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# STUDY OF INTERACTION OF COMPONENTS IN $ZnSO_4$ – $NH_4H_2PO4$ – $H_2O$ SYSTEM

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**Abstract:**

**Objective.** To theoretically substantiate the interaction of zinc sulfate with monoammonium phosphate, an isomolar series was used, based on the ratio of the components $ZnSO_4$ and $NH_4H_2PO_4$.

**Methods.** The physicochemical properties of diluted solutions were studied by the isomolar series method to justify the interaction between zinc sulfate and monoammonium phosphate. Based on the ratio of components in the $ZnSO_4$ and $NH_4H_2PO_4$ system, pH value, density, refractive index, viscosity and crystallization temperature of the mixture of 0,01 M solutions were measured.

**Results.** According to the results of the physicochemical characteristics of diluted solutions in the [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)] system, i.e., the pH environment, density, viscosity, refractive index and crystallization temperature values, one deviation corresponding to the presence networks of the initial components is observed. Based on the results of the diagram, it is expressed in the ratio [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)]=4:6.

**Conclusion.** From the obtained results, it can be concluded that changes in the physicochemical properties of solutions occur even at the above amount of zinc sulfate and monoammonium phosphate with the composition ratio [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)]=4:6. This shows that regardless of the initial concentration of zinc sulfate, when a small amount of monoammonium phosphate is added, a change in the composition of the solution occurs.

**Keywords:** zinc sulfate, monoammonium phosphate, Ostromyslensky-Job isomolar series method, pH value, density, viscosity, refractive index, crystallization temperature.

**Introduction.** In connection with the rapid growth of the population and the reduction of cultivated areas to a certain extent, there is an increasing need to develop and scientifically justify measures to increase soil fertility, and the quality and weight of the harvest from agricultural crops [1]. Measures to improve the nutritional quality of plants by growing crops, and providing them with nutrients necessary for human health are of great interest [2]. Nutrient availability is a key factor in plant growth and development [3]. In recent years, improper use of soil resources, including intensive cultivation without proper replenishment of nutrients, restriction of crop rotation, and low addition of organic matter, has led to a decrease in crop yield and quality, as well as micronutrient deficiencies [4-6] in soil, crops, animals, and humans [7]. When plants are grown in microelement-deficient soils, agricultural products with a low content of microelements are produced, which leads to hidden hunger in economically developing countries [8,9]. Globally, 1.7 million people die from micronutrient deficiencies caused by the consumption of micronutrient-deficient or low-nutrient foods [10,11]. Plants consume nutrients from the soil from germination to harvest, leading to the depletion of essential nutrients in agricultural soils [12].

Soil impoverishment can be prevented by using active fertilizers with trace elements during the intensive cultivation of plants [13]. In recent years, many studies have demonstrated the link between micronutrient supplementation and increased yields, especially in crops containing zinc, manganese, and copper [14,15]. A significant increase in grain yield due to the combined use of zinc microelements with NPK fertilizers shows the importance of trace element fertilizers in plant breeding [16-19]. In Tanzania, NPK fertilizers have been reported to increase rice yield by 1 t/ha, and combined application of NPK and micronutrients by 1.5 t/ha compared to the control [20].

**Methods.** In order to study the process of obtaining NPK fertilizers containing trace element zinc, using the Ostromyslensky-Job method [21], studies were conducted using the method of isomolar sequence according to the ratio of components in the $ZnSO_4$ and $NH_4H_2PO_4$ system to theoretically justify the interaction of zinc sulfate with monoammonium phosphate.

In the case where the isomolar sequence method is used, it is carried out by pouring isomolar solutions of research components with the same molar concentration in certain sequential proportions with a constant sum of the initial volumes.

The physicochemical properties of diluted solutions were studied by the isomolar series method to justify the interaction between zinc sulfate and monoammonium phosphate. Based on the ratio of components in the $ZnSO_4$ and $NH_4H_2PO_4$ system, pH value, density, refractive index, viscosity and crystallization temperature of the mixture of 0,01 M solutions were measured.

To accomplish this, a solution of zinc sulfate and ammonium dihydrogen phosphate was prepared at 0.01 M and 0.01 M monoammonium phosphate solution was added in increasing amounts to the zinc sulfate solution. Following that, the pH, refractive index, viscosity, crystallization temperature and density of the mixtures were measured. All measurements were made in a water thermostat at a temperature of 20 ± 0.1 $^0$C.

The kinematic viscosity of the solution was measured using a VPZh capillary viscometer with a capillary diameter of 1.16-2.75 mm with an accuracy of $\pm 0.0001 \cdot 10^{-1}$ $m^2/s$. The relative density was determined by the pycnometric method [22].

The pH value of the solutions was expressed using a Bante210 Benchtop pH/mV Meter pH meter.

**Results and discussion.** The results of changes in the physicochemical properties of solutions depending on the ratio of components in the $ZnSO_4$ and $NH_4H_2PO_4$ system are shown in Figure 1 and Table 1.

The analysis of the "pH - composition" diagram in the $ZnSO_4$ and $NH_4H_2PO_4$ system shows that as the amount of 0.01 M monoammonium phosphate solution increases from 3 ml to 30 ml, the pH values of the solutions decrease from 3.87 to 3.79 and then increase, as well as the pH in the ratio of [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)]=4:6 when the value is 3.20, break is observed.

In the "composition-density" diagrams, the density of the solutions gradually decreases from 0.98459 g/$cm^3$ to 0.98245 g/$cm^3$ as the amount of monoammonium phosphate increases and the amount of zinc sulfate decreases, and [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)]=4:6 with a composition ratio of 0.98263 g/$cm^3$, a change in density value is observed.

Analyzing the data of the "Content - Refractive Index" diagram shows that the refractive indices in the system gradually decrease from 1.3320 to 1.3317 until the [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)]=4:6 ratio, and it can be noted that there is a significant breaking point in the diagram. As the amount of monoammonium phosphate in the mixture increases, the value of the refractive index continues to decrease to 1.3316.

Based on the data of the crystallization temperature in the [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)] system of "Composition - crystallization temperature", the ratio [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)]=4:6 is characterized by the presence of a clear fracture at a temperature of -0.6 $^0$C.

Viscosity values of the investigated system solution decrease from 0.9549 $mm^2$/c to 0.9576 $mm^2$/c with a decrease in the amount of 0.01 M zinc sulfate and an increase in the amount of 0.01 M monoammonium phosphate. It is also explained by the presence of a breaking point of 0.9481 $mm^2$/c at a ratio of 4:6.

Table 1

**Changes in physicochemical properties of solutions depending on the ratio of components in the [$ZnSO_4$(0.01M)+$NH_4H_2PO_4$(0.01M)] system**

| № | Компонент таркиби | | pH | Зичлик г/см$^3$ | Қовушқоқлик, mm$^2$/c | Кристалланиш ҳарорати, $^0$C | Нур синдириш кўрсаткичи |
|---|---|---|---|---|---|---|---|
| | $ZnSO_4$, мл | $NH_4H_2PO_4$, мл | | | | | |
| 1 | 30 | 0 | 3.87 | 0.98459 | 0.9549 | -1.0 | 1.3320 |
| 2 | 27 | 3 | 3.49 | 0.98424 | 0.9485 | -0.9 | 1.3319 |
| 3 | 24 | 6 | 3.39 | 0.98405 | 0.9466 | -0.9 | 1.3318 |
| 4 | 21 | 9 | 3.32 | 0.98371 | 0.9468 | -0.8 | 1.3318 |
| 5 | 18 | 12 | 3.25 | 0.98332 | 0.9471 | -0.7 | 1.3318 |
| 6 | 15 | 15 | 3.23 | 0.98295 | 0.9479 | -0.6 | 1.3318 |
| 7 | ***12*** | ***18*** | ***3.20*** | ***0.98254*** | ***0.9481*** | ***-0.6*** | ***1.3317*** |
| 8 | 9 | 21 | 3.22 | 0.98259 | 0.9525 | -0.4 | 1.3318 |
| 9 | 6 | 24 | 3.26 | 0.98251 | 0.9558 | -0.2 | 1.3318 |
| 10 | 3 | 27 | 3.45 | 0.98247 | 0.9570 | -0.1 | 1.3317 |
| 11 | 0 | 30 | 3.79 | 0.98245 | 0.9576 | 0 | 1.3316 |

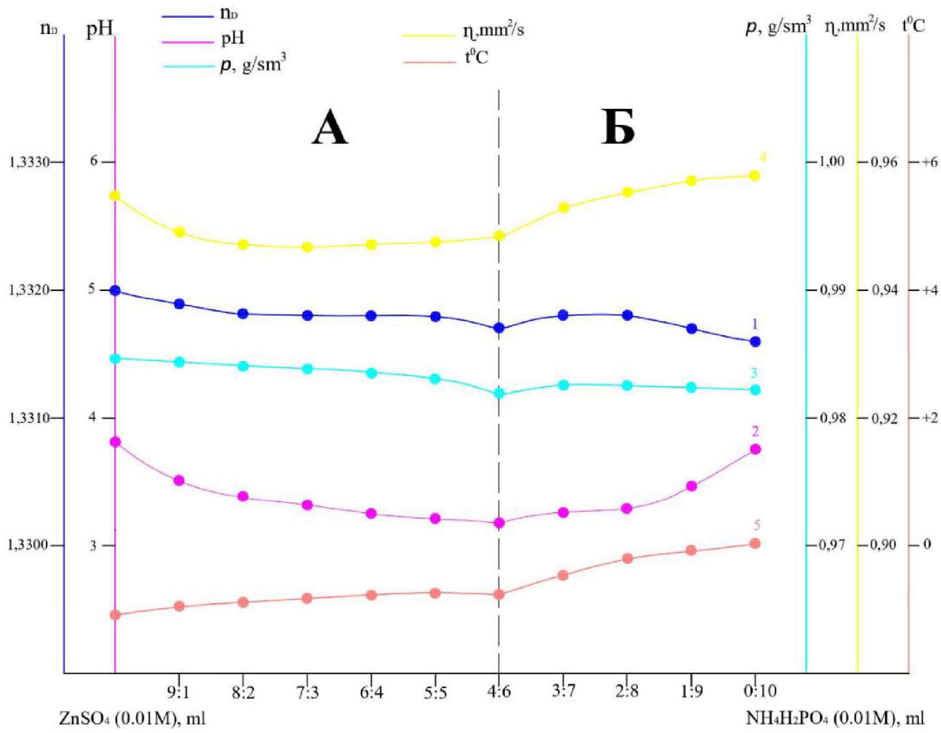


**Figure 1. Changes in physicochemical properties of solutions depending on the ratio of components in the [$ZnSO_4$(0.01M)+$NH_4H_2PO_4$(0.01M)] system**

**Conclusion.** According to the results of the physicochemical characteristics of diluted solutions in the [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)] system, i.e., the pH environment, density, viscosity, refractive index and crystallization temperature values, one deviation corresponding to the presence networks of the initial components is observed. Based on the results of the diagram, it is expressed in the ratio [$ZnSO_4$(0.01M)]:[$NH_4H_2PO_4$(0.01M)]=4:6.

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# CONTENTS