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Investigation of the Process of Ammonium Chloride Production by Conversion of Potassium Chloride with Ammonium Nitrate

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ABSTRACT

The method of combining potassium chloride with ammonium nitrate to produce ammonium chloride is the focus of the study. Using potassium chloride and ammonium nitrate as starting ingredients, this study examines the key steps in the manufacture of ammonium chloride. The primary physical and chemical characteristics of the produced product, its use, and the potential for this process' evolution moving forward are also taken into account. Given the widespread usage of ammonium chloride in industry—as a fertilizer, a catalyst, and for other things—the study has applications for the sector.

An important direction in the manufacturing of fertilizers and chemical compounds is the study of the procedure for producing ammonium chloride by converting potassium chloride with ammonium nitrate. Using ammonium nitrate, potassium chloride is transformed into ammonium chloride in this method.

Initially, a solution of potassium chloride and ammonia was converted in order to produce ammonium chloride. However, this method has drawbacks, including high reaction temperatures, significant waste production, and challenging product purification procedures.

In this context, a substitute technique for making ammonium chloride by employing ammonium nitrate has been created. Due to the lack of ammonia consumption and little waste production, this procedure is more effective and ecologically benign.

Following is the procedure for creating ammonium chloride by combining potassium chloride and ammonium nitrate. Before adding ammonium nitrate, potassium chloride is first dissolved in water. Following that, the reaction occurs at low pressure and temperature. As a consequence, potassium nitrate and ammonium chloride are produced.

This method's simplicity in scaling up to create vast quantities of goods is one of its benefits. The procedure also doesn't produce a lot of trash and doesn't call for a significant equipment investment.

There are certain drawbacks to this method, though. For instance, producing ammonium chloride in this manner is not the most effective and can result in the development of undesirable contaminants.

Therefore, research into the method of converting potassium chloride into ammonium nitrate to produce ammonium chloride is crucial for the manufacturing of fertilizers and chemical compounds. This method of producing ammonium chloride is more effective and ecologically benign, and it is simple to scale up to manufacture huge quantities of goods. However, there are a few drawbacks to this procedure that must also be considered.

The challenge of feeding the world's population has gotten much worse in recent years. This is because, in spite of rapid population expansion, the amount of arable land on the planet is essentially stagnant. Development of the manufacture of high-quality, affordable mineral fertilizers is one of the issues mentioned above. The group of halogens includes fluorine and chlorine. Fluorine, however, is a more aggressive and damaging contaminant since it demonstrates more non-metallic (oxidizing) characteristics. Agrochemical studies [1] indicate that when fertilizers contain up to 3% fluorine, there is no adverse effect on plants. Most of the existing guidelines for controlling the amount of chlorine in non-chlorine fertilizers use a number akin to this one. The growth of the manufacture of mineral fertilizers is focused on improving quality, and Belarusian agrochemists advise that the chlorine level of fertilizers used in greenhouses should not be more than 1%. The top exporters of chlorine-free, water-soluble complex fertilizers are Kemiro Agro (Finland), Norsk Hydro (Norway), Agrokhanza (Poland), Buysky Chemical Plant OJSC (Russia), Nutri SI (Belgium), Haifa Chemicals and Israil Chemicals (Israel), Vicksburg Chemicals Co. (USA), SQM SA and PCS Ymbes SCM (Chile), and The Arab Potash Compani Ltd.

The following numbers show that a potential and rapidly increasing area of the manufacture of mineral fertilizers is the development of chlorine-free water-soluble complex fertilizers. The anticipated commissioning of new capacity for the manufacture of potassium nitrate throughout the globe during 1997–2000 amounted to more than 474 thousand tons/year, according to public data on building projects for the production of NPK fertilizers [2]. The market for chlorine-free water-soluble fertilizers is expected to expand at a pace of 4% annually. The usage of mineral fertilizers is one of the most crucial factors that ensures the accomplishment of this mission. The only way to solve this issue is to intensify agricultural output by raising the yield of agricultural products [3-5]. In the meantime, quite a bit of study has been done so far on the creation of technical procedures for the manufacture of different kinds of chlorine-free water-soluble complex fertilizers. The conversion techniques for generating potassium nitrate, sulfate, carbonate, and phosphate—chlorine-free water-soluble fertilizers—are among the recognized procedures and are of special relevance because all the raw ingredients for these processes are produced at the republic's chemical businesses. In [6], in order to increase the degree of conversion and the degree of purity of the final product, contacting is carried out in a device consisting of two columns and two intermediate tanks with a ratio of useful volumes equal to 1: (0.3-0.35), connected pipelines in sequence - the top of one column - an intermediate container from another column, by processing in the first column of the Form; a cation exchanger supplied from above with an ammonium nitrate solution, in the second column of the NH4 form of the cation exchanger with a solution of potassium chloride, conclusions of the obtained solutions of potassium nitrate and ammonium chloride. In [7], the yield of the target product was increased by the flotation method. This is accomplished by mixing potassium chloride and sodium nitrate at temperatures between 80 and 900 degrees Celsius, allowing the mixture to cool for three to four hours, and then isolating the desired product via flotation. A combination of octadecylamine

in the range of 50–75 g/t of salts is employed as a flotation agent. The technique enables an up to 98% increase in potassium nitrate production.[6-7]. We have looked at the possibilities of converting potassium nitrate and potassium sulfate into the following non-chlorine potassium fertilizers. Prior to determining the range of variation in technological parameters and the order of technological operations, the study of multicomponent systems $K+$, NH_4 + // Cl^- , NO_3–H_2O, $K+$, NH_4 + // Cl^- , $H_2PO_4^{2-}$ H_2O и $Na+^1$, K^+ , $Mg+^2$ // Cl- , ½ SO_4^{-2} – H_2O was conducted.

The following range of variation of the key technical parameters was selected for this work based on the examination of the solubility diagram K^+ , NH_4^+ ,//Cl^- ,NO_3 —H_2O; KCl:NH_4NO_3 - 1,0- 1,2:1; conversion time of 1 to 40 minutes; crystallization time of 15 to 30 minutes; crystallization temperature of 5 to 20 degrees Celsius. The effects of the KCl:NH_4NO_3 ratio, conversion temperature and time, as well as the kinetics of crystallization at 5.10 and 20°C were investigated. (Table 1)

According to the findings, no solid phase is generated in the system over the time periods under study following the conversion process, independent of the conversion conditions at 900C. After the conversion process had run its course, the system was cooled to a certain crystallization temperature while being stirred at a speed of 50 to 100 rpm and chilled at a rate of 3 to 70 degrees Celsius per minute. According to the protocols [8–9], the final solid product and liquid phase were examined for the presence of K+Cl and nitrogen in the form of nitrate and ammonium. A suspension of potassium nitrate with the ratio L:T-3.42:7.44:1 forms crystals of the substance as a result of the system's decreased solubility of the substance. Within 10 minutes, the level of elucidation rises more than 36; 65%, depending on the conditions of the experiments. The suspension was filtered under vacuum at a residual pressure of 0.6 kg•s/cm^2 at a rate of 814.97:2695.06 kg/m^2• h.

Table 1. Influence of technological parameters on the process of obtaining potassium nitrate by the conversion method

№	Ratio in the conversion stage KCl/ NH4NO3	Conversion duration, min	crystallization temperature, ^0C	Duration of crystallization, min	Filtration speed, kg/m^2. h	Humidity of the solid phase, %	W:T	Exit degree K_2O, %
					by solid phase			
1.	**1:1**	1	5	15	2695,06	12,11	4,84: 1	44,34
2.		10			1694,94	15,60	4,62: 1	47,40
3.		1		30	1087,80	10,03	4,52: 1	48,31
4.		10			1894,90	10,22	4,02: 1	50,54
5.		1	10	15	1774,86	12,73	4,38: 1	47,40

6.		10			2213,85	12,87	4,14:1	47,45
7		1		30	1884,86	14,21	4,70:1	48,84
8		10			2173,56	14,28	4,31:1	49,97
9		1	20	15	1576,43	16,85	5,26:1	38,15
10		10			1801,17	19,89	5,60:1	38,49
11		1		30	1380,75	10,57	5,49:1	38,93
12		10			1585,39	11,67	5,15:1	40,75
13	**1,09:1**	5	5	15	1264,15	9,14	4,63:1	46,51
14		10			1284,13	9,76	3,90:1	49,85
15		20			1561,21	9,86	3,75:1	46,44
16		40			1380,06	9,18	3,52:1	52,86
17		1	5	30	814,97	5,52	4,06:1	52,00
18		5			1128,13	6,35	3,98:1	52,96
19		10			1142,86	7,3	3,91:1	53,05
20		20			1066,31	7,52	3,93:1	53,24
21		40			1246,89	7,3	3,93:1	54,53
22		5	10	15	1546,12	14,0	4,87:1	44,40
23		10			1185,79	10,72	4,98:1	42,07

24		20			953,58	10,59	4,97:1	44,31
25		5	10	30	1404,97	8,37	4,5:1	46,33
26		10			952,27	9,5	5,3:1	43,64
27		20			1274,98	12	5,35:1	43,36
28	**1,2:1**	1	5	15	1224,67	13,29	4,8:1	44,66
29		10			1863,05	15,05	4,47:1	41,09
30		1	5	30	1009,33	9,12	5,52:1	43,25
31		10			2425,56	16,39	4,94:1	45,78
32		1	10	15	1553,66	12,83	5,83:1	40,64
33		10			1780,08	17,58	5,98:1	35,52
34		1	10	30	1251,42	12,26	5,63:1	39,18
35		10			1458,92	14,73	5,52:1	39,63
36		1	20	15	1682,04	18,16	7,39:1	29,52
37		10			1000,72	15,06	6,96:1	31,41
38		1	20	30	1131,56	12,4	7,44:1	30,32
39		10			1345,18	15,73	6,83:1	31,78

Depending on the experimental parameters, the amount of K2O released into the product in the first cycle of the conversion process ranges from 29.49 to 54.53%. Since increasing the conversion time from 1 to 40 min only results in a 2.53% yield increase (experiment 17-21), table 1 demonstrates that the degree of K_2O yield is essentially unaffected by conversion time. The effect of the KCl:NH_4NO_3 ratio on the degree of K_2O yield is strongly correlated with crystallization temperature. A greatest degree of yield is seen at a temperature of 5.0C.

For instance, the output degree is 47.9 under the identical circumstances as the other parameters in 2.14 and 29;

Both 49.85 and 42.07% are acceptable. The K_2O yield only drops to 5.23 and 33% when the crystallization temperature and $KCl:NH_4NO_3$ ratio are raised by more than 10°C, though.

It should be noted that the degree of yield falls by more than 6.5% at a ratio of $KCl:NH_4NO_3$ = 1.2:1 compared to $KCl:NH_4NO_3$ = 1.09:1.

As the crystallization temperature drops, this tendency gets stronger. For instance, this difference reaches 7.78% at 50C. Table 1 shows that the largest degree of K_2O yield is observed at $KCl:NH_4NO_3$ = 1.09:1, a temperature of 5.0°C, and ranges from 46.51 to 54.53%; at 10°C, this indication falls to 42.07 to 46.33%.

According to the table, samples filter at a rate of 1066.31–1561.21 kg/m^2 h, which is fairly high. As a result, raw potassium nitrate crystals have moisture contents between 9.90 and 14.30% at temperatures between 5 and 10^0C for crystallization.

One of the indirect markers of the level of K^2O yield is the L:S ratio in suspension. The table shows that the L:T ratio was 4:1 at a yield ratio of more than 50%, and that for yield ratios of less than 40% and 30%, it was greater than 5.5:1 and 7.0:1, respectively.

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