ТЕХНИКАЛЫҚ ҒЫЛЫМДАР
ТЕХНИЧЕСКИЕ НАУКИ
TECHNICAL SCIENCES

UDC 661.152.3 https://doi.org/10.54251/2616-6429.2025.04.0001nu

L. Aikozova[1]*, Sh. Dzholdasova[1], A. Utebayev[1], N. Asylbek[1], N. Faizullayev[2]
[1]cand.tech.sci., associate professor, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan
[1]cand.chem.sci., associate professor, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan
[1]cand.tech.sci., associate professor, M. Auezov South Kazakhstan University, Shymkent, Kazakhstan
[1]master of chemical technology, lecturer, M.Auezov South Kazakhstan University, Shymkent, Kazakhstan
[2]Professor, Samarkand State University named after Sharof Rashidov, Samarkand, Uzbekistan
***Corresponding author's email:** laura.aykozova@mail.ru

RESEARCH ON THE TECHNOLOGY OF OBTAINING AMMOPHOSKA CONTAINING TRACE ELEMENTS

Abstract

This article examines trace elements that regulate the functional activity of living organisms, are part of tissues, enzymes, hormones involved in the synthesis of carbon, fats, proteins, vitamins and other substances. In addition, trace elements allow plants to withstand adverse weather conditions, have a positive effect on the absorption of nutrients and water by the body. It is shown that trace elements play a special role in increasing the efficiency of mineral fertilizers and increasing the yield of agricultural plants.

Special attention is paid to elements such as zinc, copper, manganese, boron, molybdenum, cobalt and iron, since even their minor deficiency in the soil can become a limiting factor for plant growth and development.

Keywords: industrial waste, waste processing, mineral fertilizers, complex mineral fertilizers, ammophos, potassium nitrate, nitrophoska, ammonium, monoammonium phosphate, diammonium phosphate.

Introduction

Mineral fertilizers are the main source of various nutrients for plants, primarily nitrogen, phosphorus, potassium, but also calcium, magnesium, sulfur, iron, and are very important for the composition of the soil. All these elements belong to the group of macroelements.

Complex mineral fertilizers are considered more important, since they contain several nutrients. This type of fertilizer includes: ammophos, potassium nitrate and nitrophoska. The first of these is obtained by the reaction of phosphoric acid with ammonia. Depending on the degree of neutralization, monoammonium phosphate $NH_4H_2PO_4$ and diammonium phosphate $(NH_4)_2HPO_4$ are formed. [1].

The use of slags with various impurities in agricultural production as chemical fertilizers and for soil improvement is of considerable scientific and practical interest. [2]. In order to use slags from metallurgical production, it is first necessary to study the amount of metals in their composition and the properties of the slag. For a long time, the theory of the structure of slags was developed, considering them as a combination of basic and acidic oxides [3]. Some of the slags combine with each other to form complex compounds, while the rest is in a "free" state. The molecular theory of the structure of slags was proposed by G. Shenkov and his colleagues [4]. According to the research of these scientists, it is based on the law of equilibrium established by slag-steins and the law of reactive masses acting in its ideal form. The chemical composition of slags after fuming: 38,6% FeO; 12,7% Fe_2O_3; 24,8% SiO_2; 13,8% CaO; 5,5% Al_2O_3; 0,12% Pb; 2,6% ZnO; 0,58% Cu and 1.1% S. Lead and copper are present in it in the form of metal droplets or sulfides. The density of the oxides in the slag is as follows, g/cm3: 2,20 SiO_2; 3,35 CaO; 5,2 FeO; 2,3 Al_2O_3. Slags from metallurgical production are crushed and sorted into grades depending on their fractions in a sorter. Fractions with a size of 0-5 mm or 0-10 mm are sorted into classes in a pneumoclassifier at an air flow speed of 12-18 m/s, and a slag concentration in the air flow of 4-10 kg/m3. Then the separated slag fractions are mixed with ammophoska fertilizer [5].

Materials and Methods

In laboratory conditions, the process of obtaining ammophoska by neutralizing phosphoric acid of known concentration with ammonia water in two stages was studied [6].

Karatau phosphorite was used for the study (composition%): 17,8 % P_2O_5, 0,38% CaO, 0,49% SiO_2, 0,5% Fe_2O_3, 0,93%SO_3, 0,23% Al_2O_3, 1,3% MgO, 1,3% F, 5% insoluble residues[6].

The first stoichiometric weight of 10.0 g of phosphorite was dissolved in a mixture of two acids (nitric and sulfuric). The resulting pulp was heated to 750C, and the solid and liquid phases were separated. The resulting liquid phase was poured into a three-necked flask with a volume of 200-250 cm3, placed in a laboratory thermostat equipped with a stirrer and a thermometer, and gradually neutralized with a 25% ammonia solution (pH-4.5-5.0). The neutralization time was 40 minutes and the temperature was 30-400C. Then the pulp was filtered using a Buchner funnel, the resulting solid phase was washed with a small amount of water and dried in a drying cabinet. The solid phase product (salts) formed in this first stage can be used as a second-grade ammophoska.

In the second stage of the neutralization reaction, ammonia water, and then the prepared solution of potassium salt are added dropwise to the separated liquid solution using a separatory funnel. The completion of the reaction is determined using the methyl orange indicator. The resulting pulp is transferred to a porcelain dish, weighed on an analytical balance, and dried in a drying oven at 60-900C with frequent stirring. When the product becomes friable, the drying is stopped and the drying time is determined. The drying temperature is selected depending on the pH value, that is, the type of salts obtained and their stability. The dried product is weighed on an analytical balance (m), ground, and analyzed for moisture content (C_{H2O}), nitrogen (CN), and P_2O_5 (C_{P2O5}).

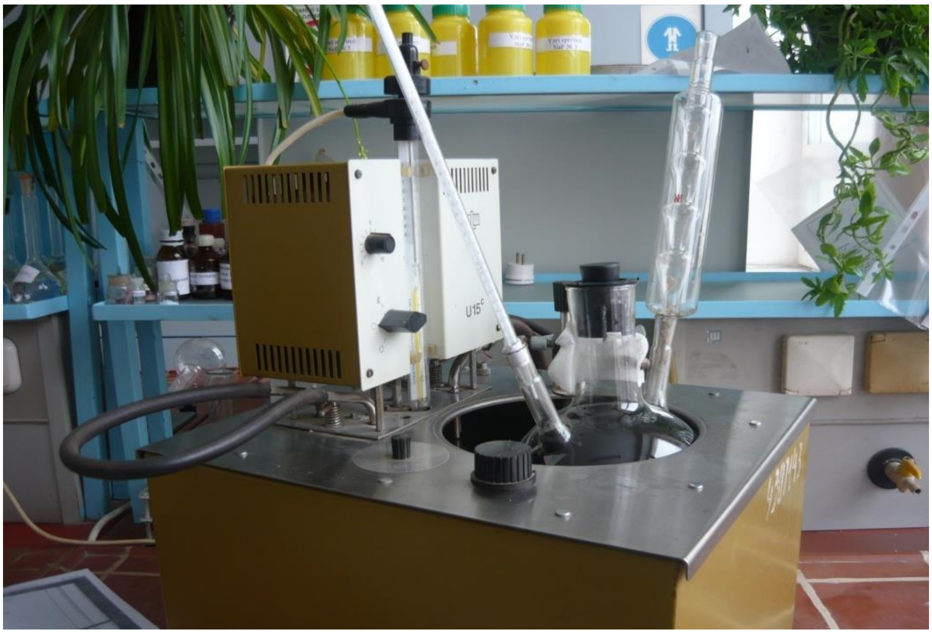

Figure 1. Laboratory equipment for the production of ammophoska

Selection of analytical methods. Study of solubility in the systems NH_3-H_3PO_4-H_2O and $NH_4H_2PO_4$-$(NH_4)_2HPO_4$-H_2O.

To ensure the accuracy of the data obtained as a result of the study, studies were conducted to determine the reactions of neutralization of phosphoric acid, i.e. the decomposition of phosphoric acid and the main technological indicators of the process, and the solubility in the NH_3-H_3PO_4-H_2O and $NH_4H_2PO_4$-$(NH_4)_2HPO_4$-H_2O systems was studied [/].

Results and Discussion

The processes under study are not only chemical, but also complex chemical-technological systems consisting of state transitions under equilibrium conditions. Therefore, it is impossible to obtain a technology for neutralizing phosphoric acid without a comprehensive physicochemical analysis of these systems and without determining the laws of phenomena occurring in these systems. These analyses are carried out by showing the dependence of the heterogeneous system on its composition and indicators and their state diagrams. In addition, information on the solubility of the specified system is also limited and does not correspond to the conditions for conducting processes in the system under study. In this regard, there is a need to study the phase diagrams of the above systems, since these obtained values are the necessary sources of information for calculating the scientific basis of technological processes occurring in the processing by the phosphoric acid method.

We conducted the solubility of aqueous-salt systems using visual-polythermal and isothermal methods.

By the visual-polythermal method, the temperature of the first crystals during uniform cooling of the solutions and the last crystals lost during heating of the solutions were visually monitored [8].

The experiment was carried out in a device equipped with a freezer, a mixer and a thermometer. The temperature was stabilized by a thermometer with an accuracy of +0.10°C. The system was studied using internal polythermal curves. Based on the data obtained, a solubility diagram was constructed using the Rosebum method [8]. In the studied systems, isotherms were constructed using interpolation based on polythermal curves at every 100°C. To clarify the intersection point and crystallization surface, polythermal projections were constructed on the system.

The study by the isothermal method [9] allows us to determine the mutual solubility of the components in the system under study. The experiment was carried out in a thermostat with a hydraulic holder, in which a three-necked flask equipped with a mixer and a thermometer was placed. The temperature was stabilized by a thermometer with an accuracy of $+0.1^0$C. After saturation was reached, samples were taken from the liquid state for analysis every 30 minutes using a thermostatic sampler. The establishment of equilibrium can be seen from the results of the last two or three samples taken. At the same time, samples were also taken from the solid state for analysis of the P_2O_5 content, for which the formed crystals were previously dried by a standard method, and the analysis was carried out by the photoelectrocolorimetric method. The solubility was determined based on the results of 3-4 parallel experiments, the maximum deviations of each two parallel analyses carried out in the liquid state should not exceed 0.5%.

The temperature dependence of the solubility of ammonium phosphate was studied. Diammonium phosphate forms stable saturated solutions. Triammonium phosphate dissolves in water by decomposition. Among the solid ammonium phosphates, monoammonium phosphate is stable; when heated to 100^0C, it does not significantly lose ammonia from its composition. Diammonium phosphate, on the other hand, loses significantly ammonia from its composition at 70^0C and passes into monoammonium phosphate. Triammonium phosphate decomposes at 30-40^0C. The boiling points of saturated solutions of monoammonium are shown in Figure 2.

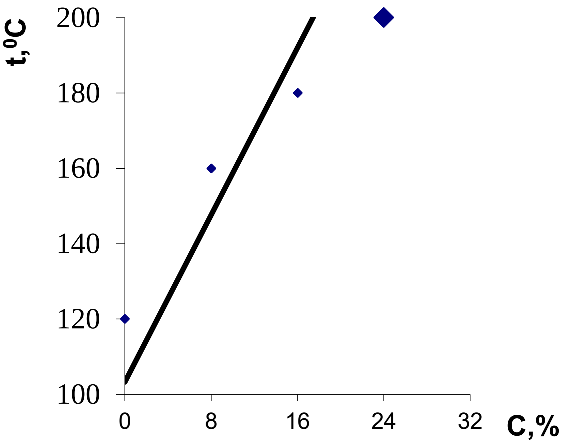

Figure 2. Boiling point of saturated solutions of monoammonium phosphate

The quality control of the experimentally obtained product was carried out by chemical and crystal-optical methods. Figure 3 shows thermograms of ammophoska.

Thermogravimetric analysis was carried out on a derivatograph of the Paulik-Eridey system. Here, the heating rate of the substances was 12 degrees/min, the maximum temperature was 600^0C and 9 degrees/min to 900^0C. During the study, a platinum-platinum-rhodium thermocouple isolated from the substances was used. The sample under study was placed in a platinum crucible with a lid. The sensitivity of the galvanometers was DTT-1/10, DTG-1/15. The weight of the sample taken for analysis was -0.1 g., calcined alumina was used as a standard [10].

Figure 3. Differential thermal derivation of ammophoska

In the differential-thermal curve, an endothermic effect was observed at 178°C. This change corresponds to the melting of diammonium phosphate and the decomposition of the salt. And at 265°C it corresponds to the melting and decomposition of monoammonium phosphate.

The technology of obtaining ammophoska by neutralizing phosphoric acid with ammonia water in two stages in laboratory conditions was considered. The study was carried out at temperatures of 40÷95°C and for 30, 60, 90 min. time intervals. Using the results of the study, a schematic diagram of the process of obtaining ammophoska is prepared.

Conclusions

The method of neutralizing ammophos - phosphoric acid and ammonia is shown. The solubility of the systems formed during neutralization is given. It is established that the studied processes consist of complex chemical and technological systems consisting not only of chemical, but also of state changes in equilibrium conditions. The raw materials necessary for the production of ammophos are described. In laboratory conditions, the process of obtaining ammophos by two-stage neutralization of phosphoric acid of known concentration with ammonia water was studied. The results of experimental tests conducted to obtain a complex fertilizer were compared with standard indicators.

References

1. Technology of phosphorous and complex fertilizers / Ed. S. D. Evenchika and A. A. Brodskogo.-M.: Chemistry, 2000.- 464 p.
2. Fedyushkin, B.F. Mineral fertilizers with trace elements. Technology and application. -L.: Chemistry, 2001. -272 p.
3. Korenko, D.A. Productive use of mineral fertilizers - M.: Rosselkhozizdat, 2000.-221 p.
4. Dmitrievsky, B.A. Properties, obtaining and application of mineral fertilizers.-SPb.:Prospekt Nauki, 2013.-326 p.
5. Petrov, D. A. Double and triple systems.-M., 2004.-65 p.
6. Dovgopol, V.I. Metallurgical slags in agriculture. -M.: Metallurgy, 2001.-40 p.
7. Dokholova, A.N., Karmyshov, V.F., Sidorina, L.V. Production and application of ammophoski.-M., "Khimiya", 2000. -240 p.
8. Bishimbaev. U.K., Narmanova R.A., Espenbetova Sh.O. Technological foundations of chemistry: Textbook for students of higher educational institutions.-Almaty: Kitap Publishing House, 2006. -296 p.
9. Erdman, S.V., Frolov I.V., Korobochkin V.V. Chemical technology of inorganic substances: textbook.-Tomsk: Institute of Tomsk Polytechnic University, 2011.-194 p.
10. Aleskovsky, V.B., Bardin, V.V., Boychinova, E.S. etc. Physico-chemical methods of analysis. -L.: Chemistry, 2000.-95 p.

Л. Айкозова[1]*, Ш. Джолдасова[1], А. Өтебаев[1], Н. Асылбек[1], Н.Файзуллаев[2]
[1]т.ғ.к., доцент, М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан
[1]х.ғ.к., доцент, М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан
[1]т.ғ.к., доцент, М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан
[1]химиялық технология магистрі, оқытушы, М. Әуезов атындағы Оңтүстік Қазақстан университеті, Шымкент, Қазақстан
[2]профессор, Шароф Рашидов атындағы Самарқанд мемлекеттік университеті, Самарқанд, Өзбекстан
***Корреспондент авторы:** laura.aykozova@mail.ru

ҚҰРАМЫНДА МИКРОЭЛЕМЕНТТЕРІ БАР АММОФОСКА АЛУ ТЕХНОЛОГИЯСЫН ЗЕРТТЕУ

Түйін

Бұл мақалада тірі организмдердің функционалдық белсенділігін реттейтін, көміртегі, майлар, ақуыздар, витаминдер және басқа заттардың синтезіне қатысатын ұлпалардың, ферменттердің, гормондардың құрамына кіретін микроэлементтер қарастырылады. Сонымен қатар, микроэлементтер өсімдіктерге қолайсыз ауа райы жағдайларына төтеп беруге мүмкіндік береді, қоректік заттар мен судың ағзаға сіңуіне оң әсер етеді. Минералды тыңайтқыштардың тиімділігін арттыруда және ауылшаруашылық өсімдіктерінің өнімділігін арттыруда микроэлементтердің ерекше рөл атқаратындығы көрсетілген.

Мырыш, мыс, марганец, бор, молибден, кобальт және темір сияқты элементтерге ерекше назар аударылады, өйткені олардың топырақтағы шамалы жетіспеушілігі де өсімдіктердің өсуі мен дамуын шектейтін факторға айналуы мүмкін.

Микроэлементтерді күрделі тыңайтқыштардың бір бөлігі ретінде немесе жапырақты үстіңгі байыту арқылы (жапырақ арқылы) енгізу дақылдардың аурулар мен зиянкестерге төзімділігін едәуір арттыратыны, жемістер мен дәндердегі қанттардың, витаминдердің, ақуыздардың және майлардың құрамын арттыру арқылы дақылдардың сапасын жақсартатыны дәлелденді.

Кілттік сөздер: өндірістік қалдықтар, қалдықтарды қайта өңдеу, минералды тыңайтқыштар, күрделі минералды тыңайтқыштар, аммофос, калий нитраты, нитрофоска, аммоний, моноаммоний фосфаты, диаммоний фосфаты.

Л. Айкозова[1*], Ш. Джолдасова[1], А. Утебаев[1], Н. Асылбек[1], Н.Файзуллаев[2]
[1]к.т.н., доцент, Южно-Казахстанский университет им. М. Ауэзова, Шымкент, Казахстан
[1]к.х.н., доцент, Южно-Казахстанский университет им. М. Ауэзова, Шымкент, Казахстан
[1]к.т.н., доцент, Южно-Казахстанский университет им. М. Ауэзова, Шымкент, Казахстан
[1]магистр химической технологии, преподаватель, Южно-Казахстанский университет им. М.Ауэзова, Шымкент, Казахстан
[2]профессор, Самаркандский государственный университет им. Шарофа Рашидова, Самарканд, Узбекистан
***Автор для корреспонденции:** laura.aykozova@mail.ru

ИССЛЕДОВАНИЕ ТЕХНОЛОГИИ ПОЛУЧЕНИЯ АММОФОСКИ, СОДЕРЖАЩЕЙ МИКРОЭЛЕМЕНТЫ

Аннотация

В данной статье изучены микроэлементы, которые регулируют функциональную активность живых организмов, входят в состав тканей, ферментов, гормонов, участвующих в синтезе углерода, жиров, белков, витаминов и других веществ. Кроме того, микроэлементы позволяют растениям противостоять неблагоприятным погодным условиям, оказывают положительное влияние на усвоение питательных веществ и воды организмом. Показано, что микроэлементы играют особую роль в повышении эффективности минеральных удобрений, увеличении урожайности сельскохозяйственных растений.

Особое внимание уделяется таким элементам, как цинк, медь, марганец, бор, молибден, кобальт и железо, поскольку даже их незначительный дефицит в почве может стать лимитирующим фактором для роста и развития растений. Доказано, что внесение микроэлементов в составе комплексных удобрений или путем внекорневой подкормки (через лист) существенно усиливает устойчивость культур к болезням и вредителям, улучшает качество урожая — повышает содержание сахаров, витаминов, белков и жиров в плодах и зерне.

Ключевые слова: промышленные отходы, переработка отходов, минеральные удобрения, комплексные минеральные удобрения, аммофос, калиевая селитра, нитрофоска, аммоний, моноаммоний фосфат, диаммоний фосфат.