

Phosphorus-containing lime-ammonium nitrate for agrochemical efficiency of crops

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Abstract. When obtaining samples of phosphorus-containing lime-ammonium nitrate (LAN) the mass ratio ammonium nitrate (AN) : dolomite mineral (DM) : ordinary phosphate rock (OPR) varied from 100 : 0.5 : 0.5 to 100 : 25 : 25. The prilling method was used to granulate the nitrate-carbonate-phosphate melt. It is shown that the saltpeter melt activates carbonate and phosphate raw materials, that is, it converts the structure of P_2O_5 , CaO and MgO, which is not assimilated in it, into a form that is assimilable for plants. The additives (DM, OPR) significantly reduce caking, porosity and absorption in relation to liquid fuel and increase the strength of fertilizer granules.

1 Introduction

Ammonium nitrate (AN) is one of the best nitrogen fertilizers due to its rapid agrochemical efficiency when applied to all types of crops. Therefore, AN is considered the most versatile nitrogen fertilizer [1, 2]. But during storage and transportation of packaged AN granules in warehouses and before they are delivered to consumers, various disadvantages are very acute, such as caking of granules in plastic bags, in which a monolithic mass is formed, and especially the problem of explosiveness [3].

Explosions with ammonium nitrate led to the fact that in a number of countries calcium and magnesium carbonates were added to it, as a result of which any danger of it was eliminated. This product is marketed under the name calcium ammonium nitrate (CAN) or ammonium nitrate with limestone or dolomite. The share of CAN production capacities in the world is estimated at about 7% [4]. In the world, 42 companies produce and supply CAN, containing 20-33.5% nitrogen, of which 31 firms are located in Europe [5, 6].

Several types of nitrogen fertilizers are produced in Uzbekistan: such as AN (34.4% N), ammonium sulfate (21% N), carbamide (46.2% N), phosphourea (34% N and 8% P_2O_5), liquid carbamide AN (urea ammonium nitrate, 28-32% N), liquid calcium nitrate (10% N), nitrogen-phosphorus fertilizer (NPF, 22-28% N and 2-6% P_2O_5) and lime ammonium nitrate (LAN, 26-33% N and 2-8% CaO). The last two types of nitrogen fertilizers, NPF and LAN, ordinary phosphorus flour are obtained by mixing into the AN melt before prilling from the Central Kyzylkum [7-9] and local limestone [10] in a granulation tower. According to the technical specifications TSh 6.1-00203849-111:2007 NPF and TSh 00203849-138:2017 LAN contains 22-28% and 28-32% nitrogen, 1-6% P_2O_5 and 2-8% CaO and have a granulometric composition: 1-4 mm - about 95%, not more than 1 mm - less than 3%. The strength of ammonium nitrate is 3-5 times lower than NPF and LAN granules. Since 2007, 493 thousand tons of NPF have been produced for the amount of 240 billion sums, including

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those sent for export in the amount of 20.8 million US dollars. And since 2018, 55.95 thousand tons of LAN have been produced in the amount of 36.24 billion sums.

Carbonate and phosphate compounds used as modifiers in the composition of AN can be promising additives for improving its commercial and consumer properties.

Therefore, we decided to test the process of obtaining phosphorus-containing LAN based on AN melt by introducing two promising additives into its melt at once - dolomite mineral (DM $\text{CaO}_{\text{tot.}}$ - 28.02%; $\text{Mg}_{\text{tot.}}$ - 26.27%) of "Ingichka deposit" (Samarkand region) and Kyzylkum ordinary phosphate rock (OPR $\text{P}_2\text{O}_{5\text{tot.}}$ 20.23%, $\text{CaO}_{\text{tot.}}$ 43.54%, $\text{Mg}_{\text{tot.}}$ 3.14%).

2 Materials and methods

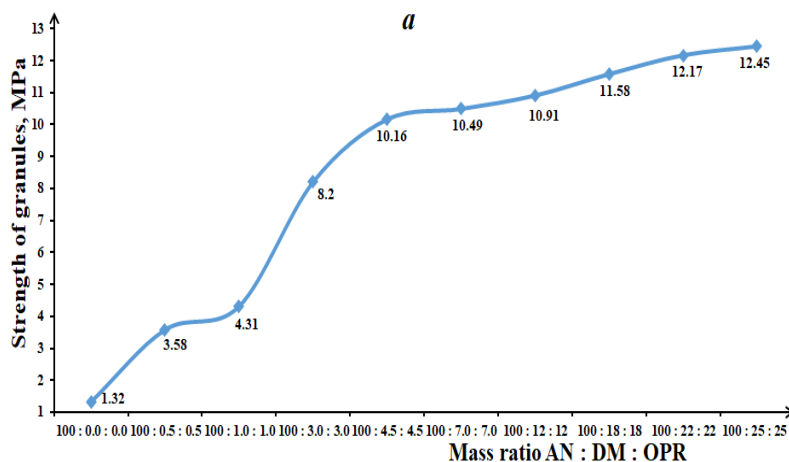
To obtain samples of phosphorus-containing LAN, performed laboratory experiments: The AN sample was melted by electric heating in a metal cup. Then, DM and OPR were taken into AN mass ratios: AN : DM : OPR = 100 : (0.5-25) : (0.5-25). Next, the nitrate-carbonate-phosphate melt was kept at 175°C for 2-5 minutes. At the same time, obtained mass is poured into a granulator with a metal cup with a hole diameter of 1.2 mm. The pump in the top of the glass generated pressure and the liquid was thrown down from a height of 40 m onto a plastic film. The obtained granules were divided into fractions, in which the granules were separated by size. Particles with 2-3 mm were tested for strength according to GOST 21560.2-82. Herewith, the obtained products were crushed and analyzed by certain methods [11].

The caking of fertilizer grains was determined by the pressing method [12].

The ability of samples to absorb diesel fuel was determined by comparison with the method provided for TU 6-03-372-74 granular porous AN brand "P".

Granulated samples of NH_4NO_3 (without addition) and AN with magnesite (0.3% MgO) was selected as a sample for comparing the composition and properties of the fertilizer grains obtained in the research work.

The results are shown in the table and in Figure 1.



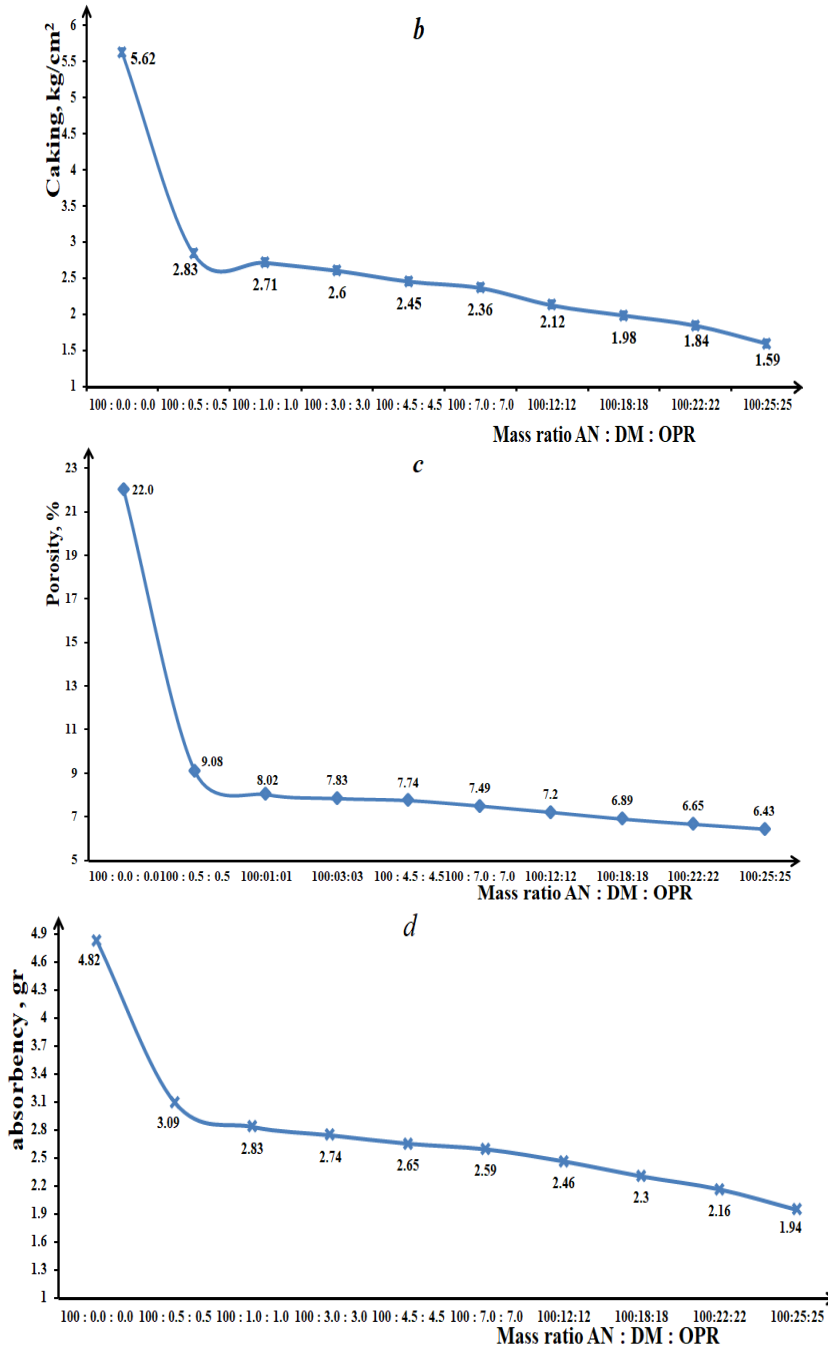


Fig. 1. Dependence of changes in strength (a), caking (b), porosity (c) and absorbency (d) granules of phosphorus-containing LAN on the ratio AN : DM : OPR.

3 Results and discussions

It can be seen from Table 1 that with the addition of AN, DM and OPR to the melt at the ratio AN : DM : OPR = 100 : (0.5-25) : (0.5-25), nitrogen-phosphorus-calcium-magnesium fertilizers can be obtained with the following composition (wt.%): 23.35-34.57% N, 0.181-4.221% P₂O₅, 0.58-13.01% CaO, and 0.18-4.28% MgO. In these brands of fertilizers, the approximate content of the digestible form of P₂O₅, CaO and MgO in relation to the total varies from 51.91 to 92.26%, from 54.11 to 91.38% and from 47.90 to 83.33% for citric acid.

When limestone or chalk is used as the starting material for the production of LAN, it contains two nutrients, nitrogen and calcium. But when a dolomite mineral is used, magnesium also appears in its composition.

Dolomite and phosphate rock are used as the starting material for the production of phosphorus-containing LAN, it contains four nutrients - nitrogen, phosphorus, calcium and magnesium. These four elements play a very important role in plant life. If they are mixed into the soil in a plant-friendly form, this will lead to a significant progress in crop.

Figure 1 shows that an increase in the mass fractions of DM and OPR leads to a incredible improvement in granule strength. The hardness of fertilizer granules obtained at a ratio AN : DM : OPR = 100 : (0.5-25) : (0.5-25) is within 3.58-12.45 MPa (Figure 1 a). At these AN : DM : OPR ratios, caking (Figure 1 b), granule porosity (Figure 1 c) and absorption by them (Figure 1 d) are 2.83-1.59 kg/cm², 8.52-6.43%, and 3.04-1.94 gr, respectively. A strength, caking, porosity and absorbency of pure AN granules are 1.32, MPa, 5.62 kg/cm², 22.0% and 4.82 gr, respectively.

This means that an improvement of nitrate granules strength indicates a decrease in its porosity and internal specific surface and leads to a falling in the addition of diesel fuel into the granule, and, thereby, a reduction in the explosiveness of nitrate.

Table 1. The composition of phosphorus-containing LAN based on the melt of ammonium nitrate, dolomite mineral and ordinary phosphate rock.

Mass ratio AN : DM : OPR	Content of components, wt. %							P ₂ O ₅ _{dig.} , P ₂ O ₅ _{tot.} for 2 % lim.acid	CaO _{dig.} , CaO _{tot.} for 2 % lim.acid	MgO _{dig.} , MgO _{tot.} for 2 % lim.acid
	N _{tot.}	P ₂ O ₅ _{tot.}	P ₂ O ₅ _{dig.} by 2 % lim.acid	CaO _{tot.}	CaO _{dig.} for 2 % lim.acid	MgO _{tot.}	MgO _{dig.} for 2 % lim.acid			
100 : 0.0 : 0.0	34.96	-	-	-	-	-	-	-	-	-
100 : 0.5 : 0.5	34.57	0.181	0.167	0.58	0.53	0.18	0.15	92.26	91.38	83.33

100 : 1.0 : 1.0	34.19	0.292	0.264	0.79	0.70	0.27	0.22	90.41	88.61	81.48
100 : 1.5 : 1.5	33.90	0.409	0.361	1.17	1.01	0.41	0.32	88.26	86.32	78.05
100 : 2.0 : 2.0	33.62	0.533	0.457	1.52	1.29	0.55	0.42	85.74	84.87	76.36
100 : 2.5 : 2.5	33.24	0.664	0.554	1.89	1.56	0.69	0.51	83.43	82.54	73.91
100 : 3.0 : 3.0	32.89	0.803	0.651	2.26	1.83	0.82	0.59	81.02	80.97	71.95
100 : 3.5 : 3.5	32.55	0.951	0.748	2.62	2.05	0.92	0.65	78.65	78.24	70.65
100 : 4.0 : 4.0	32.31	1.107	0.845	2.99	2.27	1.03	0.70	76.33	75.92	67.96
100 : 4.5 : 4.5	32.0	1.272	0.941	3.49	2.58	1.12	0.75	73.98	73.92	66.95
100 : 5.0 : 5.0	31.67	1.450	1.038	4.35	3.12	1.46	0.94	71.59	71.72	64.38
100 : 7.0 : 7.0	30.53	1.672	1.149	5.06	3.51	1.79	1.12	68.72	69.37	62.57

100 : 10 : 10	29.20	1.903	1.267	5.99	4.03	2.17	1.29	66.58	67.28	59.45
100 : 12 : 12	28.14	2.134	1.393	6.90	4.49	2.47	1.44	65.28	65.07	58.29
100 : 15 : 15	26.76	2.481	1.524	8.01	5.04	2.78	1.56	61.43	62.92	56.11
100 : 18 : 18	25.68	2.835	1.662	9.18	5.57	3.07	1.66	58.62	60.67	54.07
100 : 20 : 20	24.93	3.193	1.793	10.3 2	6.04	3.39	1.77	56.15	58.53	52.21
100 : 22 : 22	24.22	3.542	1.931	11.4 5	6.45	3.67	1.84	54.52	56.33	50.14
100 : 25 : 25	23.35	4.221	2.191	13.0 1	7.04	4.28	2.05	51.91	54.11	47.90

In this regard, the DM and OPR proved to be the most effective.

4 Conclusion

Studies have been conducted to obtain phosphorus-containing LAN based on AN melt and powdered DM and OPR. At the same time, it was investigated that the more powdered DM and OPR are introduced into the AN melt, the lower the amount of N in the product and the higher the amount of P₂O₅, CaO and MgO. It is also given that the higher the amount of DM and OPR, the lower the caking, porosity and absorbency of solar oil and the higher the hardness and solubility of saltpeter grains in water. Accordingly, specimens of phosphorus-containing LAN have made better physicochemical, agrochemical, and lowest explosive characteristics.

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