

## ABSTRACT

for the thesis «Development of technology for obtaining feed additives from coal mining waste of the Lenger deposit» by **Kambatyrov Maksat Batyrovich**, submitted for the degree of Doctor of Philosophy (PhD) in specialte 6D072000 – «Chemical Technology of Inorganic Substances»

**Relevance of the research topic.** One of the strategic problems of the agro-industrial complex of the Republic of Kazakhstan is to provide agriculture with high-quality and nutritious feed products. It is obvious that a significant share of imported products in the country's food balance, a decrease in the production of domestic food products of animal origin have a negative impact on ensuring food security and the international status of the state.

The intensification of the production of livestock products is based on ensuring the full feeding of animals. Full-fledged feeding of farm animals involves providing them with all the necessary components (proteins, carbohydrates, fats, minerals, vitamins, enzymes, etc.). Therefore, the composition of feed should be balanced in carbohydrates, proteins, fats, organic and mineral substances (macro - and microelements). Strengthening the feed base of agricultural enterprises, harvesting high-quality feed and in the necessary volumes will ensure a full balanced nutrition of animals.

An increase in the production of compound feeds and an increase in the export of demanded products is provided for by the state program for the development of the agro-industrial complex (AIC) for 2017-2021. In turn, since the increase in livestock production is one of the main tasks of the coming decade, designated by the Republic of Kazakhstan, the main core of its implementation is to strengthen the feed base of the feed industry in animal husbandry.

To date, the market of feed additives in the Republic of Kazakhstan is developing very rapidly. The increase in demand for them is explained, on the one hand, by the increase in prices for livestock products, on the other hand, by state support for this industry in the form of subsidies and preferential loans. The Ministry of Agriculture of Kazakhstan has developed a master plan for the development of feed production until 2021 in order to develop this industry. A systematic solution to this issue is the modernization of existing and newly built feed mills by providing support in the form of concessional financing and investment subsidies.

**Purpose and objectives of the research.** Development of a scientifically based technology for obtaining feed additives based on carbon-containing raw materials.

To achieve the purpose of the dissertation research, the following tasks were envisaged:

- Study of the composition, properties and structure of coal mining waste from the Lenger deposit, feed tricalcium phosphate;
- Study of the process of extraction of sodium humate from coal mining wastes of the Lengersky deposit, kinetic processing of experimental data,

chemistry, as well as the composition and structure of the resulting sodium humate and development of technology for extraction of sodium humate. Mathematical processing of experimental data, calculation of the economic efficiency of the technology;

- Study of the process of obtaining feed additives based on sodium humate and feed tricalcium phosphate, kinetic processing of experimental data, chemistry, as well as the composition and structure of the resulting product, development of technology for the synthesis of feed additives. Mathematical processing of experimental data, calculation of the economic efficiency of the technology;

- Zootechnical tests of the first synthesized feed additive based on sodium humate and feed tricalcium phosphate.

**Object of research work.** Coal mining waste, sodium humate, feed tricalcium phosphate (GOST 23999-80).

**Research methods.** Kinetic, thermodynamic, chemical, complexometric, photocolometric, titrimetric research methods were used in the performance of the dissertation work. The reliability of the experimental data obtained has been verified and confirmed by modern physico-chemical instrumentation.

**Relation to the research work plan.** The PhD thesis was carried out in accordance with the scientific direction of the Department "Chemical Technology of Inorganic Substances" of the M. Auezov South Kazakhstan University within the framework of the state budget theme B-16-02-03 "Research on the creation of alternative and innovative technologies for the enrichment of raw materials and the production of products of the synthesis of inorganic compounds from natural mining and mineral resources and man-made waste from various industries."

**Scientific novelty of the research.**

It was proposed that during the chemical interaction of coal mining waste (Lenger deposit of Turkestan region) and 1% aqueous solution of sodium hydroxide at the first stage of the formation of humates occurs by the mechanism of formation of an active complex, which in composition and structure is an internal complex organic compound (complex chelates). Double-charged metal ions ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ), some nonmetals: Si, S, N... and p-elements: Al..., d-elements: Ti, Fe... in the composition of coal mining waste, as well as several organic functional groups form powerful intra-organ complexes, complex-polydentant ligands in the mechanism proposed at the first stage of humate production. At the second stage of the interaction of the obtained humates with calcium tetrahydrodiortophosphate, according to the proposed mechanism, it was proposed that the conversion of reactants-reacting substances into a product occurs due to their composition and chemical structure into complex intra-complex chelates and, in accordance with the theory of complex compounds, the formation of a digestible organomineral compound occurs.

The obtained humates are enriched with digestible additives of calcium tetrahydrodiortophosphate in accordance with the proposed mechanisms for the formation of an organomineral compound. Here the central atom is ( $\text{Ca}^{2+}$ ,  $\text{Mg}^{2+}$ ), nonmetals: Si, S, N... , p-elements: Al..., d-elements: Ti, Fe... , several organic functional groups at the first stage of humate production are accompanied by the

formation of a cyclic (chelate) complex compound, which is part of one or more cycles of covalent bonds by a donor-acceptor or exchange mechanism and is a component of the central atomic cyclic structure.

According to the proposed mechanism, polydentant ligands in the internal complex organic compound have a cyclic (chelate) structure. Stable complex compounds of metals and nonmetals with polydentate ligands with a coordination number of 3, 4, 6 enter into a chemical bond with the complexing agent through several atoms and functional organic compounds.

It was established that the optimal operating parameters of sodium humate extraction from coal mining waste are 80<sup>0</sup>C, 100 min. The "apparent" activation energy of the sodium humate extraction process from coal mining waste was also calculated. As a result of calculations, it turned out that it is equal to  $E_A = 16.9$  kJ / mol. This, in turn, indicates that the extraction process of sodium humate occurs in the internal diffusion zone. As a result of the conducted research, a technological scheme for the extraction of sodium humate from coal mining waste has been developed. According to the developed technological scheme, a liquid-phase colloidal mixture of dark brown color was formed, consisting of sodium humate and mineral components dissolved in it-compounds of aluminum, iron, sulfur, etc. A study conducted on the synthesis of sodium humate from coal mining waste has received a patent for a utility model.

Mechanisms of formation of intra-complex organic compounds of chelated complex humates "humate-aqueous solutions of sodium hydroxide-calcium tetrahydrodiortophosphate" based on coal mining waste and feed tricalcium phosphate are proposed and can be used to explain the formation of organomineral compounds in aqueous solutions with specified properties. The composition, structure of the obtained organomineral complex compounds and the mechanism of possible chemical changes are proposed. This will allow a deeper understanding of the mechanism of similar technological processes, deepen and develop their chemical technology, and also use them as a "model" for the development of promising technologies for the production of organomineral complex compounds used in agriculture as feed additives.

The mechanisms of chemical transformation of coal mining waste are most fully described from a scientific point of view (based on the theory of complex compounds) and reflect a clearly directed way of obtaining feed additives with high economic demand in agriculture. After all, the developed technology makes it possible to fully obtain a clean (without unnecessary impurities and by-products in accordance with the proposed mechanisms) and highly effective organomineral complex compound standardized in terms of quality.

The "apparent" activation energy of the interaction of sodium humate extracted from coal mining waste and feed tricalcium phosphate was calculated. As a result of calculations, it was found that  $E_A = 10.38$  kJ/mol. This, in turn, indicates that the process of interaction of sodium humate and feed tricalcium phosphate occurs in the internal diffusion zone. Also, as a result of experimental studies, it was found that the optimal operating parameters of the interaction of sodium humate extracted from coal mining waste and feed tricalcium phosphate are 65 min

and 70°C. It is with these indicators that the digestible P<sub>2</sub>O<sub>5</sub> increased to 23.37%. As a result of the research work, a patent for a utility model was obtained.

**Basic findings for the defence:**

- results of a comprehensive study of the composition, structure and properties of coal mining waste and feed tricalcium phosphate;

- kinetic data of the extraction process of sodium humate from coal mining waste, chemistry, optimal operating parameters, technological scheme and results of a comprehensive study of the composition, structure and properties of the resulting product;

- kinetic data of the process of interaction of sodium humate and feed tricalcium phosphate, chemistry, optimal operating parameters, technological scheme and results of a comprehensive study of the composition, structure and properties of the resulting product;

- statistical processing of both mathematical and experimental data on the interaction of sodium humate and feed tricalcium phosphate;

- technical and economic indicators of the developed technology;

- the results of zootechnical tests of feed additives synthesized on the basis of sodium humate and feed tricalcium phosphate in broilers "Aibor Aikress" in the conditions of Shymkent-kus LLP.

**Practical significance of the work.** Based on the conducted research, new technological solutions for the production of feed additives with the interaction of sodium humate and feed tricalcium phosphate have been developed and proposed. In the cycle of the developed technology, it allows to dispose of such multi-ton industrial and technogenic solid waste as coal mining waste. The economic efficiency of the developed technologies has been confirmed. Zootechnical tests clearly demonstrate the applied value of the developed technologies, the high efficiency of the practical application of the obtained feed additive.

**Approbation of experimental results.** Zootechnical tests of the obtained feed additive were carried out in 2021 on broilers of the Aibor Aikress cross in a mixed herd of 100 heads under the conditions of the Shymkent-kus limited liability partnership located in the Tolebi district of the Turkestan region. Planting standards, light, temperature, humidity conditions, feeding and watering indicators corresponded to the recommendations. The birds were fed a dry, loose feed additive with nutrients in accordance with the standards for this species of Aibor Aikres. The results of zootechnical tests showed an increase in live weight in the experimental groups by 1.75% compared with the birds in the control groups.

**The doctoral student's personal contribution** consists in the analysis and generalization of literary material on the topic of dissertation research, the choice of research and analysis methods, conducting theoretical and experimental studies, performing zootechnical tests, mathematical and statistical processing and generalization of research results, calculating the economic efficiency of obtaining feed additives based on carbon-containing raw materials.

**Publications on the topic of the research.** The main results of the study have been published in publications included in the list submitted by the Committee for Control in the Field of Education and Science of the Ministry of Education and

Science of the Republic of Kazakhstan, 2 articles in journals included in the international database Scopus, 3 articles in the proceedings of the international scientific and practical conference, 1 article in scientific publications and 2 patents for utility model.

**Structure and volume of the thesis.** The work consists of an introduction, 4 chapters, a list of references and appendices. The results of the study consist of 117 pages of text, 42 figures and 33 tables.