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STUDY OF THE PROCESS OF HYDROXIDE ELECTROLYSIS POTASSIUM IN A MEMBRANE LABORATORY ELECTROLYSER

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Abstract

The article discusses the dependence of the product yield on temperature and current density in the process carried out in an electrolyzer with horizontally installed electrodes in a closed flow mode. In order to prevent side processes, oxide-ruthenium titanium anodes (ORTA) are used in the installation. The article also provides factors affecting the formation of potassium hydroxide. For the experiments, potassium chloride solutions prepared from purified potash fertilizer produced at JSC "Dekhkanabad Potash Plant" natural source materials were used.

Keywords: *potassium chloride, potassium hydroxide, mineral fertilizer, electrolysis unit, ion exchange membrane, ruthenium oxide titanium anodes, free active chlorine*

Introduction

During the electrolysis of aqueous solutions of alkaline earth metal chlorides, many substances are formed, of which the most important are gaseous hydrogen and free active chlorine, as well as hydroxides and hypochlorites, chlorates, and perchlorates of these metals. And during the electrolysis of sodium and potassium melts, metallic sodium and potassium can be obtained.

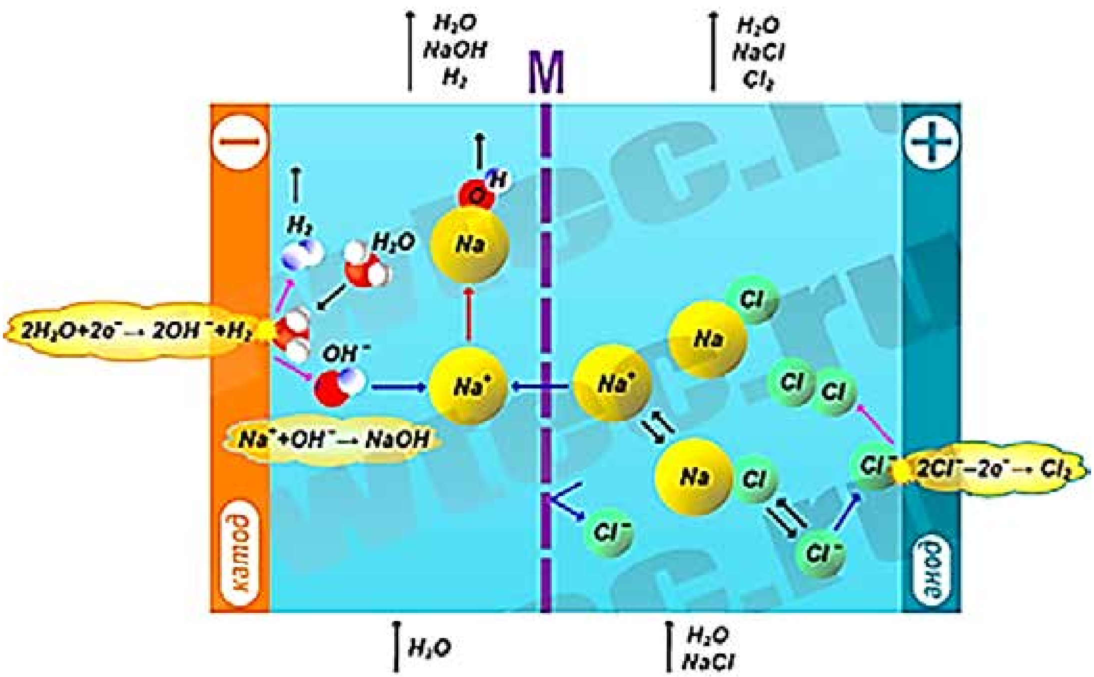
By organizing all the methods of electrolysis of these salts, it is possible to obtain the following types of chemical substances: gaseous chlorine and hydrogen, combining them and dissolving them in water – hydrochloric acid, metallic sodium and potassium, sodium and potassium hydroxides, hypochlorites, chlorates and perchlorates of both metals, a total of 13. This constitutes a significant part of the output of products of the entire chemical industry of Uzbekistan.

Uzbekistan is one of the countries where the subsoil is rich in minerals in the form of sylvinite. The mineral sylvinite mainly consists of sodium and potassium chlorides.

Caustic soda in Uzbekistan is obtained by electrolysis of an aqueous solution of table salt using a membrane method. Potassium hydroxide can be obtained from a purified aqueous solution of potassium chloride using the same method. In industrial conditions, potassium hydroxide is synthesized from an aqueous solution of potassium chloride using solid cathode, liquid mercury (mercury production method) and membrane methods in electrolysis units.

In membrane electrolysis, potassium cations, under the influence of an electric field, pass from the potassium chloride anode part of the electrolyzer through the ion-exchange membrane into the cathode hydroxide zone of the electrolyzer, where they combine with hydroxyl anions to form potassium hydroxide (Fig. 1). In this method, wastewater is returned back to the process, and a waste-free technology is created.

Figure 1. *Scheme of electrolysis of an aqueous solution of sodium chloride through a membrane*



Methods and materials

The mineral fertilizer of Dekhkanabad potash plant containing 90% potassium chloride (45% K and 45% Cl, see Table 1) and other substances was used for the study. The composition of the original mineral fertilizer was analyzed using the device “High-performance energy-dispersive X-ray fluorescence spectrometer – Japan, Rigaku NEX CG EDXRF Analyzer with Polarization in set – 9022 19000 0” (Fig. 2). The process temperature was measured using mercury glass laboratory thermometers manufactured according to GOST 215–73. The GUNT Geratebau GmbH CE – 105 unit of German manufacture was used as a DC power source. Hydrogen indicators of the obtained products were measured using a Bante 210 pH meter.

The concentration of solutions before and after the process was determined by density at 15 °C and by a chemical method (Kodirov K. Y., Adilova M. Sh., Rakhmatov H. B., Erkaev A. U., 2014; Ibragimov G. I., Erkaev A. U., Yakubov R.Ya., Turobzhonov S. M., 2010; Chavlieva F. B., Kucharov B.Kh., Erkaev A. U., Turakulov B. B., Toirov Z. K., 2023; Chavlieva F. B., Turakulov B. B., Erkaev A. U., Kucharov B.Kh., Koshanova B. T., Dzhandullaeva M. S., Reimov A. M., 2023).

Results and discussion

The mineralogical composition of the raw material is given below.

Table 1. *Elemental composition of the original mineral fertilizer, %*

No.	1	2	3	4	5	6	7	8
Elements	Cl	Br	S	K	Ca	You	Fe	Cu
Result	45.0	0.058	0.34	45.0	0.5	0.0023	0.0257	0,0016
No.	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Elements	Rb	Sr	Y	Zr	Sn	Te	Fr	Dy
Result	0.009	0.0014	0.0005	0.175	0.003	0,0017	0.0074	0.0037

Figure 2. *Mineralogical composition of the raw material*

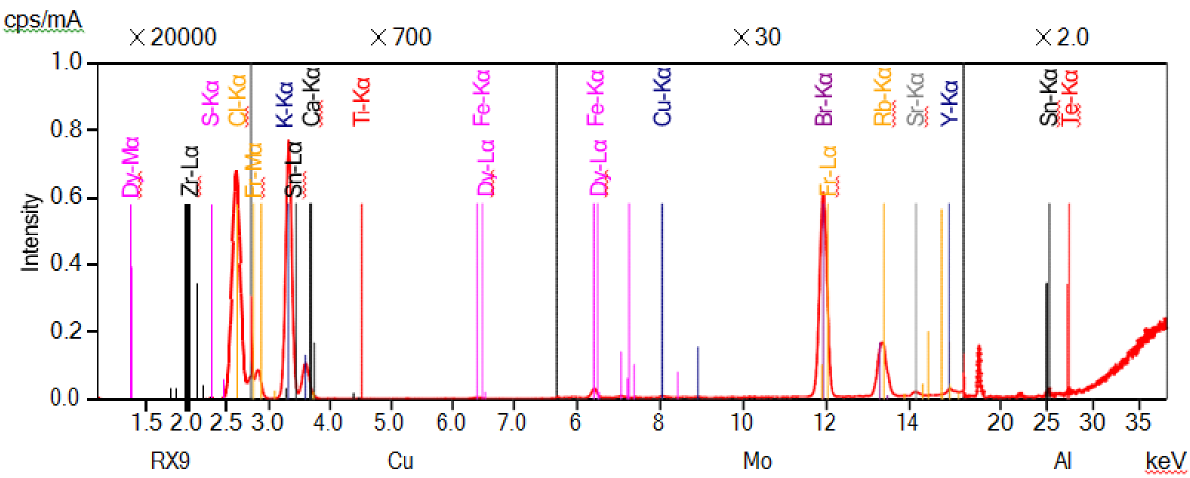
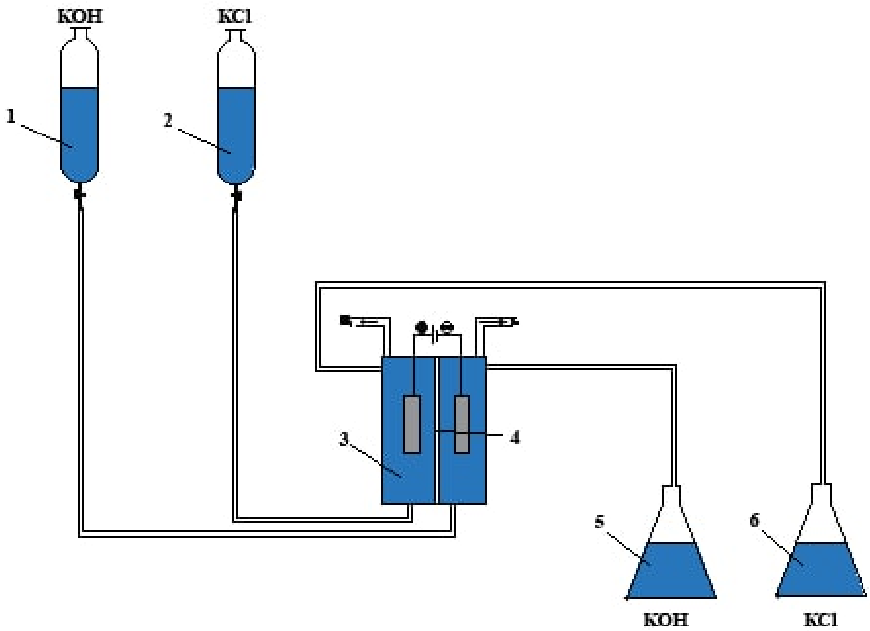


Figure 3. *Laboratory setup of the electrolyzer. 1, 2 – separatory funnels for feeding KOH and KCl respectively; 3 – electrolyzer; 4 – ion exchange membrane; 5, 6 – receiving flasks for KOH and KCl*



To conduct the research experiments, a laboratory electrolysis flow installation with an ion-exchange membrane was assembled. A sheet of stainless steel grade AISI304 (08X18H10) was used as the cathode, and a mesh ORTA anode with an area of 1 dm^2 was used for the anode. The distance between the electrodes was set at 0.16 dm. For the gravity feed of the initial solutions of potassium chloride and potassium hydroxide, two separatory funnels with a volume of 1 liter were used and connected to the installation using a heat-resistant transparent hose and installed 50 sm above the installation. To receive the reaction products, the outlet of the installation was connected using hoses to two flasks, which were installed 50 sm below the installation.

In this paper, the influence of electrolyte temperature and operating current density on the yield of potassium hydroxide during the process in a membrane electrolyzer was studied (Fig. 3).

During electrolysis, the current density varied in the range of 1.0–5.5 A/dm². Electrolysis was carried out under the following conditions: at a temperature of 60 °C, a duration of 40 minutes and a potassium chloride concentration of 30%. The obtained data are presented in Table 1. The output parameter is the concentration of hydrogen ions in the anolyte and catholyte solutions. The initial concentration of the KOH solution entering the electrolyzer is 28.488%.

Table 2. *Dependence of product yield on current density with a process duration of 40 min. and a KOH concentration of 30%*

No.	Density of KOH at 15 °C, ρ, g/sm³		Concentration of KOH after electrolysis, %	Current density, A/dm²	Increase in concentration KOH, % KOH catalyte	pH of solutions after electrolysis	
	before electrolysis	after electrolysis				KOH catalyte	Anolyte KCl
1.	1.267	1.273	29.098	1	0.61	14.48	2.35
2.		1.275	29.258	2	0.77	14.43	2.35
3.		1.277	29.468	3	0.98	14.43	2.35
4.		1.278	29.588	4	1.10	14.43	2.75
5.		1.279	29.748	5	1.26	14.50	2.91
6.		1.280	29.828	5.5	1.34	14.41	3.75

To find the optimal temperature, the experiments were carried out by changing the temperature from 30 to 90 °C. The experiments were carried out for 40 minutes and with a potassium chloride concentration of 30%. The concentration of the initial KOH solution entering the electrolyzer was maintained at 28.488%. The current density during electrolysis was set at 5 A/dm².

Table 3. *Dependence of product yield on process temperature for a process duration of 40 minutes and a KOH concentration of 30%*

No.	Density of KOH at 15 °C, ρ, g/sm³		Concentration of KOH after electrolysis, %	Process temperature °C	Increase in concentration KOH, % KOH catalyte	pH of solutions after electrolysis	
	before electrolysis	after electrolysis				KOH catalyte	Anolyte KCl
1.	1.267	1.273	29.488	30	1.10	14.48	2.35
2.		1.275	29.538	35	1.26	14.43	2.35
3.		1.277	29.628	40	1.34	14.43	2.35
4.		1.279	29.688	45	1.10	14.43	2.75
5.		1.280	29.748	50	1.26	14.50	2.91
6.		1.281	29.828	55	1.34	14.41	3.75
7.		1.282	29.958	60	1.44	14.45	2.85
8.		1.286	30.008	65	1.52	14.42	2.81

No.	Density of KOH at 15 °C, ρ, g/sm³		Concentration of KOH after electrolysis, %	Process temperature °C	Increase in concentration KOH, % KOH catalyte	pH of solutions after electrolysis	
	before electrolysis	after electrolysis				KOH catalyte	Anolyte KCl
9.		1.297	30.128	70	1.64	14.48	2.97
10.		1.308	30.218	75	1.73	14.45	2.87
11.		1.317	30.268	80	1.78	14.49	2.90
12.		1.328	30.348	90	1.86	14.48	2.88

Conclusion

According to the data obtained from Table No. 1, it is evident that with an increase in the process current density, the concentration of the resulting potassium hydroxide in the solution increases. The product increase is accordingly from 0.61 to 1.34% with a working current density range from 1 to 5.5 A/dm².

According to the data obtained from Table No. 2, it is evident that with an increase in the process temperature, the concentration of the obtained potassium hydroxide in the solution increases. The product increase is accordingly from 1.10 to 1.86% at a temperature range from 30 to 90°C.

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