

Investigation Of Physico-Chemical And Commercial Properties Of Ammonium Nitrate With Additives

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Abstract

This article presents the results of laboratory tests of the quality of ammonium nitrate with the addition of NAS (nitric acid solution of apatite) obtained by the technology developed by us in comparison with the quality of industrial samples of saltpeter with various additives.

One of the most important indicators characterizing the quality of ammonium nitrate is the strength of granules. With an increase in the strength of the granules, the rates of absorption of moisture from the atmosphere, dissolution of salt in water decrease and the traceability of the product is eliminated.

It is known that modification transformations of ammonium nitrate are accompanied by changes in the volume of crystals, processes dissolution and recrystallization of salt, as well as the release and absorption of heat. These processes take place in the entire volume of salt and therefore the granules of ammonium nitrate undergo a more significant expansion. The different effect of additives on the stability of granules during modification transitions is explained by the physico-chemical properties of the additives themselves, and also depend on the degree of interaction them with ammonium nitrate. For example, $\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$, when heated to 50°C , completely dissolves in its crystalhydrate water and, upon cooling, reverts to a crystalline state. This circumstance not only protects ammonium nitrate from recrystallization processes, but, on the contrary, aggravates them. Therefore, ammonium nitrate with the addition of DLM during modification transitions quickly loses the original strength of the granules.

Thus, the NAS additive, especially introduced using a new technology, is the most effective both in increasing the strength of granules and in eliminating the caking of ammonium nitrate and ensures the stability of granules during product storage in the harshest climatic conditions.

INTRODUCTION

One of the most important indicators characterizing the quality of ammonium nitrate is the strength of granules. With an increase in the strength of the granules, the rates of absorption of moisture from the atmosphere, dissolution of salt in water decrease and the traceability of the product is eliminated.

The strength of ammonium nitrate granules and its stability as a result of long-term storage, other things being equal, largely depend on the amount and type of additives used and their physico-chemical properties.

Studies of the effect of additives on the strength of granules and the traceability of ammonium nitrate and changes in these indicators were carried out depending on the number of modification transformations by heating to 50°C for 8.0 hours, followed by holding for 16 hours at room temperature and on the duration of storage in polyethylene bags at room temperature, i.e. without modification transformations.

Changes in the strength of ammonium nitrate granules depending on the duration of storage are shown in Table 1, from which it can be seen that ammonium nitrate with the addition of NAS, obtained using a new technology, has the greatest initial strength of granules. Samples of ammonium nitrate with additives of magnesite and NAS obtained using the existing technology is somewhat inferior to it. Ammonium nitrate has the lowest strength of granules without additives and with the addition of DLM.

№	Samples of ammonium nitrate	Amount of additive, weight %	Moisture content, weight %	Strength of granules, MPa							
				1 st day	5 th day	10 th day	20 th day	30 th day	60 th day	90 th day	120 th day
1*	NH ₄ NO ₃	-	0,23	1,20	1,25	1,07	1,07	0,91	0,63	0,64	0,63
2*	NH ₄ NO ₃ + NAS	1,0 P ₂ O ₅	0,20	3,43	3,59	3,59	3,59	3,86	3,84	3,74	3,74
3	NH ₄ NO ₃ + NAS Chirchik software electro-chemical industry	1,0 (P ₂ O ₅)	0,20	2,80	3,06	3,28	3,28	3,03	3,02	3,07	3,07
4	NH ₄ NO ₃ + magnesite Navoi software "Nitrogen"(MoO)	0,39 (MgO)	0,18	3,07	3,12	2,52	2,52	2,43	3,43	2,37	2,31
5	NH ₄ NO ₃ + H ₂ SO ₄	0,5	0,20	2,50	2,51	2,50	2,50	2,34	2,33	2,34	2,25
6	NH ₄ NO ₃ + H ₂ SO ₄ + "NF" Rivne software "Nitrogen"	0,4:0,03	0,21	2,43	2,53	2,34	2,34	2,43	2,13	1,94	1,62
7	NH ₄ NO ₃ + H ₂ SO ₄ + "LC" Nevinnomysskoye software "Azot"	0,4:0,03	0,23	2,39	1,88	1,70	1,70	1,68	1,66	1,56	1,51
8	NH ₄ NO ₃ + DLM Dneprodzerzhinsk oe software "Nitrogen"	0,4 (CaO)	0,20	1,48	1,58	1,58	1,58	1,39	1,38	1,38	1,36

Table 1. Changing the strength of granules of ammonium nitrate samples when stored in room conditions.

* - obtained under laboratory conditions.

When stored under the same conditions, the strength of ammonium nitrate granules with the addition of NAS increases slightly, while the strength of granules of other samples is significantly reduced. The change in the strength of granules during storage can be explained based on the following considerations: the indoor air temperature ranged from 16°C (at night) to 26°C (during the day) and, accordingly, the relative humidity of the air changed, as a result of which saltpeter absorbed moisture at night and dried during the day. With repeated repetition of these processes, the structure of the granules is loosened, which leads to a decrease in strength. The additives introduced have a different effect on the hygroscopic properties and solubility of ammonium nitrate. Additives H₂SO₄, Dom, magnesite reduce the speed of the recrystallization process of ammonium nitrate and therefore the strength of saltpeter granules with these additives changes less during storage than saltpeter without additives. The increase in the strength of ammonium nitrate granules with the addition of NAS during storage is explained by the fact that the additive particles have a developed specific surface area and have a high adsorption capacity. Due to this, saltpeter with the addition of NAS with minor changes in temperature and relative humidity of the air practically does not moisten and does not dry out. Therefore, it does not lose the initial strength of the granules.

Table 2 shows the results of a study of the change in the strength of granules of ammonium nitrate samples during modification transformations IU = III. They show that modification transformations of IU = II greatly reduce the strength of granules of ammonium nitrate samples without additives and with the addition of DLM. After IO and I5 multiple modification transformations, respectively, they completely collapse and lose their spherical shapes. After 30-fold modification transformations, the strength of the granules of ammonium nitrate samples with additives H₂SO₄, H₂SO₄ + NF (LC) and magnesite decreased by 50-75%, and the sample of ammonium nitrate with the addition of NAS according to the existing technology by 18%. The smallest decrease (10%) in the strength of granules is observed in ammonium nitrate with the addition of NAS, obtained using a new technology.

№	Samples	The strength of granules during modification transformations IU = III, Mpa							
		1	3	5	10	15	20	25	30
1	NH ₄ NO ₃ without additive	0,91	0,57	0,43	the granules were being destroyed				
2	NH ₄ NO ₃ + NAS (using new technology)	3,04	3,06	3,12	2,79	2,96	2,89	2,89	2,81
3	NH ₄ NO ₃ + NAS	2,53	2,50	2,49	2,13	2,11	1,99	2,05	2,05
4	NH ₄ NO ₃ + magnesite	2,52	2,51	1,59	1,67	1,31	1,29	1,09	1,14
5	NH ₄ NO ₃ + H ₂ SO ₄	2,56	2,50	2,33	2,15	2,09	1,85	1,55	1,39
6	NH ₄ NO ₃ + H ₂ SO ₄ +”NF”	2,46	2,28	2,17	2,65	1,56	1,50	1,28	1,22
7	NH ₄ NO ₃ + H ₂ SO ₄ + ”LC”	2,15	1,31	1,25	1,66	1,07	1,78	0,55	0,62
8	NH ₄ NO ₃ + DLM	1,22	0,67	0,49	0,31	the granules were being destroyed			

Table 2. Change in the strength of granules of ammonium nitrate samples during modification transformations IU = III.

It is known that modification transformations of ammonium nitrate are accompanied by changes in the volume of crystals, processes dissolution and recrystallization of salt, as well as the release and absorption of heat. These processes take place in the entire volume of salt and therefore the granules of ammonium nitrate undergo a more significant expansion. The different effect of additives on the stability of granules during modification transitions is explained by the physico-chemical properties of the additives themselves, and also depend on the degree of interaction them with ammonium nitrate. For example, Ca(NO₃)₂·4H₂O, when heated to 50°C, completely dissolves in its crystalhydrate water and, upon cooling, reverts to a crystalline state. This circumstance not only protects ammonium nitrate from recrystallization processes, but, on the contrary, aggravates them. Therefore, ammonium nitrate with the addition of DLM during modification transitions quickly loses the original strength of the granules.

For the same reason, there is a sharp decrease in the strength of ammonium nitrate granules with a magnesia additive.

Due to the formation of double compounds of ammonium sulfate with ammonium nitrate, the H₂SO₄ additive slightly increases the stability of granules during modification transformations in comparison with dolomite and magnesia additives. But due to the small amount of the additive, it is not able to prevent a decrease in the strength of the granules. When processing ammonium nitrate with a sulfate additive with emulsifiers NF and LC, a more dramatic decrease in the strength of granules during modification transitions is observed. Apparently, these organic substances weaken the bond of the sulfate additive with ammonium nitrate or they accelerate the processes of modification transformations of ammonium nitrate. The high stability of ammonium nitrate granules with the addition of NAS is explained by the fact that it helps to reduce the rate and degree of modification transformations.

Ammonium nitrate with the addition of NAS, obtained by the new technology, has a higher stability of granules compared to saltpeter with the same additive obtained by the existing technology.

The study of the traceability of ammonium nitrate showed that it is practically not tracked when stored in room conditions for 30 days.

RESULTS AND DISCUSSION

The traceability of samples, depending on the number of modification transformations, are shown in Table 3, from which it can be seen that the traceability of pure ammonium nitrate after 30-fold modification transitions is 1.65 MPa, which is almost 16 times greater than its traceability after a single modification transition. Ammonium nitrate with the addition of NAS has the least traceability. The sample obtained using the new technology does not have traceability after a 5-fold modification transition. A further increase in the number of heating and cooling cycles with a modification transition leads to a slight increase in the traceability of the product and after 30-fold modification transitions is only 0.12 MPa. The surface treatment of ammonium nitrate granules with a sulfate additive with an emulsifier NF leads to an increase in its traceability, and the treatment of LC leads to a decrease.

We also studied the change in the quality indicators of samples of ammonium nitrate with various additives during humidification.

The samples were moistened in a desiccator with water. The results of measuring the strength of granules and traceability, depending on the degree of moisture, are shown in Table 1, from which it can be seen that when moistened by 0.5%, the strength of granules of all samples decreases, and traceability increases with the exception of saltpeter samples with the addition of NAS.

№	Samples of ammonium nitrate	Traceability, MPa during modification transformations								
		1	3	5	10	15	20	25	30	
1	NH ₄ NO ₃ without additive	0,11	0,32	0,37	0,53	0,61	1,12	1,40	1,65	
2	NH ₄ NO ₃ + NAS (using new technology)	no	no	no						
3	NH ₄ NO ₃ + NAS (according to existing technology)	no	0,01	0,03	0,06	0,09	0,08	0,11	0,12	
4	NH ₄ NO ₃ + magnesite	no	0,04	0,15	0,48	0,50	0,61	0,63	0,65	
5	NH ₄ NO ₃ + H ₂ SO ₄	0,06	0,18	0,20	0,27	0,27	0,31	0,45	0,68	
6	NH ₄ NO ₃ + H ₂ SO ₄ +”NF”	0,06	0,20	0,31	0,37	0,41	0,60	0,70	0,87	

7	NH ₄ NO ₃ + H ₂ SO ₄ +" LC"	0,05	0,16	0,17	0,20	0,28	0,29	0,31	0,32
8	NH ₄ NO ₃ + DLM	0,07	0,19	0,22	0,44	0,46	0,93	1,00	1,02

Table 3. Changes in the traceability of ammonium nitrate samples during modification transformations IY = III

With a further increase in the degree of moisture, there is a more significant decrease in the strength of the granules and an increase in the traceability of all samples. When moistened by 2%, the smallest decrease in the strength of granules and an increase in traceability is observed in saltpeter samples with the addition of NAS.

Conclusion. Consequently, the NAS additive is the most effective in improving the quality indicators of ammonium nitrate and contributes to their stability when moistened. This is due to the fact that the moisture absorbed by saltpeter is adsorbed on the surfaces of the additive particles and binds to crystallohydrates, i.e. it (moisture) does not participate in the process of dissolving saltpeter. As a result, when saltpeter is moistened with the addition of NAS, there is no sharp decrease in the strength of the granules and an increase in the traceability.

Thus, the NAS additive, especially introduced using a new technology, is the most effective both in increasing the strength of granules and in eliminating the caking of ammonium nitrate and ensures the stability of granules during product storage in the harshest climatic conditions.

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