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Study Of The Physicochemical Properties Of Nitrogen-Phosphorus-Potassium Fertilizers Based On Potassium Chloride And Mineral Acids

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ABSTRACT

The article presents the results of studies on study of the physicochemical properties of nitrogen-phosphorus-potassium fertilizers based on potassium chloride and mineral acids. The physicochemical and commercial properties of triple fertilizers have been studied.

KEYWORDS

Phosphate raw materials, NPK fertilizers,

INTRODUCTION

In recent years, one of the progressive directions in the processing of phosphate raw materials is the application of the method of nitric acid decomposition of apatites and phosphorites. This method allows the use of nitric acid not only as a means for decomposing insoluble medium phosphates into a soluble form but also as an additional source of nutrients. Complex NP or NPK fertilizers are usually obtained based on the nitric acid decomposition of phosphates. This type of fertilizers can be attributed to nitroammophos.

The industry produces nitro ammophos solution grades A (N: P_2O_5: K_2O = 1: 1: 1) and B (N: P_2O_5: K_2O = 1: 1.5: 1.5). The first contains 17% N, 17% P_2O_5 and 17% K_2O, and the second contains 13% N, 19% R_2O_5, 19% K_2O.

The largest company in the world for the production of nitro ammophos solution is the Norwegian company "Norsk Hydro". This company in its country has 3 plants for the production of nitro ammophos solution with a capacity of 1100, 1400 and 2500 t / day [6]. At all of these plants, the production technology of nitro ammophos solution is similar. First, the world's best phosphate raw material is subjected to nitric acid processing, which is the apatite concentrate of the Kola Peninsula (39.5% P_2O_5, calcium module, i.e. the ratio of CaO to P_2O_5, it contains 1.32). An insoluble residue is separated from the liquid phase. Then it freezes out of the solution and calcium nitrate is separated by 90%. The latter is converted using ammonium carbonate to ammonium nitrate and chalk. After the separation of calcium nitrate, the liquid phase is subjected to two-stage neutralization with ammonia, first to pH 3.0, and then to pH 5.8. At the first stage of ammonization, a solution of ammonium nitrate is added so that the ratio of N to P_2O_5 in the system is 1.3. The nitro ammophos solution ammoniated to pH 5.8 is fed for evaporation to a vacuum evaporator to a concentration of 99.5%. Then the melt of nitroammophos is mixed with potassium chloride and subjected to prilling granulation in a granulation tower. Only at the Ukrainian enterprise "Sera" melt is granulated not by the prilling method, but in an ammonizer-granulator [1, 6, 7,].

THE MAIN PART

Taking into account the above, the existing developments in the field of technology for the production of nitro ammophos solution are not advisable for their introduction into the industry of the Republic of Uzbekistan. Because the available resource base of the republic consists of very low-grade phosphate raw materials. Which is very difficult to recycle. Highly concentrated phosphate raw material is washed calcined phosphor-concentrate of the Kyzylkum phosphorite plant, containing 28-29% P_2O_5 with a calcium modulus equal to 1.96. The latter is 48.5% higher than the calcium modulus of apatite concentrate. This means that during the nitric acid processing of the Kyzylkum concentrate, we will have a 48.5% overconsumption of nitric acid for decomposition, the content of calcium nitrate, which needs to be frozen, will increase by the same amount, and the concentration of P_2O_5 in the solution after decomposition will be minimal due to low its content in the concentrate [2.3,4,5,].

In this work, the results are carried out on the study of the physicochemical properties of nitroammophoska based on potassium chloride and mineral acids. In the experiments, we used nitric acid with a concentration of 57.87%, extraction phosphoric acid produced by JSC Ammophos-Maxam with a composition (wt.%) 18.69 P_2O_5; 0.29 CaO; 0.64 MgO; 0.73 Al_2O_3; 0.46 Fe_2O_3; 2.72 SO_3; 1.02 F; 0.093 Cl and technical potassium chloride containing 60% K_2O. Crystalline potassium chloride was previously ground in a porcelain mortar. Its dispersed composition was as follows: (+0,25 мм) 0,86%, (-0,25 + 0,16 мм) 30,88%, (-0,16 + 0,05 мм) 47,92%, (- 0,05 мм) 20,34%. The process of obtaining NPK fertilizers was carried out on a laboratory setup consisting of a heater, a cylindrical glass reactor equipped with a helical stirrer with an electric motor and placed in a water thermostat. First, a calculated amount of a mixture of nitric and phosphoric acid was poured into a reactor with a stirrer, and the contents were ammonized with gaseous ammonia to pH 4.5. During ammoniation with ammonia, the temperature in the reactor was maintained at the level of 75-80 oC. The acid mixture was taken in such an amount that in the ammonized nitrophosphate slurries the N: P_2O_5 ratio was 1: 0.7 and 1: 1, in which the moisture content was 49 and 54%, respectively. Then these pulps were evaporated with constant stirring and a temperature of 80 °C to a moisture content of 22%. After that, the calculated amounts of potassium chloride were added to the obtained one stripped off nitro phosphate pulps, and the ratio N : P_2O_5: K_2O varied 1: 0.7: 0.4 to 1: 0.7: 0.5 and from 1: 1: 0.5 to 1: 1: 1. After adding crushed potassium chloride in the resulting nitro phosphate-potassium pulps, the moisture content decreased to 17-19%. Then the pulps were analyzed. Their moisture content was determined by the drying method. The content of nutrients was found according to known methods [8].

To obtain NPK fertilizers, the pulps were dried in a drying oven at a temperature of 100 °C. Granulation of samples of wet NPK-masses was carried out during drying by the method of intensive stirring and rolling. In this case, solid particles of a rounded shape were formed. The resulting mass of these particles was dried, cooled, and then sieved. Particles 2-3 mm in size were analyzed for granule strength in accordance with GOST 21560.2-82.

The physicochemical characteristics of nitrogen-phosphorus-potassium fertilizers were determined for the following products with the ratio N : P_2O_5 : K_2O : 1 – 1 : 0,7 : 0,4; 2 – 1 : 0,7 : 0,5; 3 – 1 : 1 : 0,5; 1 : 1 : 0,7; 5 – 1 : 1 : 1.

The hygroscopic point of some fertilizer samples with granule sizes of 2-3 mm was determined by the desiccator method [9] at a temperature of 25 °C. The initial moisture content of the first sample was 1.01%, the second was 0.99%, the third was 1.12%, the fourth was 1.06% and the fifth was 0.88%.

Determination of the weight gain or loss of moisture in the substance at a constant temperature and different relative air humidity was carried out for 3 hours. The required relative air humidity was created in a closed desiccator above a layer of sulfuric acid of a known concentration poured into it. The values of hygroscopic points for our fertilizers turned out to be equal: for sample 1 - 52.6%, for sample 2 - 53.5%, for sample 3 - 54.6%, for sample 4 - 54.9% and for sample 5 - 55, 7%. Such products in the conditions of our region, where the average monthly minimum relative humidity is 46%, the average annual - 60%, and the maximum average monthly 74%, when stored in a warehouse do not absorb moisture only in short periods of the summer period, and in the rest of the year, they intensively absorb

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moisture from the atmosphere and will be humidified. According to the degree of hygroscopicity according to the school of N.E. Pestov, are among the highly hygroscopic substances.

Fig. 1-5 show the kinetic curves of water vapour sorption of complex nitrogen-phosphorus-potassium fertilizers in isothermal conditions at 25 °C, carried out at a relative humidity of 56; 60.5; 70; 80; 90; 100%.

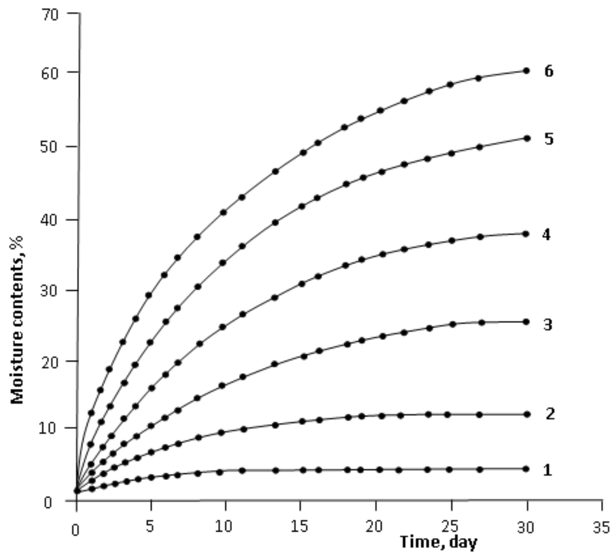

Fig. 1. Kinetics of water vapor sorption of the first sample at relative air humidity: 1-56%; 2-60.5%; 3-70%; 4-80%; 5-90% 6-100%.

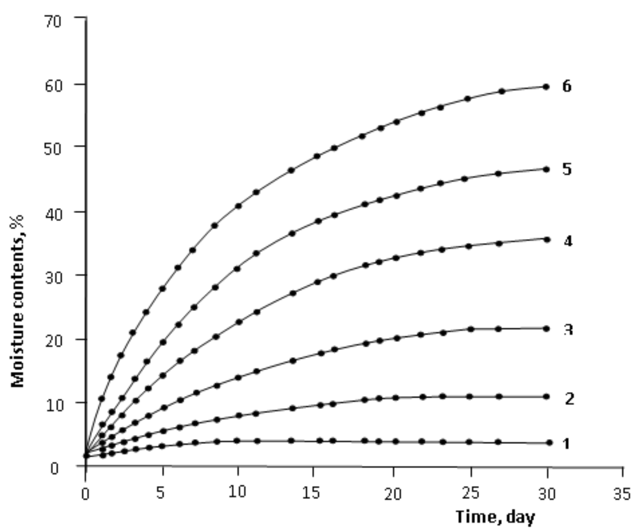

Fig. 2. Kinetics of water vapor sorption of the second sample at relative air humidity: 1-56%; 2-60.5%; 3-70%; 4-80%; 5-90% 6-100%.

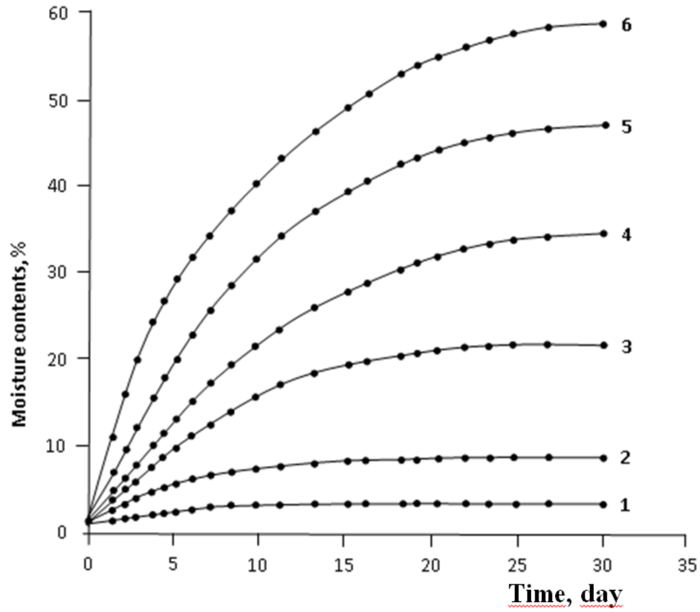

Fig. 3. Kinetics of water vapor sorption of the third sample at relative air humidity: 1-56%; 2-60.5%; 3-70%; 4-80%; 5-90% 6-100%.

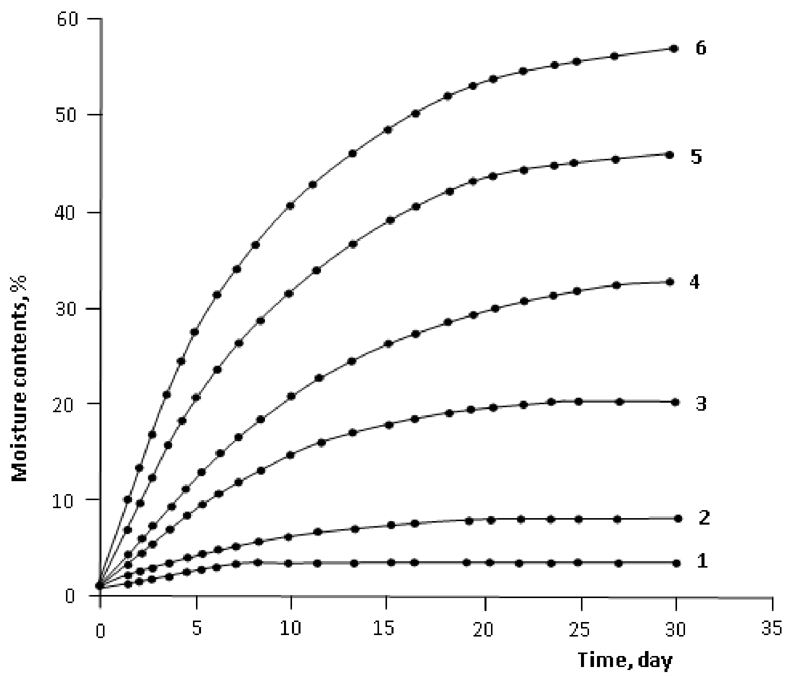

Fig. 4. Kinetics of water vapor sorption of the fourth sample at relative air humidity: 1-56%; 2-60.5%; 3-70%; 4-80%; 5-90% 6-100%.

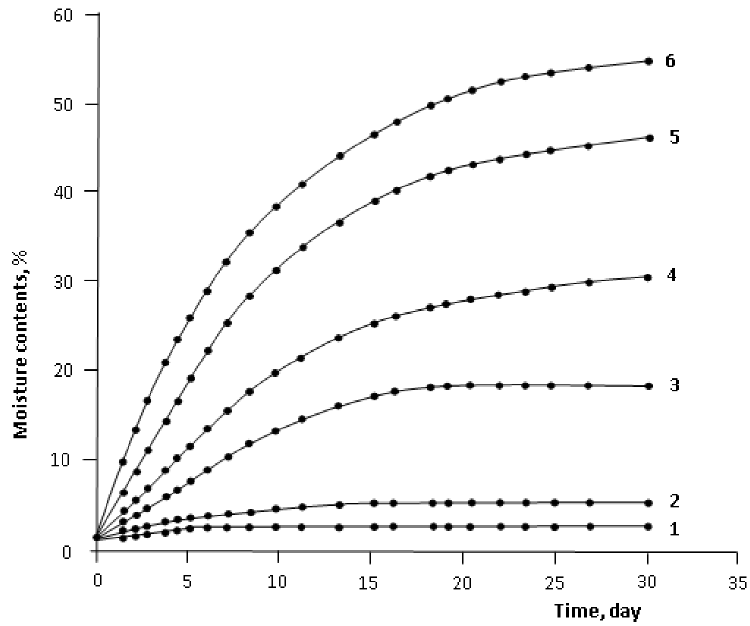

Fig. 5. Kinetics of water vapor sorption of the fifth sample at relative air humidity: 1-56%; 2-60.5%; 3-70%; 4-80%; 5-90% 6-100%.

It can be seen from the figures that for the first sample at a relative humidity of 56%, equilibrium occurs in 13 days, for the second - 11 days, for the third - 10 days, for the fourth - 8 days, and for the fifth - 5 days. At 60.5% relative air humidity, the equilibrium of the partial pressure of saturated water vapour between fertilizers of samples 1-4 occurs in 23-24 days, and for the fifth sample, it is established after 14 days. At a relative air humidity of 70%, the equilibrium for samples 1-4 came after 28-30 days, and for the fifth - 26 days. At relative humidity 80; 90 and 100% equilibrium of water vapour pressure over all samples was not reached even during the entire period (30 days) of testing.

The sorption moisture capacity of fertilizers was also determined by the desiccator method at a relative humidity of 56; 60.5; 70; 80; 90; 100%. Fertilizer samples were kept over acid for 30 days. The test results are shown in Fig. 6. Fig. 6 it can be seen that at a relative humidity of 56% in the first sample, the moisture content reaches 4.6%, in the second - 3.74%, in the third - 3.56%, in the fourth - 3.23% and in the fifth - 2, 60%. At the same time, the granules of the fertilizer samples retained their appearance and friability. At values of relative air humidity - 60.5%, moisture sorption in the first sample was 11.8%, in the second - 10.6%, in the third - 9.2%, in the fourth - 8.0% and in the fifth - 5. 04%. In this case, the granules of samples 1-3 began to cake and clump, while the granules of samples 4 and 5 remain crumbly and retain their original appearance.

Taking into account that samples 1-3, already at a moisture content of 6.0%, preserving their external shape, begin to cake, it can be said that at the specified relative humidity of the air they lose their friability, and the granules are easily destroyed under low load, i.e. the quality of the products deteriorates greatly.

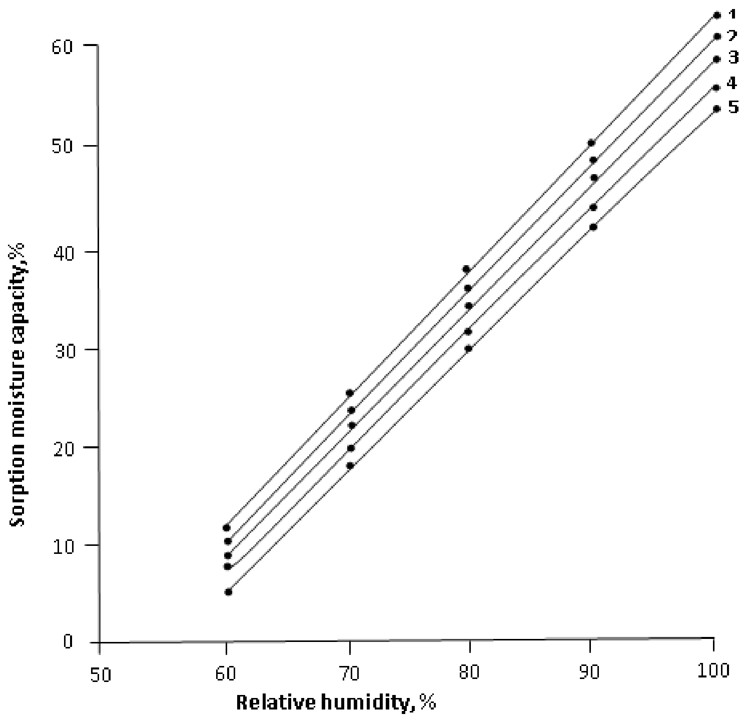

Fig. 6. Dependence of the sorption moisture capacity of nitrogen-phosphorus-potassium fertilizers on the relative humidity of the air.

Substantial sorption of water vapour by fertilizer granules is observed at a relative humidity of 70%. In this case, the first sample collects up to 24.3% of water, the second - 22.3%, the third - 20.6%, the fourth - 19.2%, and they begin to blur.

CONCLUSION

However, the fifth sample absorbed only 17% of water and retained its appearance. At other relative air humidity (80; 90 and 100%), with an increase in the amount of absorbed moisture up to 22%, the granules of all studied samples become saturated solutions. It should be noted that the fifth sample turns into a liquid state upon sorption of 28% moisture.

We have also determined the strength of NPK fertilizer granules at their initial moisture content. The average strength of the granules of the first sample was 3.14, the second - 3.03, the third - 3.57, the fourth - 3.39, the fifth - 3.25 MPa.

The results obtained indicate that all brands of nitroammophoska samples have a significantly lower hygroscopic point and high sorption moisture capacity than pure ammonium nitrate. The resulting NPK fertilizers are highly hygroscopic substances and therefore we recommend storing and transporting them in a bagged form or conditioning them.

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