ISSN Print: 2394-7500
ISSN Online: 2394-5869
Impact Factor: 5.2
IJAR 2020; 6(3): 317-321
www.allresearchjournal.com
Received: 24-01-2020
Accepted: 28-02-2020

ZT Ruzieva cand
Technical Sciences, Associate Professor of the Krishi Engineering - Economics Institute, Republic of Uzbekistan

MA Khalilova
Master of the Krishi Engineering - Economics Institute, Republic of Uzbekistan

O Kh Panjiyev
Technical Sciences, Associate Professor of the Krishi Engineering - Economics Institute, Republic of Uzbekistan

M Usmonova
Bachelor of Krishi Engineering - Economics Institute, Republic of Uzbekistan

Correspondence Author:
O Kh Panjiyev
Technical Sciences, Associate Professor of the Krishi Engineering - Economics Institute, Republic of Uzbekistan

The conversion process study of NA_2SO_4 and CA $(NO_2)_2$, CA $(NO_3)_2$ and the physicochemical properties of solutions of sodium nitrate and sodium nitrite

ZT Ruzieva cand, MA Khalilova, O Kh Panjiyev and M Usmonova

Abstract
The conversion process of myroblite and calcium nitrite-nitrate has been studied. The experiments on obtaining nitrite and sodium nitrate were carried out at temperatures of 25, 30, and 400C and the concentration of the working solution of nitrite and sodium nitrate 25.0; 40.0; 50.0%. The obtained experimental data show that with increasing concentration of the added working solution of nitrate and sodium nitrite, the degree of conversion is constantly increasing.

Keywords: Rheostat, temperature control, figurative points, four-water calcium nitrate, filterability

1. Introduction

The Republic has achieved high research results on the development of technology for processing nitrogen containing raw materials and providing the industry with sodium compounds. In the third direction of the development strategy of the Republic of Uzbekistan for 2017-2021, important tasks were pointed out aimed at advancing "the development of high-tech manufacturing industries, primarily for the production of finished products with high added value based on the deep processing of local raw materials." In this regard, the development of technology for the processing of metabolite, limestone and nitrogen oxides and the production of sodium nitrate and calcium nitrate is very important [1].

This article, to a certain extent, serves the fulfillment of the tasks provided for in the Decree of the President of the Republic of Uzbekistan No. PD-4947 of February 7, 2017, “Strategy of Action on the Five Priority Areas of the Republic of Uzbekistan in 2017-2021,” Decrees of the President of the Republic of Uzbekistan No. PP-3236 of August 23, 2017 “On the program for the development of the chemical industry for 2017-2021”, No. PD-3983 dated October 25, 2018 “On measures for the enhanced development of the chemical industry in the Republic of Uzbekistan”, No. PP-4265 dated April 3, 2019 “About measures to further reform and increase the investment attractiveness of the chemical industry”, as well as other regulatory documents adopted in this area [2].

Each of the natural mineral raw materials is unique and has a specific character, and their compositions are very different from each other. This requires for each type of mineral raw material separate scientific and technological approaches, economically viable ways of processing. One of the main directions of economic development of Uzbekistan is the development of natural resources, their integrated use and the creation of competitive, import-substituting products based on local raw materials.

2. Materials and Methods

The experiment was conducted in a laboratory setup consisting of a glass reactor equipped with a paddle stirrer, placed in a thermostat; the rotational speed of the electric motor was controlled by a rheostat device and measured with a TM-3M tachometer, using a D-1 mm sensor. The temperature of the water thermostat heating the reactor was maintained using a contact thermometer TK-300 and an electronic relay RT-230 Hz The experimental procedure was as follows: the calculated amount of $Ca(NO_3)_2$ or $Ca(NO_2)_2$ was loaded into the reactor. Na_2SO_4 and a prepared solution of sodium nitrate or sodium nitrite were added thereto, followed by distilled water.

After that, the reactor was placed in a thermostat with a given temperature and the pulp was stirred for 2 hours.

Filtration of the pulp was carried out on a filter funnel placed in a Bunsen flask, which was connected to a vacuum filter [3].

The experiments on obtaining nitrite and sodium nitrate were carried out at temperatures of 25, 30, and 400C and the concentration of the working solution of nitrite and sodium nitrate 25.0; 40.0; 50.0%.

The molar ratio of sodium sulfate and calcium nitrite (nitrate) was taken equal to unity. The ratio of T: W supported 1: 3,5.

The results of the experimental data are presented in table 1.

The obtained experimental data show that with increasing concentration of the added working solution of nitrate and sodium nitrite, the degree of conversion is constantly increasing.

Temperature significantly affects the degree of conversion of sodium sulfate with nitrate and calcium nitrite. The degree of conversion of sodium sulfate increases with temperature to 300C, and begins to decrease above this temperature. In the case of conversion with calcium nitrate at 200 °C and a concentration of a circulating solution of sodium nitrate of 25%, the degree of conversion is 89.8%, and at 30 and 400 °C, respectively, 92.6 and 91.6%.

A similar temperature dependence of the degree of conversion is also observed in the case of other concentrations of the circulating solution of sodium nitrate.

At a temperature of 200 °C and a concentration of a sodium nitrite working solution of 25.0-40.0%, the degree of conversion is 91.3 - 93.0%.

At 300 °C, for all concentrations of the sodium nitrite working solution, the degree of conversion reaches its maximum value. For a concentration of a circulating solution of 25.0%, the degree of conversion is 93.5%, with an increase in the concentration of a circulating solution from 25.0% to 50.0%, the degree of conversion increases by 3.2%. A further increase in temperature leads to a decrease in the degree of conversion. To a temperature of 300C, due to the increase in precipitation of calcium sulfate, the degree of conversion increases, since the reaction is shifted to the right. With a further increase in temperature, the solubility of calcium sulfate increases and therefore the reaction shifts to the left and the degree of conversion decreases. However, with increasing concentration of the circulating solution of sodium nitrate and sodium nitrite, the degree of conversion increases.

At 400 °C and a concentration of sodium nitrite working solution of 40.0%, the degree of conversion is 93.6%, at a concentration of 50.0% -95.6%, i.e. the degree of conversion at 400 °C with an increase in the concentration of the circulating solution of sodium nitrite from 25% to 40.0% and up to 50.0 increases by 1.2 and 3.2%, respectively.

In the next series of experiments, we studied the effect of the ratio of solid and liquid phases T: W = 1: 2.5; 1: 3.5; 1: 5 by the degree of conversion of calcium nitrate and nitrite, depending on the concentration of the circulating solution of sodium nitrate and nitrite (table 1).

The results show that with an increase in the concentration of the circulating solution of sodium nitrate and sodium nitrite, the degree of conversion of calcium nitrate and nitrite with sodium sulfate increases. The highest degree of conversion is observed at a ratio of T: L = 1: (2.5 - 3.5), and the minimum degree of conversion is observed at T: L = 1: 5.

When the ratio T: W = 1: 2.5 and the concentration of the circulating solution of sodium nitrate 25 and 40%, the degree of conversion of sodium sulfate is 89.1 and 89.7%, respectively. With a ratio of T: W = 1: 3.5, the degree of conversion reaches 89.8 and 92.2%, respectively. With an increase in the ratio T: W to 1: 5, the degree of conversion at the above concentrations of the NaNO3 working solution as compared with the ratio T: W 1: 3.5 decreases by 0.5 and 0.8%, respectively.

Table 1: The influence of the main technological parameters of the process of conversion of calcium nitrites and nitrates with sodium sulfate on the degree of conversion and filtration rate.

№	Temperature, ^{0}C	The concentration of the circulating solution, $NaNO_3$ ($NaNO_2$)	The ratio of T: W,	The ratio, $Ca(NO_3)_2$ $Ca(NO_2)_2$): Na_2SO_4	The degree of conversion,%	Filtration rate, kg / m2.h
1	2	3	4	5	6	7
Upon receipt of sodium nitrate						
1	20	25	1:2,5	1:1	89,1	1233,5
2	20	25	1:3,5	1:1	89,8	5247,4
3	20	25	1:5,0	1:1	89,3	9398,3
4	20	40	1:2,5	1:1	89,7	1003,5
5	20	40	1:3,5	1:1	92,2	5006,4
6	20	40	1:5,0	1:1	90,4	9086,3
7	20	50	1:2,5	1:1	93,1	820,1
8	20	50	1:3,5	1:1	94,1	3520,2
9	20	50	1:5,0	1:1	92,8	7451,6
10	30	25	1:3,5	1:1	92,6	5350,4
11	30	40	1:3,5	1:1	94,3	5134,5
12	30	50	1:3,5	1:1	95,6	4060,4
13	40	25	1:3,5	1:1	91,6	5450,4
14	40	40	1:3,5	1:1	92,8	5240,5
15	40	50	1:3,5	1:1	93,4	4160,4
16	30	25	1:3,5	1,1:1	94,6	5356,4
17	30	40	1:3,5	1,1:1	96,4	5144,5
18	30	50	1:3,5	1,1:1	97,9	4090,5
19	30	25	1:3,5	1,2:1	95,1	5361,4
20	30	40	1:3,5	1,2:1	97,3	5154,6

21	30	50	1:3,5	1,2:1	98,7	4101,4
Upon receipt of sodium nitrite						
22	20	25	1:2,5	1:1	90,4	1243,5
23	20	25	1:3,5	1:1	91,3	5250,5
24	20	25	1:5,0	1:1	91,1	9401,2
25	20	40	1:2,5	1:1	91,0	1010,41
26	20	40	1:3,5	1:1	93,0	5091,56
27	20	40	1:5,0	1:1	91,4	9173,51
28	20	50	1:2,5	1:1	94,2	1001,4
29	20	50	1:3,5	1:1	95,7	4040,5
30	20	50	1:5,0	1:1	93,4	8121,4
31	30	25	1:3,5	1:1	93,5	5360,4
32	30	40	1:3,5	1:1	95,4	5144,5
33	30	50	1:3,5	1:1	96,7	5034,4
34	40	25	1:3,5	1:1	92,4	5460,4
35	40	40	1:3,5	1:1	93,6	5250,6
36	40	50	1:3,5	1:1	95,6	5170,6
37	30	25	1:3,5	1,1:1	95,7	5361,3
38	30	40	1:3,5	1,1:1	96,5	5149,1
39	30	50	1:3,5	1,1:1	98,5	5240,1
40	30	25	1:3,5	1,2:1	95,8	5364,4
41	30	40	1:3,5	1,2:1	97,5	5155,9
42	30	50	1:3,5	1,2:1	98,9	5250,1

When the concentration of the circulating solution of sodium nitrite is 25.0-40.0% and the ratio T: W = 1: 2.5, the degree of conversion reaches 91.0% i.e. with an increase in the concentration of the $NaNO_2$ recycled solution from 25.0% to 40.0%, the degree of conversion remains practically unchanged (90.4% and 91.0%, respectively).

Therefore, the research results show that the optimal concentration of the circulating solution of sodium nitrate and sodium nitrite is 40-50%, and the optimal ratio T: W = 1: 2.5 ÷ 1: 3.5.

In the studies cited, a number of different suspension filtration parameters were studied obtained by the conversion of calcium nitrate and calcium nitrite with sodium sulfate [3, 4].

Experimental data show that with an increase in the ratio T: W and the concentration of the circulating solution, the time of the first filtration increases.

So, at concentrations of a circulating solution of sodium nitrite 25.0; 40.0; the ratio T: W = 1: 2.5, the time of the first filtration is 8 and 10, sec, respectively, i.e. with an increase in the concentration of the circulating solution from 25.0 to 40.0%, the time of the first filtration increases by 20%. When the ratio T: W = 1: 2.5 and the concentration of the circulating solution of sodium nitrate 25 and 40%, the time of the first filtration is 9 and 11 seconds, respectively.

With the ratio T: W = 1: 3.5, the time of the first filtration is 10 and 13 sec, respectively, i.e. compared with a 25.0% concentration of the circulating solution for a concentration of 40.0%, the time of the first filtration increases by 23 and 100%.

With the ratio T: W = 1: 5, the time of the first filtration is 14 and 19 sec, respectively, i.e. Compared with a 25% concentration of NaNO2 working solution for a concentration of 40.0, the time of the first filtration increases by 26%.

Similar results were obtained by filtering pulp with gypsum deposits in the case of conversion to calcium nitrates. With the ratio T: W = 1: 3.5, the time of the first filtration was 12 and 15 seconds, respectively, for the concentration of the NaNO3 working solution of 25 and 40%. With a ratio of T: W = 1: 5, this indicator was 15 and 20 seconds.

An increase in the filtration time with an increase in the concentration of the circulating solutions of sodium nitrate and sodium nitrite is explained by the fact that with an increase in the concentration the viscosity of the solution increases, and this slows down the filtration. A similar explanation can be given for the case of reducing the ratio T: G.

When analyzing the data of the second filtration time, we can conclude that, in general, the time of the second filtration exceeds the time of the first filtration. This can be explained by the fact that the second filtration occurs through the sediment layer on the filter and therefore the filtration is slowed down. Here, as in the case of the first filtration, an increase in the filtration time is observed with an increase in the concentration of the circulating solution of sodium nitrate and a decrease in the ratio T: G.

When the concentration of the circulating solution of sodium nitrite is 25.0 and 39.53% with a ratio of T: W = 1: 2.5, the time of the second filtration is 12 and 17 sec, respectively, i.e. Compared to increasing the concentration of the circulating solution from 25 to 40.0%, the time of the second filtration increases by 29.4%.

With the ratio T: L = 1: 3.5, the time of the second filtration is 15 and 19 sec, respectively, i.e. compared with a 25.0% concentration of $NaNO_2$ working solution for a concentration of 40.0%, the second filtration time increases by 21.05%.

With the ratio T: L = 1: 5, the time of the second filtration is 21 and 27 sec, respectively, i.e. Compared with a 25.0% concentration of NaNO2 working solution for a concentration of 39.53%, the second filtration time increases by 22.2%.

When studying the filtration of a suspension obtained by the conversion of calcium nitrate with sodium sulfate, with a ratio of T: W = 1: 2.5 and a concentration of NaNO3 working solution of 25 and 40%, the second filtration time was 14 and 18 seconds. At T: W = 1: 3.5 and 1: 5 at the above concentrations of the NaNO3 working solution, the second filtration time was 16, 20 and 19, 28 seconds, respectively.

During the experiments, the masses of the first and second filtrates were measured. The results show that, as in the case of filtration time, the mass of the first filtrate increases with increasing concentration of the circulating sodium nitrite solution. At NaNO2 circulating solution concentrations of 25.0%; 40.0% ratio of T: W = 1: 2.5; the mass of the first filtrate, respectively, is 20.9; 26.5; those. compared with an increase in the concentration of the circulating solution, the mass of the first filtrate increases by 22.6%.

At NaNO2 circulating solution concentrations of 25.0; 40.0%, and the ratio T: W = 1: 3.5; the mass of the first filtrate, respectively, is 56.4; 60.0; compared with an increase in the concentration of the circulating solution, the mass of the first filtrate increases by 6.0%.

At a concentration of a circulating solution of 25.0; 40.0%, and the ratio of T: W = 1: 5, the mass of the first filtrate, respectively, is 107.5; 114.1 i.e. the mass of the first filtrate increases accordingly by 5.8%.

In the case of the second filtrate, although the same pattern is observed as with the first filtrate, the mass changes are less significant.

A comparison of the densities shows that the density of the second filtrate is lower than that of the first filtrate, because the second filtrate was obtained after washing the precipitate with pure water [3-4].

Fluctuations in the densities of the first filtrate were observed in the range 1.25-1.40 g / cm3, and the second filtrate in the range 1.07-1.15 g / cm3.

After the first washing, the sediment contained nitrogen in the range of 2.5–4.7%, which explains the need for a second washing of the precipitate.

After the second washing of the sediments, practically no nitrogen content was found in them.

The moisture content of the precipitation after filtration when receiving sodium nitrite was in the range of 35-65%, and when receiving sodium nitrate - 45-61%.

The data obtained show that with a decrease in the concentration of circulating solutions of sodium nitrate and sodium nitrite and with an increase in the ratio of solid and liquid phases from 1: 2.5 to 1: 3.5, the filtration rate of pulp with gypsum deposits increases.

At a concentration of 40% and 50% NaNO3 working solutions and a ratio of T: W = 1: 2.5, the filtration rate of pulp with gypsum sediments is 1003.5 and 820.1 kg / m2. hour. With a ratio of T: W = 1: 3.5; 1: 5 and the concentration of NaNO3 working solutions of 40 and 50%, the filtration rate varies, respectively, between 5006.4 □ 3520.2 and 9086.3 7451.6 kg / m2.h.

With the ratio of T: W = 1: 2.5; 1: 3; 1: 5 and the concentration of the circulating solution of sodium nitrite 40.0%, the filtration rate is 1010.41, respectively; 5091.56; 91,273.51 kg / m2.h. those. led to an increase in filtration rate by 44.6%.

A decrease in the filtration rate with increasing concentration is explained by an increase in the viscosity of the solution, which affects its filterability.

With a ratio of T: L = 1: 3.5 and 1: 5, a decrease in the filtration rate with an increase in the concentration of the liquid phase does not occur as sharply as with a ratio of T: L = 1: 2.5, which is also explained by the deterioration of filterability with an increase in the amount of the solid phase.

Thus, as a result of the above studies, the following optimal technological parameters of the process of conversion of calcium nitrite to sodium sulfate were identified: temperature - 25-300C, the concentration of the circulating solution of nitrite and sodium nitrate 40 - 50.0%.

It was also found that conversion pulps have a good filterability.

To control technological processes for the production of sodium nitrite and nitrate, it is necessary to study the density and viscosity of their solutions [5-6].

In this regard, aqueous nitrite and sodium nitrate solutions with a concentration of 20, 30 and 40% were prepared from the products of the conversion of sodium sulfate by nitrite and calcium nitrate. The concentrations of these solutions were taken within the limits close to the production conditions.

Determination of the density of the solution at 20, 40 600C was carried out according to the generally accepted method using a hydrometer.

In fig. 1. and tab. 2 presents experimental data on determining the density of aqueous solutions of nitrite and sodium nitrate depending on concentration and temperature.

The experimental results showed that with an increase in the concentration of solutions of nitrite and sodium nitrate, the density value increases. With increasing temperature, on the contrary, a decrease in the density of solutions is observed.

At a temperature of 200C, the density of solutions of sodium nitrate with a concentration of 20, 30 and 40% is 1144.5, 1186.3 and 1256.1 kg / m3, respectively. an increase in density relative to a 20% concentration is 4% and 10%, respectively, for a 30 and 40% concentration of solutions. At a temperature of 400C, the density values for the studied concentration of sodium nitrate solutions were 1124.2, respectively; 1167.9 and 1237.7 kg / m3. An increase in density relative to a 20% concentration is 3.7 and 92%, respectively.

For a temperature of 600 ° C, the density of the solutions was 1116.1; 1149.6 and 1229.5 kg / m3. The increase in density relative to a 20% concentration of sodium nitrate was 3.0 and 9.3%, respectively.

Thus, for 30 and 40% solutions, relative to a 20% increase in density in the range of 20-600C, approximately the same intensity occurs and for a 30% solution it is 2.4 - 5.0%, and for a 40% solution - 8.0 - 9.3%

Table 2: The value of the density of solutions of sodium nitrate depending on temperature and concentration.

The concentration of solutions of sodium nitrate%	Density of solutions (kg / m3) at temperature, 0C		
	20	40	60
20	1144,5	1124,2	1116,1
30	1186,3	1167,9	1149,6
40	1256,1	1237,7	1229,5

The dependence of the density of sodium nitrite solutions on temperature and concentration is of a similar nature. With an increase in the concentration of NaNO2 from 20 to 30 and from 30 to 40%, the density of solutions at 200 °C increases, however, 3.65 and 9.75%. At 40 and 600 °C, an increase in the density of 30 and 40% NaNO2 solutions compared to a 20% solution is 3.9 - 10.1 and 3.0 - 10.2%, respectively.

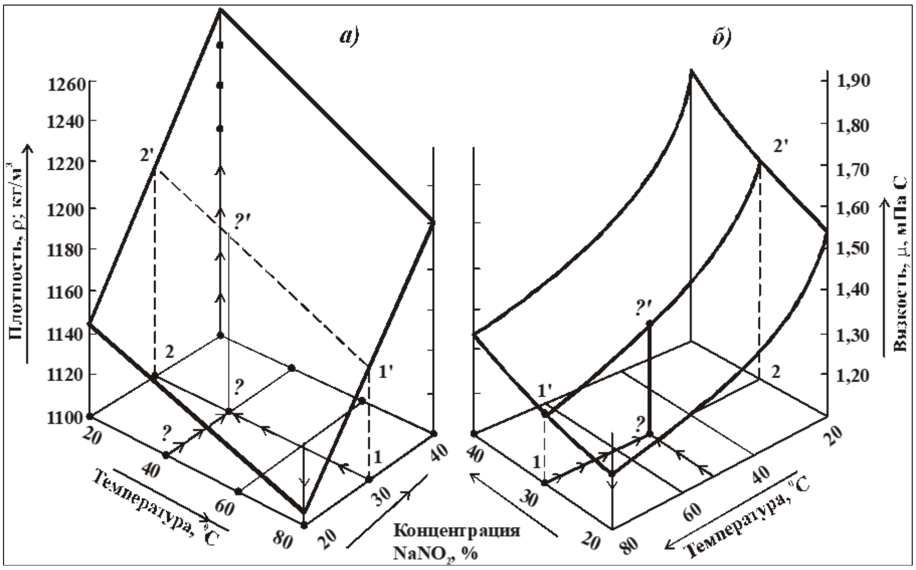

Fig 1: The dependence of the density (a) and viscosity (b) of sodium nitrite solutions on temperature and its concentration.

Data on the determination of the viscosity of solutions are presented in Fig.3.

For all concentrations of aqueous solutions of nitrite and sodium nitrate, a uniform decrease in viscosity is observed with increasing temperature in the range of 20-600C, which is in the range of 16.7 - 19.9%.

An increase in the concentration of solutions of nitrite and sodium nitrate leads to an increase in viscosity in the temperature range of 20-600C.

For a 20% solution of sodium nitrite at 200 °C, the viscosity is 1.66 mm2 / s, for a 30% solution -1.73 m2 / s, for a 40% solution 1.80; in comparison with a 20% solution, an increase in the viscosity of a 30 and 40% solution at a temperature of 200 °C is 0.07 and 0.14 mm2 / s, respectively. 3.6 and 7.2%.

An increase in viscosity with an increase in the concentration of sodium nitrite solution at a temperature of 400C is 0.07 and 0.12 mm2 / s, i.e. 5% and 9.0%. At a temperature of 600C, the increase in viscosity was 0.08 and 0.14 i.e. 5.5 and 14.7%.

3. Conclusion

Thus, an increase in temperature from 20 to 600 °C increases the viscosity of a 30 and 40% sodium nitrite solution compared with a 20% solution by 3.6 ÷ 5.5% and 7.2 ÷ 14.7%, respectively, and for 40% solution there is a sharper increase in viscosity at a temperature of 600C compared with a 30% solution (from 7.2 to 14.7%).

Table 3: The viscosity of sodium nitrate solutions as a function of temperature and concentration.

The concentration of sodium nitrate solutions,%	**Viscosity of solutions (mm2 / s) at temperature, ^{0}C**		
	20	40	60
20	1,59	1,33	1,28
30	1,68	1,40	1,36
40	1,75	1,45	1,42

For solutions of sodium nitrate at 200 °C, an increase in the concentration of solutions from 20 to 30 and 40% causes an increase in the viscosity of solutions by 5.7 and 10.0%, respectively. At 40 - 600C, an increase in the concentration of NaNO3 solutions in the above ranges leads to an increase in viscosity values in the range of 5.3 - 9.0 and 6.2 - 10.9%.

The volumetric graphical representation of the experimental results (Fig. 1.) allows one to fairly accurately and quickly determine (input and output parameters) ρ and η solutions in all ranges of the studied concentration and temperature by means of a graphical interpretation [7, 8].

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