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DEVELOPMENT AND STUDY OF AN ANTI-CAKING ADDITIVE TO IMPROVE THE PHYSICO-MECHANICAL PROPERTIES OF AMMONIUM NITRATE

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Abstract: This article presents the results of developing and studying a domestic anti-caking additive "Anti-Stick" designed to improve the physico-mechanical properties of ammonium nitrate, reducing its caking, dust formation, and agglomeration during storage. A comparative performance analysis of the developed composition and the imported reagent "Novoflow 3047", traditionally used in chemical industries, was conducted. The developed additive consists of industrial oil, technical paraffin, technical stearic acid T3, and a surface-active agent in optimized proportions. Experimental results confirmed that the use of "Anti-Stick" reduces caking by 75–85%, decreases dust formation by 1.8–2 times, improves flowability, and enhances the stability of granules during storage.

Keywords: ammonium nitrate, anti-caking agent, Anti-Stick, Novoflow 3047, caking, dusting, production technology.

Introduction. Ammonium nitrate is widely used in the chemical industry, agriculture, and the manufacture of explosives. One of its critical operational drawbacks is its tendency to cake and to form dust. This problem is aggravated by improper storage and transportation conditions, as well as by elevated humidity.

Caking and dust formation of ammonium nitrate remain among the key challenges during its production, storage, and transportation. To address these issues, anti-caking additives are traditionally used, a significant proportion of which are imported products. This leads to dependence on external suppliers and increases the cost of the final product. One of the most widely used additives in industry is the foreign reagent Novoflow 3047; however, its high cost and logistical risks reduce the stability of the technological process. Under the conditions of import substitution policies and the need to enhance technological independence, the development of domestic anti-caking formulations based on available local raw materials represents an important scientific and practical task.

According to the literature data [1], one of the known agents is the anti-caking additive D1, which includes industrial oil, paraffin, ceresin, and surfactants. The surfactant system comprises distilled fatty acids of cotton soapstocks, the bottom residue from monoethanolamine production, and the sodium salt of palmitic acid. The component composition of D1 (parts by mass) is as follows: distilled fatty acids of soapstocks – 5.9; monoethanolamine production residue – 0.6; industrial oil – 68; paraffin – 19; ceresin – 1.0; sodium salt of palmitic acid – 5.5.

Despite its effectiveness, this composition has several drawbacks [2]. Its production is costly due to the use of refined industrial oil, while the presence of two film-forming agents—paraffin and ceresin—complicates the application technology, limiting the possibility of spraying. In addition, the production process of D1 is multistage and requires significant energy consumption. In order to eliminate these disadvantages, an experimental and pilot-scale project was implemented to develop a domestic anti-caking

additive, “Anti-Stick,” capable of fully replacing the imported reagent Novoflow 3047. The development was carried out through cooperation between industry specialists and the academic staff of Fergana State Technical University.

Laboratory tests of “Anti-Stick” included evaluation of its effect on flowability, particle size distribution, and technological characteristics of ammonium nitrate. The economic analysis demonstrated a significant reduction in costs achieved by replacing the imported reagent.

The obtained results confirm the successful implementation of import substitution objectives and the rational use of local raw materials, as well as the high potential for industrial application of the new anti-caking additive. The development of “Anti-Stick” serves as an example of effective integration of scientific research into industrial practice and contributes to improving the quality and competitiveness of chemical industry products.

Aim and Objectives of the Study

The main aim of this study is the development, optimization of the formulation, and experimental evaluation of the effectiveness of the domestic anti-caking additive “Anti-Stick,” intended to reduce caking and dust formation and to improve the physicomechanical properties of ammonium nitrate, as well as its comparative analysis with the imported reagent Novoflow 3047.

To achieve the stated objective, an analysis of existing anti-caking reagents was carried out, including the imported reagent “Novoflow 3047,” and their technical and economic shortcomings were identified. An optimal composition of the anti-caking additive “Anti-Stick” was developed, based on the use of available and low-cost domestic raw materials (used industrial oils, technical paraffin, stearic acid, and surfactants). The choice of the composition was substantiated through the study of the properties of each component and their influence on reducing the hygroscopicity and dust formation of ammonium nitrate. A technological scheme for the production of the anti-caking additive was developed, including the stages of purification, mixing, heating, dissolution, and filtration. Subsequently, laboratory tests of ammonium nitrate treated with “Anti-Stick” were carried out according to the following indicators: caking tendency, dustiness, flowability, moisture content, and static strength of granules, and the effectiveness of the developed composition was compared with that of the imported “Novoflow 3047,” where advantages in technological and operational characteristics were identified. The economic effect of implementing “Anti-Stick” was evaluated, including a reduction in production cost and a decrease in dependence on imported reagents. Practical recommendations for the industrial implementation of the anti-caking additive in ammonium nitrate production were formulated.

The objective of the study is to eliminate the technological shortcomings of the imported analogue, reduce the cost of the anti-caking additive, and expand the range of effective anti-caking agents for ammonium nitrate.

The stated objective is achieved through the development of a new formulation intended to reduce the caking tendency and dust formation of ammonium nitrate. The

proposed composition includes industrial oil, paraffin, and a surfactant. In accordance with the developed approach, used industrial oil of subgroup A is employed as the industrial oil component, while the surfactant components include OP-10 and technical stearic acid.

The component composition of the developed anti-caking additive is presented in Table 1.

Table 1. Component composition of the developed anti-caking additive

No.	Component	Mass fraction, %
1	Used industrial oil, subgroup A	70,0
2	Technical paraffin	14,0
3	Technical stearic acid T3	15,0
4	Surfactant OP-10	1,0

Research Methodology

Within the framework of developing a new anti-caking agent, an analysis of the composition of existing analogues was carried out, along with an assessment of their technological, environmental, and economic characteristics. It was established that the use of distilled fatty acids of cotton soapstocks leads to the accumulation of organic compounds in wastewater during fertilizer processing, which worsens the environmental performance of treatment systems.

The still residues from monoethanolamine production were also recognized as environmentally undesirable due to their complex chemical composition. During long-term storage of fertilizers, such components are capable of participating in reactions, forming undesirable compounds that deteriorate product quality [3]. In addition, these residues require preliminary adsorption purification, which complicates the technology and increases production costs.

Special attention was paid to replacing refined industrial oil used in known formulations in large quantities. Refined oil is an imported product, which makes its application economically inefficient. In the developed composition, it was replaced with used industrial oil of subgroup A in accordance with GOST 20799-88 (I-20A, I-30A, I-40A, etc.), which is an available and low-cost industrial waste [2]. Its physicochemical properties provide additional advantages, including optimal viscosity.

The composition includes technical paraffin in accordance with GOST 23683-89, which enhances the hydrophobic properties of fertilizer granules. Unlike the D1 formulation, paraffin is used without ceresin, which is imported, increases the viscosity of the mixture, and limits the possibility of spray application.

To reduce dust formation, technical stearic acid T3 in accordance with GOST 6484 was introduced into the composition, improving the mechanical strength of granules during transportation [4].

As an emulsifying component, the surfactant OP-10 (GOST 8433) was used, characterized by high water solubility and biodegradability, which enhances the environmental safety of the formulation.

The anti-caking effect of the proposed composition is based on moisture adsorption and the formation of thin hydrophobic layers between the particles of the mineral fertilizer [5]. It is precisely this combination of the proposed components that addresses the problems associated with the high hygroscopicity of ammonium nitrate (Table 2).

Table 2. Comparison of Anti-Stick and Novoflow 3047 by main parameters

No.	Parameter	Novoflow 3047	Anti-Stick
1	Caking tendency	Medium	10–15% lower
2	Dustiness	Standard	Two times lower
3	Flowability	Satisfactory	High
4	Granule strength	Standard	+12–15 %
5	Economic costs	High	35–40% lower

Results and Discussion

Experimental studies demonstrated that the use of the proposed composition contributes to a reduction in the cohesion force and prevents electrostatic interactions between oppositely charged particles in ammonium nitrate, thereby inhibiting adhesion, agglomeration, and caking of ammonium nitrate [5].

Table 3. Physicomechanical properties of ammonium nitrate after treatment

No.	Parameter	Without treatment	Novoflow 3047	Anti-Stick
1	Caking tendency, %	100	45–50	10–15
2	Dustiness, g/kg	12–14	7–8	3–4
3	Flowability	Low	Medium	High
4	Granule stability	Low	Medium	High

The tests showed that “Anti-Stick” provides a reduction in caking by 75–85%, while dust formation decreased by 1.8–2 times compared with Novoflow 3047. In addition, the flowability of ammonium nitrate was maintained for 30 days of storage, and the treatment cost was reduced by 35–40%.

Thus, the developed additive is not inferior to the imported Novoflow 3047 and, in several parameters, surpasses it, which confirms the effectiveness of import substitution.

Conclusion. A new domestic anti-caking additive, “Anti-Stick,” has been developed, providing a significant reduction in caking and dust formation and improving the flowability of ammonium nitrate. Laboratory and pilot-scale tests demonstrated that, in terms of key technological and operational characteristics, “Anti-Stick” is not inferior to the imported reagent Novoflow 3047 and, for several indicators, surpasses it. The obtained results confirm the high efficiency of the developed

composition and its suitability for industrial implementation, contributing to a reduction in fertilizer treatment costs and a decrease in dependence on imported reagents.

References

1. Anti-caking additive for ammonium nitrate: Patent UZ 5488 A, Republic of Uzbekistan. No. FAP 20010089; filed 15.03.2001; published 30.11.2002. — 3 p.
2. Isakov, B. Sh. Development of an anti-caking additive composition for ammonium nitrate based on used industrial oil. Universum: Technical Sciences, 2025, No. 4 (133).
3. RU 2688816 C1. Composition for preventing dusting of mineral fertilizers. — 2019.
4. GOST 6484–96. Technical fatty acids. Specifications.
5. Tyc A., Nieweś D., Penkala S., Grzesik R., Hoffmann K., Hoffmann J. Influence of Anti-Caking Agents on the Highly Effective Organic Coatings for Preventing the Caking of Ammonium Nitrate Fertilizers // Coatings. — 2020. — Vol. 10, No. 11. — Article 1093. — DOI: 10.3390/coatings10111093.
6. Hamdamova Sh. Sh., Igamberdiyev B. G. Physicochemical studies of water systems based on sodium chlorate and diethanolamine // The First European Conference on Chemical Sciences. — 2015. — P. 55–59.
7. Nazirova R. M., Mirsalimova S. R., Isakov B. Sh. Obtaining Butyl Acetate by the Method of Hydrolysis // International Journal on Orange Technologies. — 2021. — Vol. 3, Issue 4. — P. 51–53. — DOI: 10.31149/ijot.v3i4.

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