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NPK Fertilizers Obtained based on the Ammonization of Evaporated Phosphoric Acid, Carbamide and Potassium Chloride

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Abstract*:*
The composition and humidity, hygroscopic point, the kinetics of sorption of water vapor were determined. The sorption moisture capacity of NPK fertilizer granules obtained by mixing ammoniated and evaporated wet process phosphoric acid with powdered potassium chloride and urea are presented.

Keywords:*evaporated wet process phosphoric acid, urea, potassium chloride, NPK fertilizer, hygroscopic point, sorption kinetics and sorption moisture capacity*.

I. INTRODUCTION

Currently, the governments of all countries of the world literally are faced with the task of providing food to the population of their countries. Although progress in the fight against hunger is obvious, it is unacceptable that a large number of people still feel lack of the food necessary for an active and healthy life. Over the two decades since the turn of the millennium, global food demand has been growing steadily stand in increase in the member of population. At the same time, the area of land occupied by food grains (per capita) from the middle and to the end of the 20th century shortened from 0.24 to 0.1 ha. According to estimates by 2050 it will decrease to 0.08 ha per person.

The decrease in the size of arable land occurs not only as a result of rapid population growth. Population grows exponentially, the amount of water and arable land stays the same. The resource base of agriculture is virtually everywhere affected by negative factors. The deterioration of the agricultural resource base is occurring on almost all continents: soil erosion in North America; soil acidification in Europe; deforestation and desertification in Asia and Latin America; unreasonable waste and water pollution in almost all countries of the world. It follows that by 2020 it will take about 410 million hectares of land not for food production. From one third to half of the arable land in the world is used in such a way that their fertility has essentially turned from renewable to non-renewable [1]. The question arises, how in such conditions, when there is a rapid population growth and the proportion of irrigated arable land per person decreases, to provide humanity with food? They understood all over the world - this can only be done by intensifying agricultural production and, in particular, by chemicalization it.

One ton of mineral fertilizers provides an annual need for food products of 5-6 people. Thanks to the use of mineral fertilizers, an average of 40-50% of

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the increase in crop yield is provided. Therefore, there is an increase in the production of mineral fertilizers throughout the world [2-5]. The second half of the 20thcentury was called the “era of chemicalization” due to the use of mineral fertilizers and pesticides. Over 40 years (1951-1990), the global consumption of mineral fertilizers has increased tenfold - from 14 million to 140 million tons [2]. By 2020, it will increase to 215 million tons, including nitrogen fertilizers - up to 127 million tons, phosphate - up to 52 million and potash - up to 36 million tons per 100% nutrients (N, P_2O_5 and K_2O) [6-7].

In the chemical industry, the creation of the production of granular NPK fertilizers is an urgent task. Triple NPK fertilizer can be obtained on the basis of ammonium phosphates (ammonization of steamed extraction phosphoric acid), potassium chloride and a nitrogen-containing component - urea, both from solutions and from melts [8-9].

Nitrogen-phosphorus and nitrogen-phosphorus-potassium fertilizers are valued for their high agrochemical effectiveness, since when applied to the soil, plants are provided simultaneously with the three most important nutrients (nitrogen, phosphorus and potassium) and are in the greatest demand in the world market . NPK fertilizer brands: 15-15-15; 17-17-17; 10-26-26; 12-32-16; 22-22-11; 14-35-14; 14-28-14; 19-19-19; 16-16-16; 12-11-18 with the addition of MgO, 15-15-15-9 with the addition of S and 9-25-25, 20-10-10 are mainly produced by TVA, Simon Carves, Dorr Oliver (USA), Uhde (Germany) , Norsk Hydro (Norway), as well as Russian plants and others [10].

The component composition of the complex fertilizer consists of nitrate (urea or ammonium sulfate), monoammonium phosphate (MAP), diammonium phosphate (DAP) and potassium chloride. Ammonium phosphates are the dominant additives for NPK fertilizers [11]. According to [12] from 2012 to 2018. phosphate fertilizer production increased from 42.7 to 46.6 million tons, calculated on 100% P_2O_5. Of these, the share of MAP and DAP is 64.1%.

According to calculations, the cost of delivery, storage and application of complex fertilizers compared with simple fertilizers is 10% lower; due to the presence of several complex nutrients in one granule of solid complex fertilizers, it allows them to be distributed more evenly over the soil surface; the absence of impurities makes it possible to use in conditions where an increased concentration of salts is undesirable, for example, in arid conditions or when fertilizing crops that are sensitive to an increase in the osmotic pressure of the soil solution (sloth, cucumbers).

Hence, the aim of this communication is to prepare NPK fertilizer and to study its physiochemical property.

II. Materials and Methods

In laboratory conditions, the authors showed that based on MAP and DAP, carbamide and potassium chloride, it is possible to obtain high-quality nitrogen-phosphorus and nitrogen-phosphorus-potassium fertilizers with different ratios of nutrients. The feedstock was the production evaporated wet process phosphoric acid (WPA) of Ammophos-Maxam JSC, composition (wt.%): 18.14 P_2O_5, 0.20.

CaO; 0.28 MgO; 1.27 SO_3, urea with a content of 46.2% N and potassium chloride with 60% K_2O. The possibility of producing urea-ammophos and urea-ammophos-potassium based on the clarified and purified parts of evaporated WPA with concentrations of 35.92; 40.85; 46.41 and 51.07% $P_5O_5$was studied.

In order to obtain balanced NP fertilizers – urea-ammophos, 70% aqueous urea solution was added to the granulation of MAP (at pH = 5.3) and DAP (at pH = 7.0) at a ratio of N: P_2O_5 = 1: (0.5-1). The duration of mixing the starting components was 15 min. And in the case of obtaining carbamide-containing NPK fertilizers – urea-ammophos-potassium after 15 minutes stirring, a weighed portion of potassium chloride (60% K_2O) of -0.25 mm was introduced into the urea-ammophos pulp. The weight ratio of N: P_2O_5: K_2O = 1: (0.7-1) :(0.3-

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1) was varied. All these ratios of nutrient components are considered the most demanded by agriculture. The mixing process NPK-pulp lasted another 15 minutes. In all experiments, the temperature was maintained at 70-80 °C. To obtain finished products, granulation of both NP- and NPK-pulps was carried out in the process of drying by intensive mixing and pelletizing. In order to avoid ammonia loss, the DAP-based pulp was dried at a temperature not exceeding 60 °C, and MAP, first at 60 ° C, then at 100 °C to a constant weight (not more than 1% H_2O). As the melt cools, solid rounded granules formed. The mass was cooled, and then sieved by particle size. Chemical analysis of the products was carried out by known methods [13].

Some physicochemical characteristics of nitrogen-phosphorus-potassium fertilizers is given based on the clarified and purified portion of WPA with a concentration of 40.85% P_2O_5, the composition of which is listed in the table.

The assimilable form of the P_2O_5 product was determined both by solubility in 2% citric acid and in a 0.2 M solution of Trilon B.

Table

Chemical composition of NPK fertilizers based on stripped and ammoniated WPA, urea and potassium chloride

№	Correlation of unitial components $N:P_2O_5:K_2O$	Concentrations of steamed WPA, % P_2O_5	Contentsinproducts, %						Humidity, %
			N	$P_2O_{5общ.}$	K_2O	$\frac{P_2O_{5citric}}{P_2O_{5total}}$ %	$\frac{P_2O_{5EDTA}}{P_2O_{5total}}$ %	$\frac{P_2O_{5water}}{P_2O_{5total}}$ %	
Steamed ammoniated WPA (pH-5.3)									
1	1:0.7:0.3		23.22	16.30	7.20	95.83	95.15	93.87	0.55
2	1:0.7:0.5		23.17	16.31	11.59	96.69	95.22	94.18	0.47
3	1:1:1	40.85	19.07	19.08	19.09	97.38	95.60	95.28	0.54
Steamed ammoniated WPA (pH-7.0)									
4	1:0.7:0.3		23.28	16.34	7.31	95.96	95.34	94.19	0.35
5	1:0.7:0.5		23.27	16.37	11.66	96.82	95.42	94.50	0.51
6	1:1:1	40.85	19.66	19.67	19.65	97.97	95.73	95.37	0.70

The hygroscopic point of fertilizer samples with granule sizes of 2–3 mm was determined by the desiccation method [14-16] at a temperature of 25 °C. The initial humidity in the samples of nitrogen-phosphorus-potassium fertilizers based on MAP was 0.55% in the first, 0.47% in the second, 0.54% in the third, and 0.35% on the basis of DAP, 0.51% in the fifth and 0 in the fifth, 70%.

The determination of the gain or loss of moisture in a substance at a constant temperature and certain relative humidity was carried out for 3 hours. The required relative humidity was created in a closed desiccator above a layer of sulfuric acid poured into it with a known concentration. The values of hygroscopic points for nitrogen-phosphorus-potassium fertilizers turned out to be the following, based on MAP: for sample 1 - 42.7%, for sample 2 - 42.9%, for sample 3 - 43.5%, and based on DAP for Sample 4 - 45.0%, for sample 5 - 45.2% and for sample 6 - 45.5%.

The reason for the low hygroscopic point of the products is explained by the fact that the salt mixture is more hygroscopic than its constituent components [8]. Relative to humid air for Uzbekistan is characterized by the following figures: average monthly minimum - 46%, average monthly maximum - 74%, average annual - 60%. According to the N.E. Pestovhygroscopicity scale, all our nitrogen-phosphorus-potassium fertilizers are hygroscopic substances.

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III. Results and Discussion

Figures 1-6 show the kinetic curves of sorption of water vapor by fertilizer granules under isothermal conditions at 25 ° C, which were studied at relative air humidity to be 52.5; 60.5; 71; 80 and 100%. The numbering of the figures corresponds to the fertilizer numbers in the table.

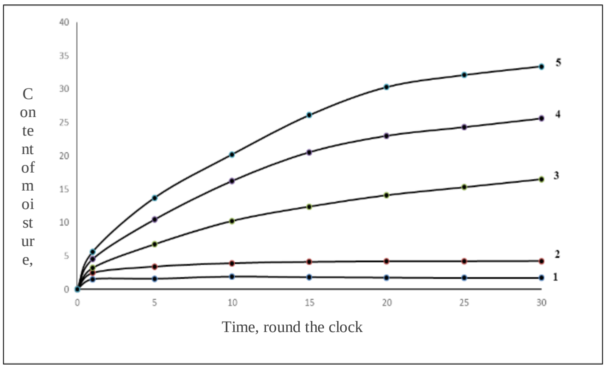

Fig. 1. The kinetics of sorption of water vapor by the first fertilizer sample at relative air humidity: 1-52,5%; 2-60,5%; 3-71%; 4-80%; 5-100%

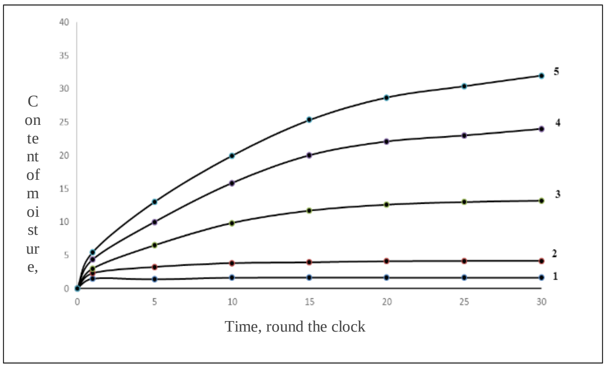

Fig. 2. The kinetics of sorption of water vapor by the second fertilizer sample at relative air humidity: 1-52,5%; 2-60,5%; 3-71%; 4-80%; 5-100%

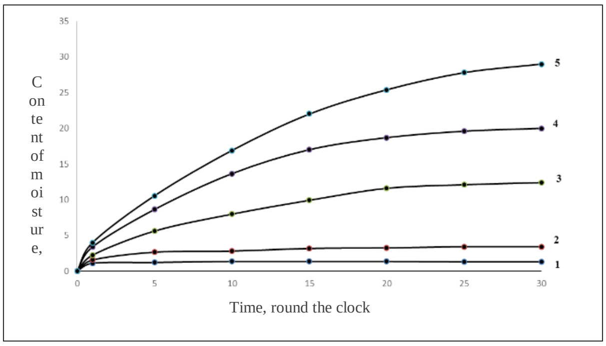

Fig. 3. The kinetics of sorption of water vapor by the third fertilizer sample at relative air humidity: 1-52,5%; 2-60,5%; 3-71%; 4-80%; 5-100%

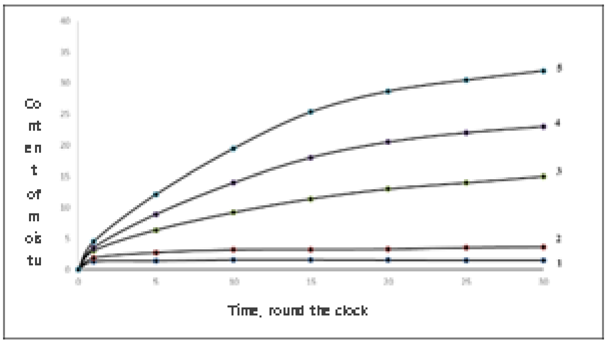

Fig. 4. The kinetics of sorption of water vapor by the fourth fertilizer sample at relative air humidity: 1-52,5%; 2-60,5%; 3-71%; 4-80%; 5-100%

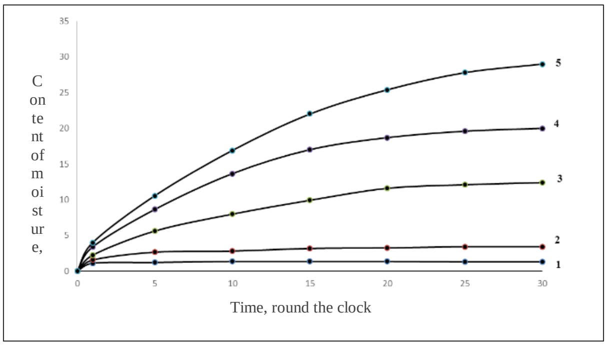

Fig. 5. The kinetics of sorption of water vapor by the fifth fertilizer sample at relative air humidity: 1-52,5%; 2-60,5%; 3-71%; 4-80%; 5-100%

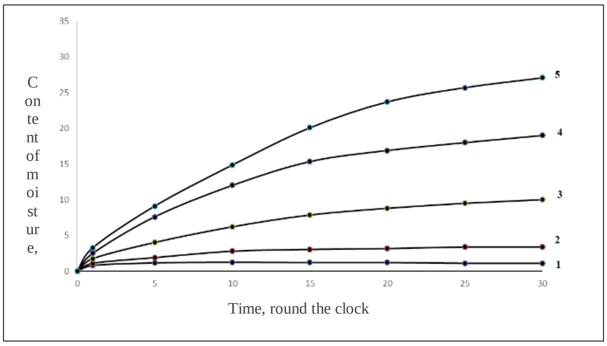

Fig. 6. The kinetics of sorption of water vapor by the sixth fertilizer sample at relative air humidity: 1-52.5%; 2-60.5%; 3-71%; 4-80%; 5-100%

According to the results of the studies, it is clear that at a relative air humidity of 52.5%, the equilibrium for the first, second, third samples occurs in 18-20 days, the fourth and fifth samples in 20 and 22 days. Only in the sixth sample, equilibrium occurs in a short time, i.e. after 13 days. At a relative humidity of 60.5%, equilibrium over 1-3 samples of fertilizers occurs after 20-22 days, and

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over 4 and 5 after 25 days, for the sixth sample after 20 days. At 71% relative air humidity for samples 1-3, equilibrium almost occurred after 28-30 days and the remaining 4-5-6 samples after 30 days. With other relative air humidity of 80 and 100%, the equilibrium for all six samples was not achieved during the entire test period.

Sorption moisture capacity is a very important indicator of the quality of fertilizers, as it indicates the maximum amount of absorbed moisture at which fertilizers retain their appearance and friability. The mechanical sieving of fertilizers depends on it. The sorption moisture capacity of fertilizer samples was determined by the desiccation method also at relative air humidity of 52.5; 60.5; 71; 80 and 100%. Samples corresponding to the numbers in table 1,2,3 over acid were aged for 30 days.

The test results are presented in Fig. 7. At a relative air humidity of 52.5%, nitrogen-phosphorus-potassium fertilizers based on MAF: the first sample (N: P: K – 1: 0.7: 0.3) absorbed moisture 9.8%, the second (N: P: K – 1: 0.7: 0.5) - 6.8%,the third (N: P: K – 1: 1: 1) - 4.6%. Such amounts of water do not affect the quality of the products, that is, the fertilizer granules retain their appearance and initial friability.

At a relative air humidity of 60.5%, the water content in samples 1,2 and 3 reaches 17, respectively; 13.55 and 11%. In this case, the granules of the samples begin to coalesce and lose the ability to sift.

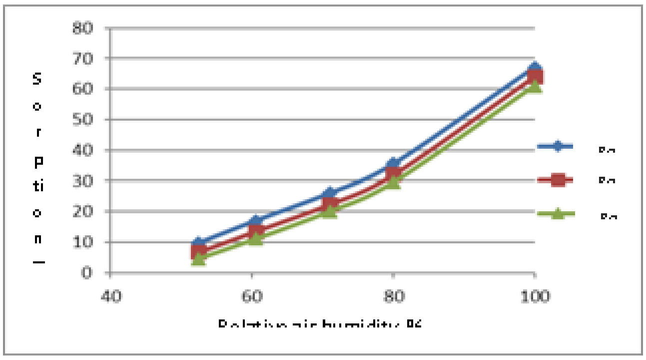

Fig 7. Sorption moisture capacity of NPK fertilizers based on MAF (pH = 5.1), carbamide and potassium chloride at a mass ratio of N: P_2O5: K_2O = 1: 0.7: 0.3 (row 1), 1: 0, 7: 0.5 (row 2) and 1: 1: 1 (row 3)

At a relative air humidity of 70%, all samples begin to intensively absorb moisture. So, in the first sample, the amount of water increased to 26%, in the second - up to 22.4% and in the third - up to 20%. In this case, the granules of the samples began to spread. With other relative air humidity (80, 100%), with an increase in the amount of absorbed moisture up to 61%, the granules of all the samples studied were spread.

It was determined the strength of the granules of the fertilizers obtained at their initial moisture content. The average strength of the granules (according to the table) of the first sample was 3.94, the second - 4.37 and the third 4.42. According to these indicators, they fully meet the requirements of agriculture.

IV. Conclusions

Based on the studies, we can conclude that, in terms of their physicochemical characteristics, the fertilizers obtained meet the requirements of the existing State standard for urea-ammophos. This suggests that we have the opportunity to obtain carbamide with a high content of nutrients (19% N, 19% P_2O_5 and 19% K_2O) based on local raw materials and equipment available at our plants. Urea-ammophos-potassium are highly hygroscopic substances and therefore they are recommended to be stored and transported in plastic bags, or they must be used in a short time.

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