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TECHNOLOGY FOR OBTAINING NPS-FERTILIZERS BASED ON AMMONIUM NITRATE MELT, KYZYLKUM PHOSPHORITE, AND PHOSPHOGYPSUM

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Abstract: This article investigates the technology for obtaining multicomponent NPS-fertilizers based on ammonium nitrate melt, Kyzylkum phosphorite, and industrial waste—phosphogypsum. The study examines the influence of mineral additives on the physicochemical properties of the ammonium nitrate melt, specifically focusing on granule strength and hygroscopicity. The research results demonstrate that the addition of phosphogypsum and phosphorite enhances the thermal stability of the final product and enriches it with essential nutrients such as nitrogen, phosphorus, and sulfur.

Keywords: Ammonium nitrate melt, Kyzylkum phosphorite, phosphogypsum, NPS-fertilizers, granule strength, hygroscopicity, technological process, mineral additives.

AMMIAKLI SELITRA SUYUQLANMASI, QIZILQUM FOSTORITI VA FOSFOGIPS ASOSIDA NPS-O'G'ITLAR OLISH TEXNOLOGIYASI

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Annotatsiya: Ushbu maqolada mahalliy xomashyolar — ammiakli selitra suyuqlanmasi, Qizilqum fosforiti va sanoat chiqindisi hisoblangan fosfogips asosida ko'p komponentli NPS-o'g'itlar olish texnologiyasi tadqiq etilgan. Tajribalar davomida mineral qo'shimchalarning ammiakli selitra suyuqlanmasining fizik-kimyoviy xossalariga, xususan, granulalar mustahkamligi va gigroskopikligiga ta'siri o'rganilgan. Tadqiqot natijalari shuni ko'rsatadiki, fosfogips va fosforit qo'shilishi tayyor mahsulotning termik barqarorligini oshiradi va tarkibini o'simliklar uchun zarur bo'lgan azot, fosfor va oltingugurt elementlari bilan boyitadi.

Kalit so'zlar: Ammiakli selitra suyuqlanmasi, Qizilqum fosforiti, fosfogips, NPS-o'g'itlar, granulalar mustahkamligi, gigroskopiklik, texnologik jarayon, mineral qo'shimchalar.

ТЕХНОЛОГИЯ ПОЛУЧЕНИЯ NPS-УДОБРЕНИЙ НА ОСНОВЕ ПЛАВА АММИАЧНОЙ СЕЛИТРЫ, КЫЗЫЛКУМСКИХ ФОСФОРИТОВ И ФОСФОГИПСА

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Аннотация: В данной статье исследована технология получения многокомпонентных NPS-удобрений на основе плава аммиачной селитры, Кызылкумского фосфорита и техногенного отхода — фосфогипса. В ходе экспериментов изучено влияние минеральных добавок на физико-химические свойства плава аммиачной селитры, в частности, на прочность гранул и гигроскопичность. Результаты исследований показывают, что введение фосфогипса и фосфорита повышает термическую стабильность готового продукта и обогащает его состав азотом, фосфором и серой, необходимыми для питания растений.

Ключевые слова: Плав аммиачной селитры, Кызылкумский фосфорит, фосфогипс, NPS-удобрения, прочность гранул, гигроскопичность, технологический процесс, минеральные добавки.

INTRODUCTION

The sustainable development of the agricultural sector directly depends on the efficiency and quality of the mineral fertilizers used. Currently, ammonium nitrate (NH_4NO_3) remains one of the most widely used nitrogen fertilizers globally due to its high nitrogen content and rapid solubility. However, its high hygroscopicity, tendency to cake during storage, and potential fire and explosion hazards limit its efficiency and safety. Enhancing the physical and chemical properties of ammonium nitrate while enriching it with additional nutrients like phosphorus and sulfur is a critical task for modern chemical technology.

In the Republic of Uzbekistan, particularly within the framework of utilizing local raw material bases, the integration of Kyzylkum phosphorites and industrial waste such as phosphogypsum into the production of complex fertilizers is of great strategic importance. Kyzylkum phosphorites serve as a vital source of phosphorus (P_2O_5), while phosphogypsum—a byproduct of phosphoric acid production—is a rich source of

calcium and sulfur. The accumulation of phosphogypsum in dumps creates significant environmental pressure, making its processing into fertilizers a dual-purpose solution: improving soil fertility and addressing environmental waste management.

The development of NPS-fertilizers (Nitrogen, Phosphorus, Sulfur) by introducing mineral additives into the ammonium nitrate melt allows for the production of balanced, multicomponent fertilizers. Previous studies have shown that the interaction between ammonium nitrate and calcium sulfate (the primary component of phosphogypsum) leads to the formation of stable double salts, such as ammonium sulfate and calcium nitrate:

$$2NH_4NO_3 + CaSO_4 \rightarrow (NH_4)_2SO_4 + Ca(NO_3)_2$$

This chemical transformation significantly reduces the moisture absorption of the final product and increases the mechanical strength of the granules. Furthermore, the addition of phosphorite flour provides a prolonged release of phosphorus, ensuring a steady nutrient supply to crops throughout the growing season.

This research aims to establish the optimal technological parameters for obtaining NPS-fertilizers based on the ternary system of ammonium nitrate melt, Kyzylkum phosphorite, and phosphogypsum, evaluating their impact on the structural and qualitative characteristics of the resulting mineral complex.

MATERIALS AND METHODS

The following components were used for the synthesis of NPS-fertilizers:

- Ammonium Nitrate (AN): Industrial grade (34.4 % N) in the form of a melt.
- Kyzylkum Phosphorite (KP): Ground phosphorite flour containing 17.5-18.0% P_2O_5.
- Phosphogypsum (PG): A byproduct of phosphoric acid production, primarily consisting of calcium sulfate dihydrate ($CaSO_4 \cdot 2H_2O$), containing approximately 20-22% S and traces of P_2O_5.

The synthesis was conducted in a laboratory-scale reactor equipped with a high-speed stirrer and a heating mantle. The process followed these stages:

1. Melting: Ammonium nitrate was heated to a temperature of 170-175°C to obtain a stable melt.
2. Dosing: Predetermined ratios of Kyzylkum phosphorite and phosphogypsum (ratios of AN:KP:PG ranging from 100:5:5 to 100:20:20) were added to the melt.
3. Homogenization: The mixture was stirred for 15–20 minutes to ensure uniform distribution of mineral particles.
4. Granulation: The resulting slurry was granulated using a laboratory prilling tower and then cooled to room temperature.

The chemical composition was determined using standard titrimetric and photometric methods. The mechanical strength of the granules was measured using a **P-5 brand** static pressure tester. Hygroscopicity was evaluated by the desiccator method at a relative humidity of 70-80%.

RESULTS AND DISCUSSION

The primary objective of the experimental studies was to determine the optimal ratio of ammonium nitrate (AN), Kyzylkum phosphorite (KP), and phosphogypsum (PG) to ensure high nutrient content and superior physical properties.

In this research work, the processes of obtaining potassium ammonium nitrate by adding potassium chloride-KCl to ammonium nitrate liquefied (96-99.8%) or concentrated (92, 85, 80 and 70%) solutions in the weight ratio N : K2O = 1 : (0.3-1.6) were studied. According to the chemical analysis of the composition of the new type of fertilizers, it was found that the total amount of nitrogen element in the product obtained by adding KCl from 6.17 to 61.7% stoichiometrically to 99.8% AS liquefied decreased from 32.6 to 21.9%, and the amount of K2O increased from 3.26 to 21.89%. In this case, the sum of the nutrient components (N + K2O) was in the range of 35.86-43.79%.

Using the acetone extraction method, the salt content of potassium-ammonium nitrate samples obtained by reacting potassium chloride with 99.8% ammonium nitrate liquefaction for 5 to 30 minutes

and the degree of conversion of potassium chloride to potassium nitrate-KNO3 were determined. The longer the reaction time of potassium chloride with ammonium nitrate liquefaction, the higher the amount of potassium nitrate in the product and the degree of conversion of potassium chloride. For example, the product obtained with a weight ratio of N : K2O = 1 : 0.5 and a reaction time of 5 minutes

contained 66.11% NH4NO3;

11.55% KCl; It was found that the conversion of potassium chloride was 48.26%. The product obtained from the same ratio of N:K2O and 30 minutes of reaction of the initial components contained 56.18% NH4NO3; 2.29% KCl; 27.16% KNO3; 14.37% NH4Cl, and the conversion of potassium chloride was 89.75%. The strength of fertilizers obtained from the interaction of potassium chloride with ammonium nitrate liquefaction in the weight ratio N : K2O = 1 : (0.1-1) for 5 minutes was in the range of 3.48-6.94 MPa, and after 30 minutes of holding, these indicators were 4.52-8.76 MPa.

The viscosity of potassium-ammonium nitrate samples obtained in the ratio N : K2O = 1 : (0.1-1) is 3.54-2.48 kg/cm2, which is 1.6-2.3 and 1.32-1.88 times lower than that of pure (5.62 kg/cm2) and nitrate with magnesite addition (4.67 kg/cm2), respectively.

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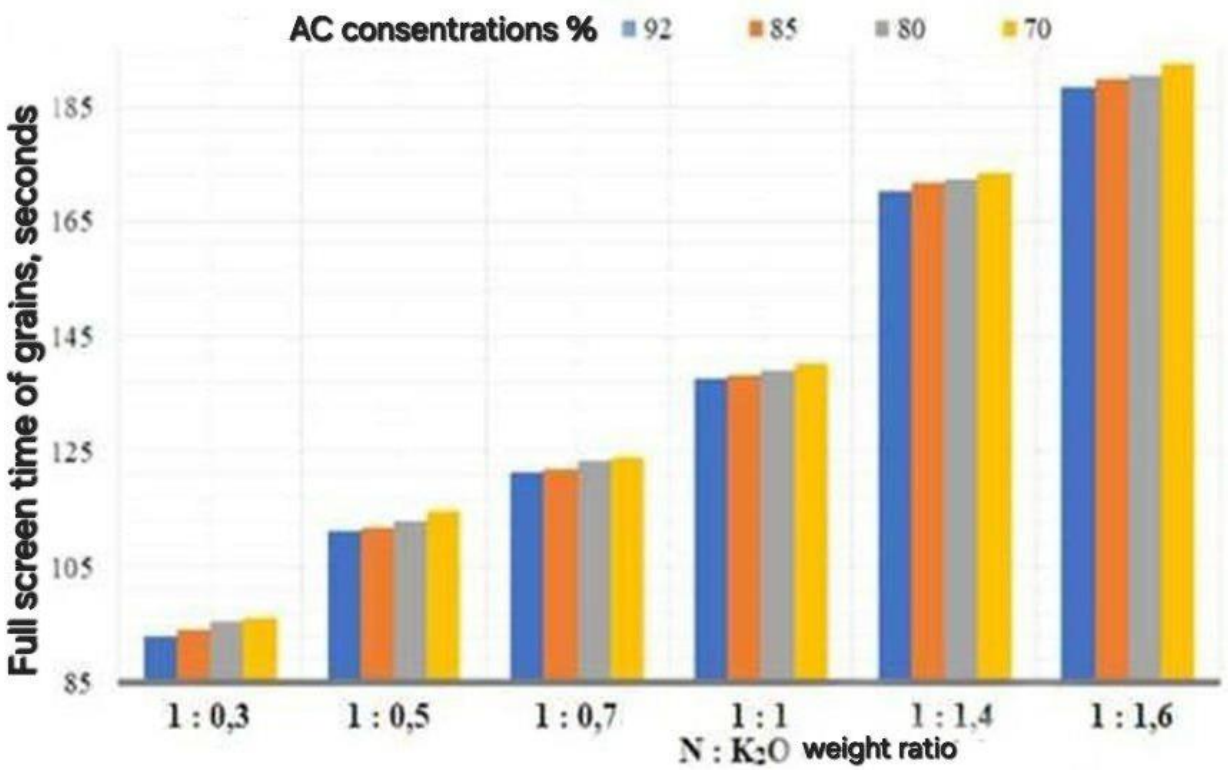

Dissolution rate of NK fertilizer granules based on concentrated solutions of ammonium nitrate and potassium chloride.

The total water solubility rate of potassium-ammonium nitrate grains obtained depending on the concentrated solution of ammonium nitrate and the mass ratio of N : K2O is 93.1 to 192.3 minutes, which is 2-4.11 times slower soluble in water than in magnesite celitra (46.8 minutes) (Figure 1.4). The rheological properties of potassium-nitrate liquefaction were in the range of density and viscosity 1,275 - 1,537 g/cm3 and 1,19-5.48 sPz in the range of 1,000-110g C, depending on the mass ratio of N : K2O, and it was recommended to carry out their granulation in the granulator-drum. The laboratory model device tested the optimal technological parameters of potassium-ammonium nitrate and developed a principled technological system for obtaining this fertilizer. There is one main obstacle in the large-scale production of potassium-ammonium nitrate based on ammonium nitrate and powder Holi potassium chloride, which is also

obtained if nitrogen-potassium fertilizer the presence of a chlorine element in the composition is considered, while chlorine increases the susceptibility of saltpeter to thermal decomposition

Kyzylkum, Ingichka, Shursu deposits natural gypsum and the dispersed composition of man-made waste phosphogips

Seniority class, mm	The yield of sample fraction outputs is, heavy. %			
	Kyzylkum	Ingichka	Shursu	Man-made waste Phosphogips
0,5	10,85	14,38	21,56	19,35
- 0,5 + 0,315	9,57	11,73	14,35	11,19
- 0,315 + 0,25	6,35	7,62	6,63	5,46
- 0,25 + 0,16	43,26	42,87	27,68	28,89
- 0,16 + 0,063	19,44	14,18	15,91	21,77
- 0,063 + 0,05	10,53	9,22	13,87	13,34
Initial robbery	100	100	100	100

2Table2. Kyzylkum, Ingichka, Shursu *deposits of natural gypsum and man-made waste phosphogips chemical composition*

Selected object names	Komponentlar miqdori, og‘ir. %									
	CaO	SiO_2	MgO	MnO	TiO_2	Na_2O	K_2O	P_2O_5	SO_3	F
Kyzylkum	32,74	2,98	0,014	0,04	0,06	0,07	0,35	0,05	49,12	
Ingichka	31,91	2,05	0,021	0,057	-	0,05	0,23	0,04	46,81	
Shursu	32,18	2,56	0,036	0,02	0,03	0,06	0,09	0,09	46,09	
Phosphgypsum	37,47	1,73	-	0,072	0,08	-	0,10	1,59	54,49	0,358

From table 2.2 it can be seen that natural casts from the mines of "Boysun" (Surkhandarya vil), "thin" (Samarkand vil) and "Shursu" (Fergana vil), ground to a size of 0.25 mm, selected as acceptable in obtaining NS-fertilizers, contain 32.74%, 31.91%

and 32.18% CaO element respectively, while these pointers contain 49.12%, 46.81% and 46.09% for SO3 element respectively was found to be equal.

While phosphogips, a man-made waste of" Ammofos-Maxam " AJ production, has been found to have a total sulfur (VI) oxide (SO3) content of 54.49%, the total calcium (II) oxide (CaO) content is 37.47%.

The analysis of the obtained results indicates that the inclusion of Kyzylkum phosphorite and phosphogypsum into the ammonium nitrate melt leads to significant qualitative changes in the fertilizer structure. According to the data, increasing the proportion of mineral additives promotes the formation of a stable crystalline framework, which in turn increases the static strength of the granules by 3–3.5 times compared to pure ammonium nitrate. This strengthening is primarily attributed to the chemical interaction between ammonium nitrate and calcium sulfate, resulting in the formation of double salts that reinforce the granule's internal matrix.

CONCLUSION

The research conducted on the development of NPS-fertilizers based on ammonium nitrate melt, Kyzylkum phosphorite, and phosphogypsum leads to the following conclusions:

Technological Optimization: The optimal conditions for introducing mineral additives into the ammonium nitrate melt were established at a temperature range of 170–175°C. It was found that a mass ratio of AN:KP:PG ranging from 100:15:10 to 100:20:15 provides the best balance between nutrient content and physical properties.

Physical-Mechanical Enhancement: The addition of phosphogypsum and phosphorite flour significantly improves the structural integrity of the granules. The static strength increased from 1.2 MPa to over 4.0 MPa, while the hygroscopic point rose from 55% to 72-74%, significantly reducing the tendency of the fertilizer to cake during storage.

Chemical Interaction: It was scientifically confirmed that the interaction between ammonium nitrate and calcium sulfate in the melt leads to the formation of stable salts, which act as a thermal stabilizer for the NH_4NO_3 polymorphic transitions.

Economic and Environmental Impact: The proposed technology enables the effective utilization of industrial waste (phosphogypsum) and low-grade natural

phosphorites, resulting in a more cost-effective and environmentally friendly production process for multicomponent fertilizers.

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