

ABSTRACT

of dissertation of **Shaimerdenova Guldana Smakhulovna**
on the topic “Development of technology of obtaining diammonium phosphate from
substandard phosphate raw materials of Zhanatas deposit”
for the degree of Doctor of Philosophy (PhD)
in the specialty 6D072000 – “Chemical technology of inorganic substances”

The relevance of the work. The message of Kassym-Jomart Tokayev, the President of the Republic of Kazakhstan, to the people of Kazakhstan dated 1 September 2020 was dedicated to the country’s economic development in the new conditions. The head of the state noted that the long oil era is coming to an end and stressed the need to be ready for the global market. He noted seven principles of high economic development of the country:

- fair distribution of benefits and duties;
- place of observation for private entrepreneurship;
- fair market competition for a new generation of entrepreneurs;
- increasing productivity, increasing the scale and manufacturability of the economy;
- attracting investments in a new type of education with the development of human capital;
- development of “green” economy, environmental protection;
- clarification of specific decisions of the state and its responsibility to society.

In the agricultural sector of the economy, mineral fertilizers play an important role in increasing the yield and quality of crops. Taking into account the export orientation of the phosphate industry, it should not be considered outside of macroeconomics, as the situation in this direction remains complex and unstable.

The chemical industry, excluding petrochemistry, based on large phosphorite deposits in the Karatau depression, more than 70% of the export of phosphorus, phosphorous fertilizers and chemical products is based on export-oriented industries. In the process of mining, crushing and classification, 55-60% of phosphorite ore of a fine fraction passes into fine-grained, class -10 mm, which, according to its granulometric composition, cannot be used for electrothermal processing, however can be used for processing by a chemical method into extraction phosphoric acid with a P_2O_5 content of more than 24.5%.

In connection with the growth in the production of phosphorites and phosphorous fertilizers, the problem of developing new effective technologies for processing substandard fine fractions of phosphorite raw materials into complex fertilizers is an important task for the national economy.

During the processing of raw materials for the phosphorus industry in the Karatau phosphorite basin, about one hundred million tons of off-balance minerals have been accumulated. These wastes cause irreparable environmental damage not only in Kazakhstan, but also in neighboring countries. The disposal of these wastes is a very important issue for the production of finished products, including diammonium phosphate (DAP) highly balanced in nitrogen and phosphorus.

The use of mineral fertilizers plays an important role in increasing crop yields, as well as in the production of renewable energy sources.

It should be noted that the study of the issues of modernization of existing production facilities, both for the creation of new capacities and for the production of fertilizers with the provision of the required amount of P_2O_5 , from 100% evaporating extraction phosphoric acid (EPA), will lead to significant capital investments. Therefore, the development and presentation of the maximum possible share of consumption of non-evaporating extraction phosphoric acid (EPA) based on the use of an effective technology for the production of DAP and heat neutralization, using a drum granulator-dryer (DGD), seems to be promising and very relevant.

Connection with the research plan.

The dissertation work was carried out in accordance with the state budget research plan of NPJSC “M. Auezov South Kazakhstan University” for 2016-2020 in the direction B-16-02-03-Research on the creation of alternative-innovative technologies for the enrichment of raw materials and the production of products for the synthesis of inorganic compounds from natural ore-mineral resources and technogenic wastes from various industries.

Section 1. Research on the development and creation of innovative technologies for thermochemical enrichment and the production of mineral fertilizers and salts from natural raw materials and technogenic wastes from various industries.

Stage 4. Preparing an experimental enriched product from industrial shale phosphate of substandard dump rocks and target products based on them – acids, fertilizers and pesticides.

The research objective and tasks.

The research objective is to develop a technology for preparing diammonium phosphate from off-balance and substandard phosphate raw materials from the Zhanatas deposit.

To achieve this objective, the following tasks were solved:

- study of the mineralogical and chemical composition of off-balance and substandard siliceous-phosphate raw materials from the Zhanatas deposit;
- development of a technology for the extraction of phosphoric acid from off-balance phosphorites from the Zhanatas deposit by the dihydrate method;
- determination of the efficiency of extraction and purification of extraction phosphoric acid from off-balance and substandard phosphorites from the Zhanatas deposit;
- study of effective technological indicators of the process of evaporation and desalination of extraction phosphoric acid prepared from off-balance and substandard phosphorites;
- development of a technology for the production of diammonium phosphate by neutralizing evaporating extraction phosphoric acid with ammonia and development of a mathematical model for planning an experiment;
- determination of the economic efficiency of the developed technology for the production of diammonium phosphate.

During the dissertation work, modern methods and instruments of analysis were used: initial, intermediate and final products – chemical, X-ray phase, infrared spectroscopy, differential thermal analysis (DTA), X-ray phase scanning electron microscope. Under industrial conditions, experimental studies were carried out on the production of DAP from concentrated and non-concentrated phosphoric acid and the results of industrial tests were analyzed.

Technological regime parameters obtained in laboratory conditions were confirmed by experimental tests.

The research object: the Zhanatas deposit's off-balance, substandard in terms of chemical and granulometric composition phosphorites, phosphorus and phosphorus complex fertilizers of prolonged action.

The scientific novelty of the research:

- effective indicators of the process of acid treatment of the Zhanatas deposit's phosphate-siliceous raw materials were established: phosphate raw materials' decomposition coefficient is 95%; phosphogypsum washing off coefficient is 98.5-99.0%; extraction process time in dihydrate mode is 2-3 hours; extraction process temperature is 65-85°C;

- the main parameters for obtaining diammonium phosphate from off-balance deposit of phosphorites were determined: the molar ratio of $\text{NH}_3:\text{H}_3\text{PO}_4$ at the first stage of ammoniation is 1.4, the molar ratio of $\text{NH}_3:\text{H}_3\text{PO}_4$ at the second stage of ammoniation is 1.7;

- production of diammonium phosphate from a non-concentrated mixture of evaporated and non-evaporated EPA was substantiated on a technological scheme with a drum granulator dryer, a high-speed ammoniator-evaporator and a tubular reactor for two-stage ammonization of gaseous compounds;

- to ensure high static strength and low impermeability of DAP granules, it was found that the content of evaporated EPA in the current acid mixture is at least 30%, the fluorine content is up to 2%, reduce the fluorine content and the static strength of the granules and improve the compacting properties.

The practical significance of the work:

The practical significance of the dissertation work's research results:

- the developed technological model of EPA production using substandard off-balance phosphorites from the Zhanatas deposit and preparing diammonium phosphate on their basis;

- technological regime parameters of EPA prepared by the dihydrate method from substandard phosphorites from the Zhanatas deposit;

- technological regime indicators for preparing EPA by the dihydrate method, based on substandard phosphorites from the Zhanatas deposit, dehydration of its part by mixing with another part in certain quantities and preparing diammonium phosphate on their basis.

- all the main indicators of the effective regimes of the DAP production technological stages were confirmed in experimental conditions;

- technology for extracting phosphorus pentoxide from substandard off-balance phosphorites from the Zhanatas deposit, containing less than 24.5% of P_2O_5 into extraction phosphoric acid;

- patent of the Republic of Kazakhstan for a utility model No. 5689 on the topic "Method for preparing diammonium phosphate from substandard phosphate raw materials from the Zhanatas deposit";

- environmental and economic results of the technology for extracting phosphorus pentoxide without disturbing the natural landscape, from substandard off-balance phosphorites of the Zhanatas deposit, containing less than 24.5% of P_2O_5 into extraction phosphoric acid and preparing diammonium phosphate on their basis by double ammonization.

The expected economic efficiency of the proposed technological process in the production of 100 000 tons of DAP is 23 319 600 million KZT compared to the traditional method.

In addition, when off-balance phosphorites are used for processing, about one hundred hectares of agricultural and livestock lands are released.

The developed technology is flexible and has the possibility of a wide and complex use of off-balance phosphorite raw materials for the production of fertilizers.

The main provisions for the defense:

- the mechanism of influence of fluorine and magnesium additives on the physicochemical and physico-mechanical properties of DAP;

- the research results, mechanism and chemistry of the influence of effective technological regimes for the production of DAP on the physicochemical and physico-mechanical properties;

- the results of a two-stage neutralization of a mixture of evaporating and non-evaporating acids in the production of granulated DAP from high concentration EPA by the traditional method of drying and granulating in DGD;

- the efficient modes of processes of two-stage ammonization, drying and granulation of DAP pulp in DGD.

The doctoral student's personal contribution consists in direct participation in generalization and analysis of literary and patent materials on the topic of the dissertation research, choice of analysis methods, theoretical and experimental research, and experimental testing of the process of EPA and DAP preparing.

Approval of the experimental results. The main results and hypotheses of the dissertation were presented and discussed at the following international and republican scientific conferences: "The contribution of youth potential to the modernization of Kazakhstan 3.0" (22 November 2018), Proceedings of VI International Conference "Industrial Technologies and Engineering" (ICITE) (24-25 October 2019), Collected scientific works of International Scientific Conference "Modern Scientific Challenges and Trends" (20 January 2019), Proceedings of V International Scientific and Practical Conference in Tokyo, Japan (12-14 February 2020), Revista de Chimie (Vol. 71 / Number 12 /2020), News of the National Academy of Sciences of the Republic of Kazakhstan, Series of chemistry and technologies (July-August 2020), Reports of the National Academy of Sciences of the Republic of Kazakhstan (December 2021), RASĀYAN Journal of Chemistry (October-December 2021), RASĀYAN Journal of Chemistry (April-June 2022), published in journals of near and far abroad, a patent for utility model No. 5689 was received on the topic "Method for preparing diammonium phosphate from substandard phosphate raw materials from the Zhanatas deposit".

Publications on the topic of the work. The obtained research results on the dissertation work were published in 16 scientific works, including 4 articles in publications included in the list provided by the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 2 articles in journals included in the international Scopus database, 5 articles in international conferences, 4 articles in collections of foreign conferences and 1 patent for utility model No. 5689 was received.

The structure and scope of the dissertation. The dissertation work consists of introduction, 5 main chapters, 47 figures, 20 tables, conclusions, a list of 148 used literary and patent sources and appendixes. The scope of the work is 130 pages, including 108 pages of the main text.