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Editorial board:

CONTENTS

CONTENTS

CONTENTS

CONTENTS

THEORETICAL BASIS FOR OBTAINING ORGANOMINERAL FERTILIZER IN THE SYSTEM $2K^+, 2NH_4^+ // 2CL^-, SO_4^{2-} - H_2O$

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Abstract: This paper examines the theoretical foundations for producing organomineral potassium fertilizer by converting potassium chloride with spent sulfuric acid followed by ammoniation. Based on the analysis of the reciprocal system $2K^+$, $2NH_4^+ // 2Cl^-, SO_4^{2-} - H_2O$, polythermal solubility diagrams were constructed and crystallization regions were determined. The choice of process mode is governed by the figurative point position and component ratio. A comparative analysis of two processing options was performed, and the optimal conditions for K_2SO_4 production were established. The second option provides a maximum K_2SO_4 yield of up to 87.04 % and is technologically preferable.

Key words: organomineral fertilizer, potassium sulfate, potassium chloride, reciprocal system, solubility diagram, crystallization regions.

INTRODUCTION

Recycling acidic and saline liquid waste from the chemical industry is a pressing scientific and technological challenge aimed at reducing environmental impact and producing valuable products. One promising area is the production of chlorine-free potassium fertilizers from potassium chloride using waste sulfuric acid.

A key role in substantiating technological parameters is played by the physicochemical analysis of multicomponent aqueous systems, which allows determining the conditions of phase equilibria, crystallization regions, and routes for the targeted production of final products. The theoretical study of the reciprocal system $2K^+, 2NH_4^+ // 2Cl^-, SO_4^{2-} - H_2O$ is characterized by complex phase behavior due to the formation of both individual salts (K_2SO_4, NH_4Cl) and double compounds ($K_2SO_4 \cdot (NH_4)_2SO_4$).

LITERATURE REVIEW

The production of potassium sulfate from potassium chloride using various acidic agents has been studied extensively. Patent No. 8,409,542 [1] describes a method for producing potassium sulfate from potassium chloride. Previous work by Koshanova et al. [2] examined methods for processing acidic waste from caustic soda and PVC production to obtain fertilizers. The chemical and physicochemical characteristics of waste sulfuric acid formed during caustic soda production were established by Koshanova et al. [3]. General principles of sulfuric acid production are presented in the Sulfuric Acid Man's Handbook [4].

Despite considerable progress, the theoretical basis for the multistage processing of potassium chloride through the intermediate formation of double salts in the quaternary system $2K^+, 2NH_4^+ // 2Cl^-, SO_4^{2-} - H_2O$ remains insufficiently studied. This work aims to fill this gap by constructing polythermal solubility diagrams and analyzing phase equilibria for process optimization.

RESEARCH METHODOLOGY

The study is based on the physicochemical analysis method applied to multicomponent aqueous salt systems. Polythermal and isothermal solubility diagrams were constructed using the extrapolation method based on published experimental data for the subsystems. Phase equilibrium calculations were performed using material balance equations for the system $2K^+, 2NH_4^+ // 2Cl^-, SO_4^{2-} - H_2O$.

Two processing options were modeled: (1) processing of the double salt $K_2SO_4 \cdot (NH_4)_2SO_4$ with KCl solutions and (2) dissolution of the double salt in water or recirculating solutions. Solid-phase yields were calculated based on phase equilibrium data from the ternary system $K^+, NH_4^+ // SO_4^{2-} - H_2O$ at temperatures of 25, 50, 70, and 95 °C. A comparative analysis was carried out to determine the technologically preferable option.

ANALYSIS AND RESULTS

Based on the extrapolation method, a polythermal solubility diagram was constructed for the system $2NH_4^+, 2K^+ // SO_4^{2-}, 2Cl^- - H_2O$ (Fig. 1). The analysis showed that a significant part of the region corresponds to the crystallization of the double salt $K_2SO_4 \cdot (NH_4)_2SO_4$. The initial compositions of the system are located at points a_1, a_2, and a_3, while the equilibrium compositions of the liquid phase are located at points b_1, b_2, and b_3 (Figure 1).

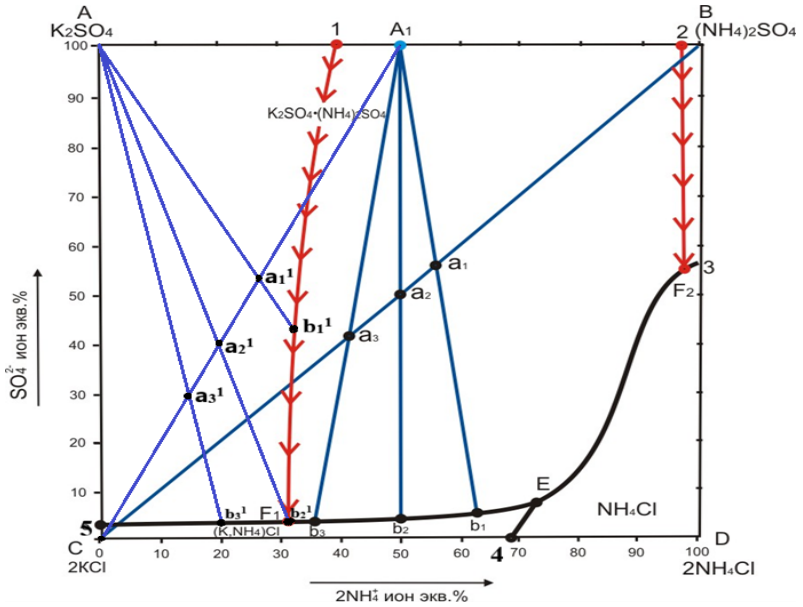

Figure 1. Polythermal diagram of solubility of the system $2NH_4^+, 2K^+ // SO_4^{2-}, 2Cl^- - H_2O$[1]

It has been established that at a temperature of 25 °C the crystallization process of the double salt occurs in the region of its stability. An increase in the sulfuric acid rate (movement from $a_3 \rightarrow a_1$) leads to an increase in the yield of the solid phase from 37.5% to 52.6%. This indicates that a stoichiometric excess of H_2SO_4 (at least 90%) is a necessary condition for increasing the product yield. The results are presented in Table 1.

Table 1. Theoretical analysis of the yield of potassium-containing solid phase based on phase equilibrium in the mutual system $2K^+, 2NH_4^+ // 2Cl^-, SO_4^{2-} - H_2O$[2]

No.	Solid phase composition	Ratio m_k/m_s = a_n b_n'(b_n)/A(A')a_n	W:T	Solid phase yield, %
1	$K_2SO_4 \cdot (NH_4)_2SO_4$	1.11	0.90	52.60
2		0.91	1.10	47.64
3		0.60	1.67	37.50
4	K_2SO_4	0.18	5.55	15.25
5		0.89	1.12	47.09
6		0.37	2.70	27.00

1 authors' development
2 authors' development

When the sulfuric acid rate increases to 115% and 100% saturation is reached, the system reaches the eutonic point E, where $K_2SO_4 \cdot (NH_4)_2SO_4$, $NH_4Cl \cdot KCl$ and NH_4Cl are simultaneously present. This mode is undesirable because sediment filterability deteriorates, removal of chloride ions slows down, and the subsequent release of NH_4Cl becomes more complicated. Therefore, the technological limits are: H_2SO_4 rate ≤ 115% and saturation degree ≤ 100%.

In the second processing variant, the double salt $K_2SO_4 \cdot (NH_4)_2SO_4$ is dissolved in water or circulating solutions. Isothermal solubility diagrams of the ternary system K_2SO_4 – $(NH_4)_2SO_4$ – H_2O at 25, 50, 70, and 95 °C are shown in Figure 2.

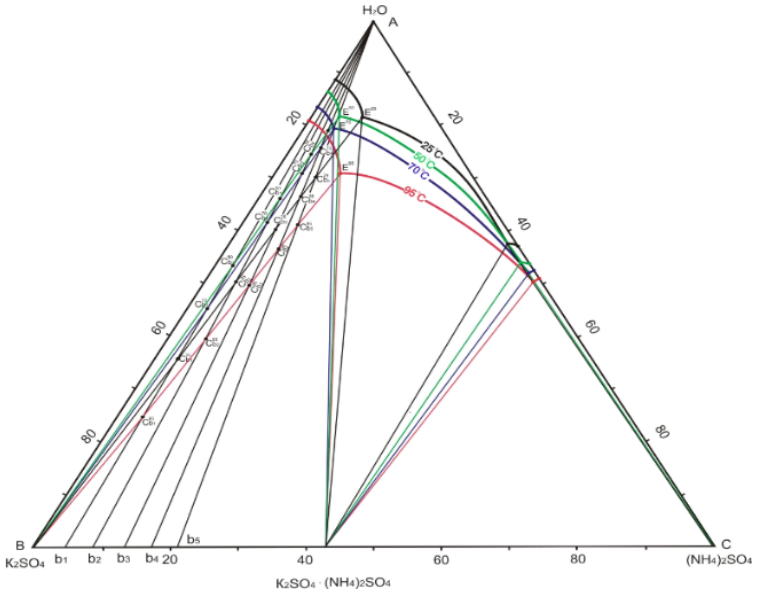

Figure 2. Isothermal diagrams of solubility of the K_2SO_4 – $(NH_4)_2SO_4$ – H_2O system at temperatures of 25, 50, 70 and 95 °C[3]

The yield of K_2SO_4 from the ternary system at various operating points is presented in Table 2.

Table 2. Theoretical analysis of the release of potassium sulfate from the solid phase based on phase equilibrium data of the ternary water-salt system $K^+, NH_4^+ // SO_4^{2-} – H_2O$[4]

No.	Figurative point	Temp, °C	Water/sediment ratio (bnCt/ACt)	Ratio K_2SO_4/EtCt/BCt	K_2SO_4 yield, %
1	b_1	25	0.54	1.30	87.04
2		50	1.15	0.54	75.38
3		70	0.84	0.75	78.85
4		95	0.33	1.88	86.82
5	b_2	25	1.01	0.62	76.92
6		50	1.95	0.24	57.09
7		70	1.60	0.28	56.87
8		95	0.65	0.81	73.84
9	b_3	25	1.49	0.36	65.91
10		50	2.90	0.10	35.45
11		70	2.34	0.12	35.78
12		95	0.96	0.44	59.89
13	b_4	25	1.99	0.23	55.90
14		50	4.00	0.03	14.56
15		70	3.11	0.05	19.57
16		95	1.30	0.26	47.46
17	b_5	25	2.37	0.16	46.48
18		50	4.51	0	0
19		70	3.91	0	0
20		95	1.58	0.16	35.58

3 authors' development
4 authors' development

According to the analysis, the maximum yield of K_2SO_4 in the first variant (processing the double salt with KCl solutions) is 47.09%, while the second variant (dissolution in water/circulating solutions) achieves a maximum yield of 87.04%. In the second variant, the resulting solution is reused in a closed cycle, enabling more efficient phase separation.

A comparative analysis showed the advantages of the second option: exclusion of the KCl dissolution stage, the use of flotation KCl without preliminary purification, removal of impurities at the filtration stage, and the possibility of organizing a closed water cycle.

CONCLUSION AND RECOMMENDATIONS

A theoretical analysis of the $2K^+, 2NH_4^+ // 2Cl^-, SO_4^{2-} - H_2O$ system revealed that the key factor in process control is the position of the figurative point on the solubility diagram. Increasing the sulfuric acid rate to 90–115 % increases the solid-phase yield; however, exceeding these values degrades the process characteristics of the system. The second processing option was shown to provide the maximum potassium sulfate yield (up to 87.04 %) and is therefore technologically preferable.

The obtained results can be used in the development of resource-saving technologies for processing industrial waste into environmentally friendly chlorine-free fertilizers. It is recommended to implement a closed water-salt cycle in order to minimize waste generation and maximize product recovery.

REFERENCES

1. Method for Producing Potassium Sulfate from Potassium Chloride: U.S. Patent No. 8,409,542; filed June 14, 2011; published April 2, 2013. – 3 p.
2. Koshanova B.T., Toshtemirov A.B., Erkaev A.U., Bekanov S.Y., Erkayeva N.A. Methods for Processing Acidic Waste from Caustic Soda and PVC Production and Obtaining Fertilizers for Plants // Development of Science. – Vol. 7. – December 12, 2026. – ISSN 3030-3907.
3. Koshanova B.T., Chavlieva F.B., Turakulov B.B., Erkaev A.U., Kucharov B.Kh., Dzhandullaeva M.S., Reymov A.M. Chemical and Physicochemical Characteristics of Waste Sulfuric Acid Formed during the Production of Caustic Soda // Uzbek Chemical Journal. – 2024. – No. 1. – Tashkent. – P. 56–61.
4. Sulfuric Acid Man's Handbook. – Moscow: Chemistry, 1971. – 744 p.
5. Perry's Chemical Engineers' Handbook / Perry R.H., Green D.W. Perry's Chemical Engineers' Handbook. – 8th ed. – New York: McGraw-Hill, 2008. – 2700 p.
6. Kirk-Othmer Encyclopedia of Chemical Technology / Kirk-Othmer Encyclopedia of Chemical Technology. – 5th ed. – Hoboken: John Wiley & Sons, 2004. – Vol. 23. – P. 1–45.
7. Food and Agriculture Organization. Fertilizer Use by Crop in Central Asia. – Rome: FAO, 2023. – 120 p.

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