

## ANNOTATION

of the dissertation of Raimbekova Ainur Saginzhankyzy on the topic: "Preparation and study of the properties of manganese-containing anti-corrosion materials based on technogenic raw materials from Kazakhstan", submitted for the degree of Doctor of Philosophy (PhD) in the specialty 8D07109 - "Innovative technologies and new inorganic materials"

**The relevance of the topic under study.** One of the urgent global problems of our time is the problem of recycling a huge mass of industrial waste, among which the central place is occupied by waste from mining and processing enterprises, including dumps of overburden and host rocks, as well as tailings of ore dressing. This waste is used only in small quantities in the production of construction materials, and the bulk is stored in tailings dumps and is not recycled. Also relevant for Kazakhstan as well as for the CIS countries is the problem of corrosion of steel structures and pipelines, which are operated without special protective measures. Corrosion not only leads to metal loss, but also has a negative impact on the environment due to accidents caused by corrosion damage.

**Research objects.** Overburden rocks of manganese ore from the Zhairam deposit, dump tails of gravitational enrichment of manganese ore from the Zhairam deposit.

### **The purpose and objectives of the research.**

*The purpose* of this work is to investigate the possibility of obtaining manganese-containing anticorrosive materials based on mining waste and to study the properties of the products obtained.

To achieve the goal, the following scientific tasks were set:

- physical and chemical studies of the material and phase composition of overburden rocks and dump tails of gravitational enrichment of manganese ore of the Zhairam deposit and the choice of possible ways of their use in the processes of obtaining manganese-containing anticorrosive materials;

- synthesis and investigation of the composition and anticorrosive properties of calcium-manganese phosphate product obtained on the basis of enrichment tailings as a corrosion inhibitor of low-carbon steel in neutral aqueous media;

- investigation of the process of phosphoric acid leaching of overburden rocks of the Zhairam deposit and study of the possibility of using the resulting productive solution as a film-forming agent in the processes of phosphating low-carbon steel.

### **Scientific novelty:**

- for the first time, based on the study of the material and phase composition of waste from overburden and beneficiation of manganese ore at the Zhayrem deposit, manganese-containing phosphate products have been obtained and showed the possibility of their use as anticorrosion materials for protecting low-carbon steel from corrosion in aqueous medium;

- acid-thermal synthesis of calcium-manganese phosphate products based on ore dressing tailings was carried out. It was shown for the first time that the formation of highly soluble reagents that can be used as corrosion inhibitors of low-carbon steel in neutral aqueous media is possible at a temperature of 200 ° C and a molar ratio of the main components in terms of oxides  $\text{CaO}:\text{MnO}:\text{P}_2\text{O}_5 = 1.00:0.11:1.54$ ;

- for the first time, the corrosion behavior of low-carbon steel (St3) in a neutral aqueous medium in the presence of a calcium-manganese phosphate product synthesized on the basis of waste from the enrichment of manganese ore from the Zhairam deposit at 200 °C was studied and it was shown that calcium-manganese phosphate inhibitor  $(Ca,Mn)(PO_3)_2$  reduces the rate of corrosion of steel (St3) in the entire studied concentration range from 1.0 to 100.0 mgR<sub>2</sub>O<sub>5</sub>/l. At the same time, the degree of inhibitory effect lies in the range of 20.2 - 98.2%. For the first time, the morphology of the surface of protective films formed on a steel surface in solutions of a synthesized inhibitor was studied and a distribution map of the chemical elements included in the films was compiled;

- it was shown, for the first time, that the calcium-manganese phosphate inhibitor synthesized from the beneficiation tailings of the Zhairam deposit exhibits high inhibitory efficiency in waters with a high content of corrosion promoters, such as sulfate and chloride ions;

- the process of phosphoric acid extraction of manganese from overburden waste has been studied for the first time. The optimal conditions for conducting the process are determined by the heat. Corrosion tests of phosphate coatings formed on steel in the resulting phosphating solution have shown that their characteristics meet standard requirements.

#### **Practical significance:**

- based on the conducted experimental studies, conceptual technological schemes have been proposed for processing the beneficiation tailings of manganese ore from the Zhayrem deposit into a calcium-manganese phosphate corrosion inhibitor for metals, as well as processing overburden waste into phosphating solutions;

- based on the established optimal parameters for producing the calcium-manganese phosphate inhibitor and the manganese-containing phosphating solution, as well as the determined raw material consumption coefficients, material balances were calculated for the acid-thermal synthesis process of the inhibitor using beneficiation tailings from the Zhairam deposit and for the phosphoric acid leaching process of overburden waste from the Zhairam deposit;

- the optimal concentration parameters of the process of anticorrosive treatment of neutral aqueous media, as well as waters with a high content of sulfate and chloride ions by the developed calcium-manganese phosphate inhibitor have been revealed;

- practical application of the developed new anticorrosive materials based on waste from the extraction and enrichment of manganese ores. Heat treatment both during phosphating and as a result of water treatment with inhibitors will reduce material losses of metal due to corrosion, increase the reliability of metal equipment and pipelines, contribute to the preservation of natural metal reserves and environmental protection;

- According to the results of the research, 2 patents for a utility model of the Republic of Kazakhstan were obtained (Utility model Patent №7655 "Charge for producing a water-soluble metal corrosion inhibitor", Bulletin №2022/0686.2 dated 12/9/2022. Utility model Patent №7652 "Method for obtaining manganese phosphating concentrate", Bulletin №2022/0735.2 from 09.12.2022).

#### **The main provisions submitted for protection:**

Calcium-manganese phosphate inhibitor synthesized on the basis of dump tailings of large-scale deposition of manganese ore from the Zhairem deposit by acid-thermal method at 200°C has a solubility of 92.6 rel.% and provides high inhibition efficiency of low - carbon steel grade St3 in aqueous media.

- The highest inhibition efficiency of steel (St3) 98.2% is achieved in neutral aqueous media at a concentration of synthesized calcium-manganese phosphate inhibitor 50 mgP<sub>2</sub>O<sub>5</sub>/l, whereas in waters with a high content of sulfates (1000 mg/l), the inhibition efficiency of 96.2% is achieved at a concentration of 100 mgP<sub>2</sub>O<sub>5</sub>/L;

- A phosphating solution isolated from the overburden waste of the Zhairem deposit by phosphoric acid leaching at a temperature of 75 ° C, a ratio of S:A = 1:10, a concentration of H<sub>3</sub>PO<sub>4</sub> = 10%, a leaching time of 4 hours, has the technical characteristics Mn(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> : Fe(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> = 8,1; Mn(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> : Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub> = 1: 2.19; Co/Ks = 6.33 and creates protective coatings on the surface of steel (St3) with an average weight of the phosphate layer of 11.2 g/ m<sup>2</sup> and a protective effect of 240 seconds, determined by the average time of the drip sample.

**Connection with the research plan.** The work was carried out in accordance with the research plan of the Department of Chemical Processes and Industrial Ecology of the K.I. Satbayev Kazakh National Research Technical University for state-funded research №BR05236302 "Scientific and technical justification of chemical cluster innovations in the field of creating new materials and technologies to increase the efficiency and environmental sustainability of industrial production" (2018-2020 yy.) and №BR21881939 "Development of resource-saving, energy-generating technologies for the mining and metallurgical complex and creation of an innovative engineering center" (2023-2025 yy.).

**The degree of reliability and approbation of the results.** The results of the dissertation work were obtained using modern physical and chemical methods of scientific research and classical chemical analysis, as well as using well-known standard methods and techniques. The results of the dissertation work were obtained using modern physical and chemical methods of scientific research and classical chemical analysis, as well as using well-known standard methods and techniques. The degree of reliability is confirmed by a sufficient degree of coincidence of the results of instrumental and chemical methods of analysis, laboratory and integrated tests.

The research results were tested at the international scientific and practical conference "Correlation interaction of science and practice in the New World" (2020, St. Petersburg, Russian Federation); III International Scientific and Practical Conference "Science and Business-2021" (2021, Almaty, Republic of Moldova); 5th International Scientific and Technical Internet Conference "Innovative development of resource-saving technologies and sustainable use of natural resources" (2022, Petroshani, Romania); international conference "Satbayev Readings -2021" and "Satbayev Readings – 2023" (Almaty, Kazakhstan); International Scientific and Technical Conference. "Actual problems of creation and use of high technologies for processing mineral resources" (2023, Tashkent, Uzbekistan).

**Publications on the topic of the dissertation.** The main provisions of the completed dissertation research are reflected in 9 scientific publications, including 2 articles in an international journal included in the Scopus database, 1 in publications

recommended by the Committee for Quality Assurance in Science and Higher Education, 6 articles published in the materials of international conferences. According to the research results, 2 patents for a utility model of the Republic of Kazakhstan were obtained.

**The structure and scope of the dissertation.** The dissertation work is presented on 122 pages of typewritten text, contains 29 tables, 47 figures. The work consists of an introduction, 6 sections, a conclusion, a list of 160 references and 2 appendices.