disposal and conditions for heat treatment of initial raw materials and intermediate products, with the creation of a technology for producing chromite pigments from technogenic wastes for printing on cotton and mixed fabrics.

In this regard, the development of new technologies for processing technogenic wastes into chromite pigments for printing on cotton and mixed fabrics is a very urgent task.

The purpose of the work is to create a resource- and energy-saving technology in the production of pigments from fired carbon-containing chromite pellets, as well as the application of chromite pigment to a cotton and mixed fabric base.

The research objectives. To achieve the research purpose, the following scientific objectives were solved:

- comprehensive study of the composition, properties and structure of substandard chromite ore, dust from aspiration systems and internal overburden rocks of coal mining;
- increasing the chromium content in chromite technogenic wastes from mining and production of conditioned raw materials, by introducing a surfactant based on internal overburden rocks and metallurgical coke into the composition of technogenic wastes;
- identification of kinetic patterns in the process of obtaining fired chromite pellets containing carbon;
- study of physicochemical foundations and thermodynamic laws of the process of producing pigments based on carbon-containing chromite raw materials, with the determination of optimal synthesis conditions and the development of a production flow chart. Statistical processing of the results obtained;
- pilot testing of chromite pigment production technology with identification of the possibility of applying the resulting pigment to a cotton and mixed fabric base.

The research methods. When carrying out the research, modern physicochemical methods of research and analysis of initial and final products were used: IR Fourier spectroscopy (Shimadzu JR Prestige-21); X-ray phase analysis (DRON-3 and D8ENDEAVOR “Bruker”); differential analysis (Q-DERIVATOGRAPH) and electron microscopy with energy dispersive analysis. When processing the results of experimental studies, methods of mathematical modeling and statistical data processing were used.

The research objects. Substandard chromite ores from JSC “Aktobe Chromium Compounds Plant” and internal overburden rocks of coal mining, chromite pigment obtained from technogenic wastes.

The research subject is the interaction processes between dusty wastes from the production of chromium compounds and internal overburden rocks, the physicochemical foundations of the technology for producing chromite pigment from technogenic wastes.

The main provisions for the defense:

- physicochemical properties of substandard chromite ore and internal overburden rocks of coal mining and patterns of obtaining pellets based on them;
- influence of the temperature of preliminary heat treatment of technogenic wastes on the process of synthesis of chromite pigment;
- physicochemical foundations and features of the proposed technology for producing chromite pigment from technogenic wastes;
- technology for the integrated processing of technogenic wastes, allowing the production of chromite pigment that meets the quality requirements of current regulatory documents;
- feasibility study of the technology for producing chromite pigments from technogenic wastes.

The main research results:

- it is shown that substandard chromite ore and dust from aspiration systems can be used in various branches of industry and technology, including as a source for producing chromite pigments for the textile industry.
- it is shown that the use of boric acid in a ratio of 3:1 to chromite pellets makes it possible to synthesize chromite pigments with rich color, with an utilization rate of chromite pellets of up to 98%.
- fundamental IR spectroscopic and X-ray data were obtained to study the process of obtaining chromite pigments from technogenic wastes.
- the apparent activation energy of the interaction between chromite wastes and boric acid was determined to be about 40 kJ/mol, which means that the interaction process occurs under diffusion control.
- the main physicochemical parameters of the technology for producing chromite pigment based on technogenic wastes were determined:
- the density of the material is 3.4 kg/m^3;
- is resistant to concentrated sulfuric, hydrochloric and nitric acids, as well as alkalis;
- withstands heating up to a temperature not exceeding 95°C.
- the following optimal conditions were established: 2-3 times the weight of chromite pellets the amount of boric acid, the calcination temperature is 600°C, the calcination duration is ~ 1 hour.
- the possibility of using chromite pigment from technogenic wastes for printing on cotton and mixed fabrics is shown.
- a technological scheme for the integrated processing of technogenic wastes with the production of chromite pigments for the textile industry was developed.
- the quality of the obtained chromite pigments was tested for compliance with the requirements of regulatory documents (GOST) by determining physical-chemical and physical-mechanical parameters in specialized accredited laboratories.

- it is calculated that chromite pigment, obtained on the basis of technogenic wastes, will allow consumers of this product in Kazakhstan to save up to 300 000 KZT per ton.

Justification of the novelty and importance of the results obtained:

- the mineral composition and structure of the studied samples and finished products were determined using modern physicochemical research methods (X-ray phase analysis, differential thermal analysis, infrared spectroscopy, scanning electron microscopy);
- based on electron microscopy, the distribution of key elements of chromium, magnesium, aluminum, iron, silicon and calcium in the composition of substandard fine powder, chromite ores, tailings and internal overburden was revealed.
- the processes taking place at the stage of preparing a mixture of chromite pellets and boric acid during the production of pigment and the optimal parameters for firing and grinding the charge mixture, washing, filtration and drying of the semi-finished product, calcination of chromium oxide in the presence of activated carbon and in burnt carbon-containing pellets, as well as during repeated washing, filtering, drying and grinding pigment, were determined;
- kinetic dependences of changes in Cr_2O_3 content on the parameters of time-technological processes for producing pigments in the presence of surface-active modifiers were established;
- the main technological and thermal parameters for producing carbon-containing chromite pellets with an increase in strength to 140-215 kg/pellet and a residual carbon content in fired chromite pellets up to 2% were identified;
- the optimal parameters for obtaining an emerald green pigment were worked out and identified, such as a threefold increase in the mass of boric acid in the mixture of chromite pellets, the calcination temperature of 600°C and the calcination time of 60 minutes;
- optimal conditions for applying paint pigment to a cotton and mixed fabric base were identified, which showed the fundamental possibility of using a pigment with color fastness to washing, wet and dry friction of 4 points, wear resistance rating, respectively – 4860 and 6485 cycles.

The theoretical significance of the work lies in establishing the patterns of quantitative interaction of substandard chromite ores and internal overburden rocks during the production of pellets, the mechanism of synthesis of chromite pigment based on carbon-containing chromite pellets. The practical significance lies in the fact that the possibility of obtaining chromite pigment from technogenic wastes for printing on cotton and mixed fabrics was shown.

Compliance with directions of scientific development or government programs.

The work was carried out within the framework of the theme of the plan No. B-16-02-03 for 2011-2015 of “Chemical Technology of Inorganic Substances” chair, M. Auezov SKSU, in the direction of research work “Research on the creation of alternative innovative technologies for enrichment of raw materials and production of synthesis products of inorganic compounds from natural ore and

mineral resources and technogenic wastes from various industries".

The principle of reliability. The scientific data of the dissertation are based on the results obtained by conducting experimental works and physicochemical studies using modern research equipment and instruments. Works related to thermodynamic calculations, mathematical modeling and data processing were performed using computer technologies.

Publications on the dissertation theme. 10 scientific works were published on the dissertation theme, including 4 articles in international scientific editions included in the Scopus database, 6 articles in proceedings of international and republican conferences.

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

1. Article "Research on the production of pigments based on composite pellets in the recycling of industrial waste" in the journal "Journal of Composites Science" – preparation of review and data analysis, obtaining and processing of results.
2. Article "Improvement of a Preparation Process of Chromite Raw Material Used for Ferroalloys and Pigments Manufacture" in the journal "Eurasian Chemico-Technological Journal" – preparation of review and analysis of literature data, obtaining and processing of results.
3. Article "The possibility of obtaining fired chromite pellets for production of textile pigments and intermediate products from technogenic wastes" in the journal "News of HEIs. Textile Industry Technology" – obtaining and discussing experimental data.
4. Article "The possibility of obtaining textile pigments and intermediate products from fired chromite pellets" in the journal "News of HEIs. Textile Industry Technology" – preparation of review and analysis of literary sources.
5. Article "Investigation of the possibility of obtaining chromite pigments from technogenic waste for the textile industry" in Proceedings of XIV International Scientific Practical Conference "Digital Technologies in Science and Education" obtaining and discussing experimental data.
6. Article "Beneficiation of off-grade chromite ore for production of inorganic substances" in the collected works "European International Journal of Science and Technology" – obtaining and discussing experimental data, preparing a review of literature sources.
7. Article "Research and development of technology for production of raw materials from industrial wastes to obtain chromium extract" in Proceedings of International Scientific Practical Conference "Auezov Readings – 12: The Role of a Regional University in the Development of Innovative Areas of Science, Education and Culture" – preparation of a review of literature data.
8. Article "Research on enrichment of chromite ores used to obtain textile pigments" in Proceedings of International Scientific Practical Conference "Auezov Readings – 21: NEW KAZAKHSTAN – THE FUTURE OF THE COUNTRY" dedicated to the 80^{th} anniversary of M. Auezov South Kazakhstan University – obtaining and discussing experimental data, preparing a review of literature sources.

9. Article “Research and development to obtain high-quality raw materials for non-ferrous metallurgy and chemical industry” in Proceedings of International Scientific Practical Conference “Development of science, education and culture of independent Kazakhstan in the context of global challenges of our time” – description and presentation of experimental data and analysis results.

10. Article “Application of chromite pigments from technology waste for printing on cotton and mixed fabrics” in Proceedings of V International Scientific Practical Conference “ICITE” – search and analysis of analogs and prototypes, obtaining experimental data.

The structure and scope of the dissertation. The dissertation consists of introduction, three chapters, conclusion, references and appendices. The work is presented on 116 pages, contains 34 tables, 24 figures, 4 appendices. The list of sources used includes 113 titles.