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STUDY OF THE PROCESS OF COMPLEX FERTILISER PRODUCTION

***Saparova G.D.*[1], *Khairiev F.B.*[2], *Erkaev A.U.*[3], *Kucharov B.H.*[2], *Obidjonov D.*[2]**

[1] Karakalpak Research Institute of Natural Sciences, Karakalpak Branch of the Academy of Sciences of the Republic of Uzbekistan, Nukus, Uzbekistan

[2] Institute of General and Inorganic Chemistry, Academy of Sciences of the Republic of Uzbekistan, Tashkent.

[3] Tashkent Institute of Chemical Technology

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Abstract

This paper presents data on the production of magnesium-containing fertilizers based on the processing of serpentinite of Karakalpak deposit. Their chemical composition, physico-chemical properties (moisture content, volume weight, hygroscopicity, fluidity) were investigated. Chemical analyses of the obtained sample showed that the sample consists mainly of iron-13.7, magnesium-27.2, aluminium-5.66, nickel-7.66, silicon-1.30%. Also present are: calcium-1.25, manganese-0.578, cobalt-0.210 and titanium-0.0662% giving the material strength, heat and corrosion resistance. After the process of ammonization and packing to solid state, the magnesium-containing nitrogen fertilizer (three samples) consists of the sum of nutrient elements 39.5; 44.2 and 41.46%, in particular N-21.86; 22.5; 23.86%, of which 5.44; 4.74; 6.7% in ammonium form, Mg-18.3; 21.7; 17.4% respectively at pH 3; 4 and 5.

Keywords: *serpentenite, magnesium nitrate, magnesium-containing nitrogen fertilizer, physical and chemical properties*

Introduction

The main task of the agro-industrial complex of Uzbekistan is to increase the production of agricultural products in such volumes that will allow to ensure the food programme, as well as to increase the quantity and quality of exported agricultural products, which is inextricably linked to the intensification of the industry, one of the most important conditions of which is the rational use of fertilizers that provide not only an increase in crop yields, but also the preservation and improvement of the overall level of soil fertility

In recent publications magnesium is considered on a par with other basic nutrition elements, since its deficiency in mineral nutrition limits not only the possibility of obtaining high yields, but also a decrease in the quality of agricultural products (Aristarkhov A. N., 2002).

Magnesium is a mesoelement that is directly involved in many metabolic processes in plant development: including photosynthesis, phosphorus uptake and transport, amino acid and protein synthesis, and helps maintain turgor pressure, which is essential for maintaining plant form and structure.

The authors (Aristarkhov A. N., 2000; Mittler R., 2006) state that magnesium supply has a positive effect on the growth of roots and vegetative mass of plants, frost and drought resistance, resistance of plants to leaf burns from solar radiation, and resistance to fungal diseases

Magnesium deficiency has a major impact on the distribution of dry matter and carbohydrates between shoots and roots. One of the earliest plant responses to magnesium deficiency stress is a marked increase in shoot to root dry weight ratio, which is associated with massive accumulation of carbohydrates in leaf sources, especially sucrose and starch. Studies with common bean and sugar beet plants have shown that Mg plays a fundamental role in sucrose loading of the phloem. These results indicate that the accumulation of carbohydrates in magnesium-deficient leaves is directly caused by magnesium deficiency stress (Cakmak I., Kirkby E. A., 2008).

Our interest in obtaining magnesium fertilizers is understandable, one of which magnesium nitrate – a 2-component fertilizer containing the most important elements necessary for the basic life processes of plant organisms – nitrogen and magnesium, in our opinion, can find a worthy application. As part of the development of technology for obtaining magnesium-containing fertilizer from serpentinite, we set the task to create a product that combines high agrochemical activity and a minimum level of impurities. The research is focused on the formation of magnesium-ammonium nitrate, which combines the key nutrients – magnesium and nitrogen.

Materials and Methods. Quantitative analysis of elemental composition was performed on a high-performance energy dispersive X-ray fluorescence spectrometer Rigaku NEX CG EDXRF (Japan). The analyser captures concentrations from tenths of mg/kg. This method indicates the optimum wavelength of the determined micro- and macroelement at which it has maximum emission (Fig. 1). Determination of CaO and MgO content was carried out by volumetric complexometric method: titration with 0.05n Trilon B solution in the presence of indicators fluorexon and chromium dark blue (Vinnik M. M., Erbanova L. N., Zaitsev P. M. et al., 1975). Nitrogen content in the products was determined by Kjeldahl method – by ammonia distillation in alkaline medium with Devard’s alloy followed by titration (GOST 30181.4–94.; Myrzakozha, D.A., Mirzakhodzhaev A. A., 2013).

Results of the study. In the process of nitric acid decomposition of local raw material – serpentinite of Karakalpak deposit, composition (weight %): 33–34% MgO and 41–42% SiO_2. It is shown that with increase of pH of the medium up to 3.0–3.5 the degree of iron and aluminum settling is only 99.47–99.52%, and the precipitation of semithin oxides completely falls out, releasing the composition of magnesium nitrate and ammonium nitrate solution. The wet precipitate was dried at room temperature to constant weight. The dry magnesium nitrate contains about 90–95% Mg O. The liquid phase containing ammonium, calcium and magnesium nitrates can subsequently serve as a liquid fertilizer $Mg(NO_{3)2}$, containing up to 15.40% nitrogen, which is in nitrate and ammonium forms in amounts of 7.26% and 8.14% (Saparova G. D., Dzhandullaeva M., Erkaev A. U. Kucharov B. Kh., 2022; Saparova Gulnar Dauletmuratovna, Zhandullaeva Munavvara, Erkayev Aktam Ulashevich, Kucharov Bakhrom Khairievich, Bauatdinov Saliy, 2023; Saparova G. D., Kucharov B. H., Jandullaeva M. S., Erkaev A. U., Zakirov B. S., 2024).

The ammoniated slurry was brought dry state at pH 4 and 5 by packing, resulting in solid iron-magnesium-ammonium-nitrate fertilizer with total nutrient elements of 44.2 and 41.46% and content of 22.5; 4.76 and 23.86 6.7% nitrogen and magnesium respectively.

The resulting iron-magnesium-nitrate-ammonium fertilizer (Fe-Mg-NH_4-NO_3), a complex mineral fertilizer containing iron, magnesium and nitrogen in ammonium and nitrate forms, can provide plants with the necessary elements for photosynthesis, growth and metabolism. The presence of iron and magnesium also stimulates chlorophyll formation, improves metabolic processes and increases resistance to stress. The balanced composition of the fertilizer promotes rapid assimilation of nutrients, reduces the risk of micronutrient deficiency, which will recommend its use for growing grain, vegetable and fruit crops when applied to the soil or as foliar fertilizer to increase yields and product quality.

Figure 1. *Obtained iron-magnesium-nitrate-ammonium nitrate fertiliser (IMNAU)*

pH4.1 **pH5.12**

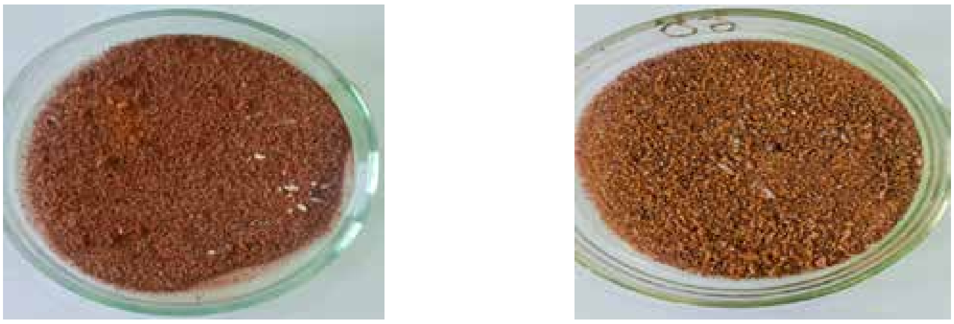
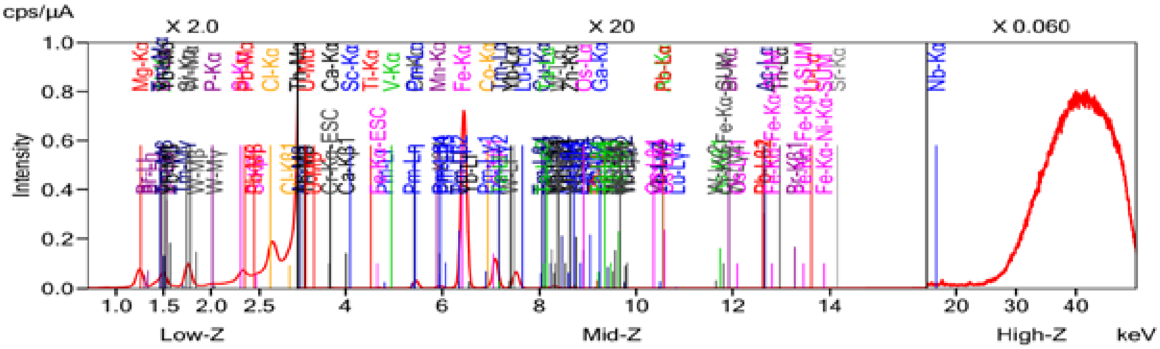


Figure 2. *Analysis of the chemical composition of the udolbronium sample (IMNAU) at pH 5.12 using the FP method*



The sample consists mainly of: iron-13.7, magnesium-27.2, aluminium-5.66, nickel-7.66, silicon-1.30%. Calcium-1.25, manganese-0.578, cobalt-0.210 and titanium 0.0662% are also present, giving the material strength, heat and corrosion resistance.

After the ammonization process and packing to solid state, a magnesium-ammonium-nitrate fertilizer with 0.02 and 0.012% aluminum and iron content can be obtained.

Figure 3. *Obtained magnesium-nitrate-ammonium fertilizer (MNAF)*

pH4.1 **pH5.12**

Thus, the magnesium-nitrate-nitrogen fertilizer **MNAF** (three samples) consists of the sum of nutrient elements 39.5; 44.2 and 41.46%, in particular N-21.86; 22.5; 23.86%, of which 5.44; 4.74; 6.7% in ammonium form, Mg – 18.3; 21.7; 17.4% respectively at pH 3; 4 and 5. The obtained magnesium-nitrate-ammonium fertilizer (MNAF) is a complex mineral fertilizer containing magnesium, ammonium and nitrate nitrogen, provides plants with important nutritional elements. Due to high solubility and availability of elements for plant nutrition, MNAF promotes active photosynthesis, stimulates growth and development of plants, improves their resistance to unfavorable conditions. It is well soluble in water, ensuring a uniform supply of nutrients. Unlike traditional magnesium fertilizers, magnesium-ammonium-nitrate fertilizer has a synergistic effect due to the combination of magnesium and ammonium form of nitrogen.

The obtained MNAF and IMNAF have the following marketable properties.

Table 1. *Commodity properties of the fertilizer's obtained*

No.	Fertiliser	Humidity, %	Volume weight, (g/cm³):	Natural slope angle,°C	Hygroscopic point, %	Current, c
1	IMNAF pH 4.1	18.69	0.742	40	50	5.4
2	IMNAF pH 5.12	20.48	0.839	30	55	5.1
3	MNAF pH 4.1	18.19	0.717	35	48	6.2
4	MNAF pH 5.12	18.76	0.723	30	43	6.0

IMNAF has a higher moisture content compared to MNAF, which may be related to the hydrophilicity of iron-containing compounds. Variations in pH (4.1 and 5.12) are related to changes in salt solubility and moisture retention capacity.

Volumetric weight (g/cm³): IMNAF has a high volume mass due to the presence of iron-containing compounds with high density. Increasing the pH increases the bulk mass, probably due to changes in the crystal structure of the fertiliser.

Hygroscopic point (%): IMNAF is less sensitive to moisture than MNAF, which may require special storage conditions to prevent clumping. The exact quantitative hygroscopicity depends on conditions, but, for example, at relative humidity above 45–55% the resulting fertiliser starts to actively absorb water, and at 70–75% it completely dissolves in its own absorbed moisture, forming a saturated solution.

The flowability index characterises the ability of the fertiliser to pour freely. All values are in a similar range, which indicates good bulkiness and convenience for mechanised application.

Conclusion

Thus, as a result of nitric acid decomposition of serpentinite of Karakalpak deposit a liquid phase containing ammonium, calcium and magnesium nitrates is formed, which can serve as a liquid fertiliser $Mg(NO_{3)\,2}$, containing up to 15.40% of nitrogen, which is in nitrate and ammonium forms in the amount of 7.26% and 8.14%. After the process of ammonisation and packing to a solid state the commercial properties of the obtained fertilizers were investigated. It was found that the volume weight (g/cm³) of the fertilisers has a large volume mass, which is due to the presence of iron-containing compounds with high density. hygroscopic point is less sensitive to moisture, which may require special storage conditions to prevent clumping

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Contact: gulnor-sayler@mail.ru