# STUDY OF THE PHYSICAL CHEMICAL PROPERTIES OF NPK FERTILIZER OF 16;16;16;5 BRANDS OBTAINED IN LABORATORY CONDITIONS.

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**Abstract.** In this article, the physicochemical properties of 16;16;16;5 NPK fertilizer were studied in depth in laboratory conditions. Ammaphos, urea, potassium chloride, and ammonium sulfate were crushed to 0.3 mm and mixed and granulated in special mixers. During the study, the appearance, internal structure, and quality of NPK granules were evaluated. In particular, the surface structure of NPK granules, particle shape, and the degree of intergranular adhesion (agglomeration) were visually and microscopically analyzed using a Euromex Microscopen B.V. microscope. This provided information about the quality of the granules, their mechanical strength, and physical changes that occur during storage. At the next stage of the study, the content of the main nutrient elements - nitrogen (N), phosphorus ($P_2O_5$), and potassium ($K_2O$) - in the NPK granules obtained was determined spectrophotometrically. This method provided an accurate and rapid analysis of the fertilizer composition and made it possible to estimate the concentration of each element in the granules with high accuracy. In particular, the nutrient elements nitrogen, phosphorus, and potassium were separately determined for the NPK brand in the ratio 16:16:16:5, and their actual amounts in the granules were determined. Also, during the study, the physical properties of NPK granules - density, hygroscopicity, solubility, granulometry composition, and mechanical stability - were studied. These indicators are considered essential factors determining the quality of the fertilizer and serve as the basis for deciding the agrotechnical efficiency of NPK granules. The results obtained in this work serve as an essential scientific and practical basis for improving quality control in the production process of NPK fertilizers, and for the production of fertilizers with a highly effective and balanced composition in practice.

**Keywords:** Ammafos, urea, potassium chloride, ammonium sulfate, NPK, feed, solubility.



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**Аннотация.** В данном статье в лабораторных условиях были подробно изучены физико-химические свойства NPK-удобрения 16;16;16;5. Аммафос, мочевина, хлорид калия и сульфат аммония были измельчены до 0,3 мм, смешаны и гранулированы в специальных смесителях. В ходе исследования оценивали внешний вид, внутреннюю структуру и качество гранул NPK. В частности, структура поверхности гранул NPK, форма частиц и степень межкристаллитной адгезии (агломерации) были проанализированы визуально и микроскопически с помощью микроскопа Euromex Microscopen B.V. Это позволило получить информацию о качестве гранул, их механической прочности и физических изменениях, которые происходят в процессе хранения. На следующем этапе исследования спектрофотометрический определяли содержание основных питательных элементов - азота (N), фосфора ($P_2O_5$) и калия ($K_2O$) - в полученных гранулах NPK. Этот метод обеспечивал точный и быстрый анализ состава удобрения и позволял с высокой точностью оценить концентрацию каждого элемента в гранулах. В частности, для марки NPK были отдельно определены питательные элементы азот, фосфор и калий в соотношении 16:16:16:5, и были определены их фактические количества в гранулах. Также в ходе исследования были изучены физические свойства гранул NPK - плотность, гигроскопичность, растворимость, гранулометрический состав и механическая стабильность. Эти показатели считаются существенными факторами, определяющими качество удобрения, и служат основой для принятия решения об агротехнической эффективности гранул NPK. Результаты, полученные в данной работе, служат важной научной и практической основой для улучшения контроля качества в процессе производства NPK-удобрений, а также для производства удобрений с высокоэффективным и сбалансированным составом на практике.

**Ключевые слова:** Аммафос, мочевина, хлорид калия, сульфат аммония, NPK, питательные вещества, растворимость.

**Annotatsiya.** Ushbu maqolada 16;16;16;5 NPK o'g'itining fizik-kimyoviy xususiyatlari laboratoriya sharoitida chuqur o'rganildi. Ammafos, karbamid, kaliy xlorid va ammoniy sulfat 0,3 mm gacha maydalangan va maxsus mikserlarda aralashtirilgan va donadorlangan. Tadqiqot davomida NPK granulalarining ko'rinishi, ichki tuzilishi va sifati baholandi. Xususan, NPK granulalarining sirt tuzilishi, zarracha shakli va intergranular yopishish darajasi (aglomeratsiya) Euromex Microscopen B. V. mikroskop yordamida vizual va mikroskopik tahlil qilindi. Bu granulalarning sifati, ularning mexanik kuchi va saqlash paytida yuzaga keladigan jismoniy o'zgarishlar haqida ma'lumot berdi. Tadqiqotning keyingi



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bosqichida olingan NPK granulalarida asosiy ozuqa elementlari - azot (N), fosfor ($P_2O_5$) va kaliy ($K_2O$) tarkibi spektrofotometrik tarzda aniqlandi. Ushbu usul o'g'itlar tarkibini aniq va tezkor tahlil qilishni ta'minladi va granulalardagi har bir elementning kontsentratsiyasini yuqori aniqlik bilan baholashga imkon berdi. Xususan, azot, fosfor va kaliyning ozuqaviy elementlari NPK markasi uchun 16:16:16:5 nisbatida alohida aniqlandi va ularning granulalardagi haqiqiy miqdori aniqlandi. Shuningdek, tadqiqot davomida NPK granulalarining fizik xususiyatlari - zichligi, gigroskopikligi, eruvchanligi, granulometriya tarkibi va mexanik barqarorligi o'rganildi. Ushbu ko'rsatkichlar o'g'it sifatini belgilovchi muhim omillar hisoblanadi va NPK granulalarining agrotexnik samaradorligini aniqlash uchun asos bo'lib xizmat qiladi. Ushbu ishda olingan natijalar NPK o'g'itlarini ishlab chiqarish jarayonida sifat nazoratini takomillashtirish va amalda yuqori samarali va muvozanatli tarkibga ega o'g'itlar ishlab chiqarish uchun muhim ilmiy va amaliy asos bo'lib xizmat qiladi.

**Kalit so‘zlar.** Ammafos, Karbamid, Kaliy xlorid, Ammoniy sulfat, NPK, ozuqa, eruvchanlik.

**Introduction**

Nowadays, the importance of mineral fertilizers in achieving high yields and increasing soil fertility in agriculture is unparalleled.[1] In particular, NPK complex fertilizers, which contain a balanced composition of the primary nutrients such as nitrogen (N), phosphorus (P), and potassium (K), are widely used in agriculture.[2] These fertilizers not only have a positive effect on plant growth and development [3] but also serve to maintain the balance of nutrients in the soil. [4]

NPK fertilizers are produced in different brands, and their physicochemical properties, granule quality, solubility, and ratio of constituent elements may vary depending on the manufacturer.[5] Therefore, assessing the quality of NPK fertilizers, 6 conducting an in-depth study of their composition, and making a preliminary determination of agrotechnical efficiency are of great importance in agricultural production. [6,7]

In this study, the physicochemical properties of laboratory-produced NPK fertilizers were investigated under controlled laboratory conditions.[8,9] The shape of the granules, degree of aggregation, solubility properties, and concentration of constituent nutrients (N, P, K) were analyzed using modern equipment, including a Euromex Microscopen B.V. microscope and a spectrophotometer.[10] The results obtained were used to assess the quality of NPK fertilizers, their agrotechnical value, and suitability for practical use. [11]

**METHODS.**

1. Urea: nitrogen (N) – 46.0%; moisture ($H_2O$) – 1.0%.



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2. Ammophos: nitrogen – 10.0%; phosphorus ($P_2O_5$) – 46%; moisture (H2O) – 1.0%.

3. Fine-grained potassium chloride: Potassium ($K_2O$) – 60.0%; moisture ($H_2O$) – 1.0%.

4. Ammonium sulfate: nitrogen (N) – 21.0%; sulfur (S) – 24.0%; moisture ($H_2O$) – 1.0%.

5. Bentonite clay. Montmorillonite mineral content –not less than 70%; moisture ($H_2O$) – 1.0%.% %.

**The ratio of nutrients: N:$P_2O_5$:$K_2O$ = 1:1:1, which will be:**

- nitrogen (N) – 16%;
- phosphorus ($P_2O_5$) – 16%;
- potassium ($K_2O$ – 16%;
- sulfur (S) – 5%;
- moisture ($H_2O$) – 1%.

**Calculation:**

a) To ensure that the product passes the tests for compliance with the requirements of the NTD, the calculated content of nutrients in the NPK is taken as:

- nitrogen (N) – 16.1%;
- phosphorus ($P_2O_5$) – 16.1%;
- potassium ($K_2O$ – 16.1%;
- sulfur (S) – 5.1%;
- moisture ($H_2O$) – 1%.

b) Calculation for a specific component - potassium chloride (KCl) is carried out based on 16.1% $K_2O$ or 151.0 kg per 1000 kg in NPK. We find the required amount of KCl in the fertilizer:

$$G_{KCl} = \frac{161.0 \times 100}{60} = 268{,}33 \text{ kg}$$

where 60 is the content of $K_2O$ in potassium chloride, %. c) Taking into account the ratio of $K_2O$: $P_2O_5$ = 1:1, we take the amount of $P_2O_5$ equal to 161.0 kg and calculate the amount of required ammophos:

$$G_{am.} = \frac{161.0x \ 100}{46} = 350{,}00 \text{ kg}$$

Where 46 is the content of $P_2O_5$ in ammophos, %.

d) Considering the amount of ammophos in the fertilizer, 350.00 kg, we find the amount of nitrogen (N) introduced with ammophos:

350,00x 10,0



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$$G_{N.} = \frac{\text{----------}}{100} = 35{,}00 \text{ kg}$$

where 10.0 is the nitrogen (N) content in ammophos, %. To achieve a total nitrogen content in NPK fertilizer of 161.0 kg, it is necessary to add additional nitrogen in the form of ammonium sulfate and urea in the amount of:

$G_{N.} = 161{,}0 - 35{,}00 = 126{,}00$ kg,

Which is in the ratio of 84.4:41.6.

The amount of urea in this case will be:

$$G_{urea} = \frac{84{,}41 \times 100}{46} = 183{,}50 \text{ kg},$$

And the amount of ammonium sulfate will be:

$$G_{urea} = \frac{41{,}61 \times 100}{21} = 198{,}14 \text{ kg},$$

Find the amount of sulfur in ammonium sulfate:

$$G_{S.} = \frac{198{,}14 \times 24}{100} = 47{,}55 \text{ kg}$$

where 24 is the sulfur content (N) in ammonium sulfate, %.

Nitrogen is introduced in the amount of 198.14 kg of ammonium sulfate:

$$G_{N.} = \frac{198{,}14 \times 21}{100} = 41{,}61 \text{ kg}$$

The total content of NPK fertilizer components is:

$$268{,}33 + 350{,}00 + 183{,}50 + 198{,}14 = 999{,}97 \text{ kg},$$

Then the amount of bentonite clay introduced will be:

$$1000 - 999{,}97 = 0{,}03 \text{ kg}$$

where 1000 is the total mass of NPK fertilizer.

The total content of NPK fertilizer components will be:

**Table 1.**

| Components | Weight, | kg % content |
|---|---|---|
| Urea | 183,50 | 18,350 |
| Ammophos | 350,00 | 35,000 |
| Potassium chloride | 268,33 | 26,833 |
| Ammonium sulfate | 198,14 | 19,814 |
| Bentonite | 0,03 | 0,003 |
| TOTAL: | 1000,00 | 100,00 |



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In this article, the 16-16-16-5 brand of NPK was thoroughly studied, and the full results were calculated and obtained, determining the quantities of each component (ammonium sulfate, urea, potassium chloride, and ammonium sulfate) required to produce 1 ton of product.

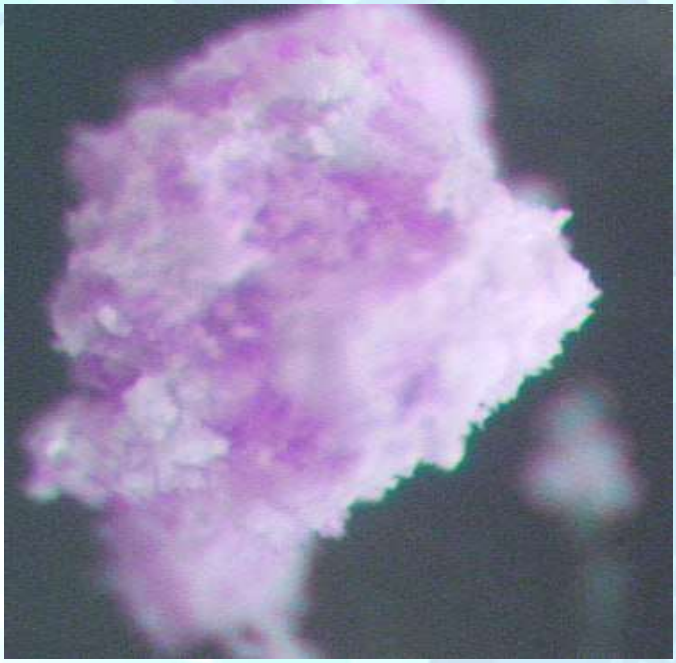


**Figure 1. This figure shows the morphology of 16, 16, 16, 5 NPK.**

**16:16:16:5 NPK granule micromorphology (analysis):**

**Granule appearance:**

The granules depicted in Figure 1 are soft, dark purple-pink, with an uneven and convex surface. Such a microstructure indicates that the granules are glued together and agglomerated. The degree of crystallinity and surface hardness is low, which means they have high hygroscopicity.

Physical properties of granules:

As you can see, although the granules have a solid shape, their edges are soft, indistinct, and have a porous structure. This indicates that the mechanical strength of the granules is average, meaning they may disintegrate into dust during transportation and storage.

Distribution of constituent components:

In fertilizers of the 16:16:16:5 brand:

Nitrogen (N) - 16%

Phosphorus ($P_2O_5$) - 16%

Potassium ($K_2O$) - 16%

Sulfur (S) - 5%.

Dark areas visible under a microscope may indicate the distribution of phosphorus and sulfur components. The uneven distribution of constituent elements on the surface affects the physical quality and solubility of the granules.



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This type of NPK fertilizer has high solubility and is quickly absorbed by the plant. However, the quality of the granules and their mechanical stability are highly dependent on storage conditions. Agglomeration between the granules indicates greater sensitivity to moisture. Although these granules possess all the basic properties typical of quality NPK fertilizers, it is recommended to take precautions during storage and transportation, such as hermetic packaging and storage in a dry place.

## RESULTS.

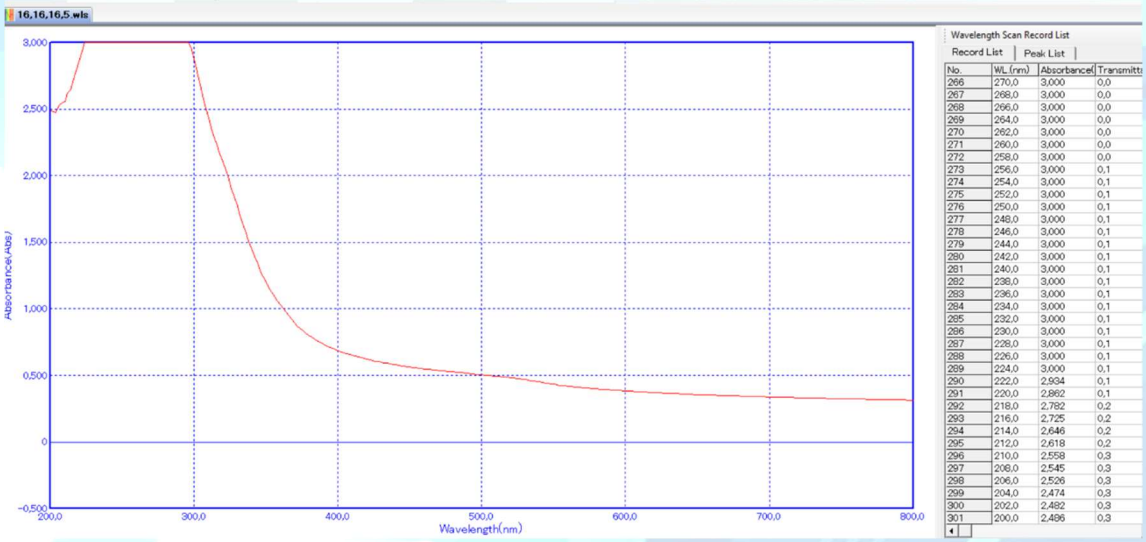



**Figure 2. Spectrophotometric analysis results of 16:16:16:5 NPK fertilizer**

**Research Objective:**

The primary objective of this experiment was to determine the concentrations of the primary nutrient elements - nitrogen (N), phosphorus ($P_2O_5$), and potassium ($K_2O$) - in the composition of 16:16:16:5 NPK fertilizer granules using the spectrophotometric method.

Research conditions:

Instrument: UV-Vis spectrophotometer

Wavelength range: 200–800 nm

Measurement: Absorption (optical density)

The spectrogram above graphically reflects the distribution of the optical density of 16:16:16:5 NPK fertilizer by wavelength.

Key observations:

1. A sharp absorption peak was observed in the 200–300 nm range (A ≈ 3.000). In this range, absorption of phosphorus ($P_2O_5$) and ammonia nitrogen ($NH_4^+$) ions occurs.

In particular, in the range of 230–250 nm, intensive absorption of phosphorus ions is detected.

2. In the range of 300–400 nm, the absorption level slowly decreases.



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This may be the effect of nitrogen and phosphorus complex compounds. Absorption of organic compounds and other anions in this range is also possible.
3. In the range of 400–800 nm, the absorption decreases sharply, remaining almost in the range of 0.1–0.2.

Potassium ions ($K^+$) are not absorbed in the visible region, which is as expected.

The obtained spectrophotometric results confirm the high concentration of phosphorus and nitrogen elements in the composition of the 16:16:16:5 NPK fertilizer.

Potassium ions are not absorbed in the visible region of the spectrum, which corresponds to the properties of $K_2O$, a component of the fertilizer.
The sharp decrease in the graph indicates that the main active components in the fertilizer are properly dissolved and can be detected by spectrophotometry.
The results correspond to normal quality indicators for a 16:16:16:5 brand fertilizer.

The analysis results were compared with the manufacturer's passport data. Spectrophotometric analysis has demonstrated its reliability as a method for evaluating the quality of NPK granules. In subsequent studies, it is recommended to draw up a separate calibration graph for each element.

**DISCUSSION**

In this work, the physicochemical properties of NPK mineral fertilizers produced under the 16:16:16:5 brand and the amounts of their constituent nutrients were studied using spectrophotometry. According to the study's results, the presence of particles bonded to each other in the external structure and microstructure of the granules, as well as surface roughness and porosity, was observed. This indicates that it can increase the hygroscopic properties of the granules and lead to agglomeration during storage.

The results of spectrophotometric analysis confirmed the presence of nitrogen (N), phosphorus ($P_2O_5$), and potassium ($K_2O$) elements in the specified concentrations in the composition of 16:16:16:5 NPK granules. Intense absorption peaks of phosphorus and nitrogen ions were detected in the 200–300 nm range. In the 400–800 nm range, the absorption level was almost minimal, and potassium ions were not absorbed in the spectrum.

In general, the studied NPK fertilizers possess high-quality indicators and are considered suitable for use from an agrotechnical perspective. The results obtained during the study serve as an essential scientific and practical basis for the quality, efficiency, and correct application of NPK fertilizers in practice.


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