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Қ. И. Сәтпаев атындағы Қазақ ұлттық техникалық зерттеу университеті

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ИЗВЕСТИЯ

НАЦИОНАЛЬНОЙ АКАДЕМИИ НАУК
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Қазақстан Республикасы Ұлттық ғылым академиясы "ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы" ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Webof Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.

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SORPTION METHODS OF PROCESSINGOF HYDROMINERAL LITHIUM RAW MATERIAL OF KAZAKHSTAN

Abstract. In the contemporary world of high technologies lithium (Li) is a key component. Kazakhstan has the required potential for its production. The most attractive raw materials for lithium extraction are natural and saline lake brines. Investigation and search of new technological solutions with the purpose of inclusion thereof in the sphere of lithium-containing hydromineral raw material processing is an important and relevant scientific and technical task. This article provides analysis of the literature data on lithium sorption by organic resins and inorganic sorbents. Generally, cation exchange resins, both in protonated and sodium forms, are mostly used for lithium sorption. They include widespread cationite KU-2-8 or its equivalents. In the investigations on lithium sorption extraction from lithium-containing solutions from amongst of inorganic sorbents mainly manganese, titanium and aluminum based compounds are used. For the static lithium extraction from natural brines we performed sorption using ion-exchange resins: CU-2-8, Purolite C100, Purolite C160S, Purolite S940, Amberlite IR 120, CYBBER CRX 210, and CYBBER CRX 300. It was demonstrated that almost no lithium is sorbed on ionites. Insignificant amount of lithium was extracted on sulphocationite CU-2-8 and made up 0.49%. Investigations were made on natural brines processing using inorganic sorbents (in the form of commercial reagents): aluminum hydroxide, titanium and manganese oxides, and activated carbon. Besides, such inorganic sorbents as aluminum hydroxide, hydrated titanium and manganese oxides were synthesized. It was established that the highest rates were achieved when aluminum hydroxide was used as sorbent, at that lithium extraction made up 21.87%, and on synthesized sorbent – hydrated manganese oxide, where Li extraction reached 20.11%. For lithium extraction from brines inorganic sorbents were chosen as the sorption method using aluminum and/or manganese compounds as sorbents.

Key words: lithium, natural brines, sorption, ion exchange resins, inorganic sorbents, synthesis, extraction.

Introduction. Lithium legitimately can be called the most important element of the modern civilization and technology development. Many lithium compounds and metal itself have become of utmost economic and strategic importance, which resulted in a stable and steady growth of lithium and lithium products output. As forecasted by Goldman Sachs, the lithium demand may triple by 2025 to 570,000 t due to the stable demand by smartphone and electromobile manufacturers. Lithium is already branded "white oil" as Tesla and other automobile companies use it for the manufacture of lithium-ion accumulators. Apart from the accumulators, nowadays it is widely used in the production of glass and ceramics (30%), lubricating materials (11%), metallurgy (4%), as well as in the production of chemicals, pharmaceuticals, rubber, and others [1]. The established global high demand for this metal forces to search new potential sources of its production.

The main sources for lithium production globally are ores, salt lake brines, and a secondary source – dead lithium batteries. Basic studies are currently aimed at development of the efficient technologies of lithium extraction from the said types of raw materials.

For lithium extraction from ores and minerals they use roasting with subsequent leaching, and its extraction from brines includes operations of preconcentration, in other words evaporation, precipitation, adsorption, and ion exchange [2]. For lithium extraction from dead lithium batteries they use leaching with subsequent precipitation, sorption or liquid extraction, electrolysis [3].

Ore processing, especially spodumene, is the most expensive if compared to lithium extraction from brines due to the necessity to use mines, energy consuming preliminary preparation of the ore raw material, and application of the high-temperature opening and subsequent leaching. That is why many spodumene deposits are not producing and not processed now.

Lithium is also present in sea water, but its concentration is too low – about 0.1-0.2 mg/l [4] to be cost-effective. The total amount of metal lithium in sea water (globally) is estimated at ~230 Ht. However, due to the low original concentrations it cannot be considered as a real source of lithium.

Brine sources include lithium detected in the salt water deposits – saline lakes, salt mines, oil field brines, and geothermal brines. Oil brines, which on an industrial scale contain many valuable components, including lithium [5-9], represent subsurface brine reservoirs located with oil. Geothermal brines represent subsurface biologically heated brines, for example, in the Salton Sea, California. Subsurface brines containing lithium make up 66% of global lithium resources and become a dominating raw material for Li_2CO_3 all over the world due to the lower costs compared to production of lithium carbonate of hard ore [10, 11].

While processing hydromineral lithium raw material they use such methods as evaporation and precipitation, offering schemes with the use of extraction, sorption [12-15] and electrolysis [9] processes. This paper describes lithium extraction and concentration methods at natural brines processing using ion-exchange resins and inorganic sorbents.

In the paper [12] for lithium extraction they used resins of nomenclature LSC-100, LSC-500, and D001 with fixed ions–$N(CH_2COO^{-})_2$, $–NHCH_2PO^{2-}$, and $–SO_3$, accordingly. It is demonstrated that resins LSC-100 and LSC-500 had higher selectivity for lithium extraction with adsorption capacity ≥ 5.5 mmole/g as compared to other alkali metal ions, following the extraction sequence: $Li^+ >> K^+ \sim Rb^+ \sim Cs^+$ and $Li^+ >> K^+ > Rb^+ \sim Cs^+$, accordingly. The authors explain [12] that strong ligands LSC-100 and LSC-500 are prone to strong complex formation with lithium than any other alkali metals. To the contrary, at sorption with resin D001 there was an inverse extraction trend, where first Cs and later lithium were adsorbed. In the paper [13] for lithium adsorption from synthetic chloride solution they used resin Amberlite IR 120 in sodium and hydrogen forms. The results demonstrated that ion exchange between Li^+ and Na^+ is more favourable if compared to the protonated form. In the ion-exchange method of lithium separation from other alkali metals they use sorption of metal ions on the column filled with cationite CU-2 in N-form and subsequent elution with acid solutions [14]. Lithium ions sorbed on sulphocationite CU-2 with 20% divinylbenzene are the least tightly bonded, desorb at lower saline acid concentration, and elute before ions of Na, K, Rb, and Cs. Sulphocationite KU-2-8, as is known, is an analogue of Amberlite IR 120.

The paper [15] describes studies, where for the selective lithium adsorption they used strongly basic (Dowex MSA-I) and weakly basic (Dowex MWA-l) anion exchangers. Before the contact with the original solution an active chloride form of Dowex MWA-l was transferred to the hydroxide form, while at the time of using Dowex MSA-I change of the active chloride form was not obligatory. Since during the work with Dowex MSA-I the active chloride form of resins was exchanged with $AlCl_3$ by treatment with a saturated aluminum chloride solution. Thereafter, by the ammonia solution treatment they transferred $AlCl_3$ to the form of $Al(OH)_3$, which contacts with brine containing LiCl at pH> 6. Using NaOH instead of solution NH_4OH had an unfavourable effect at resins hydroxylation, since it caused formation of alkali aluminates, which elute $AlCl_3$ of modified resins. Lithium chloride LiCl was extracted from brine into modified resin as a complex of lithium halogenide with aluminate. Lithium eluting from saturated resin was made using hot water.

There are known methods of lithium extraction by sorption from sea water and brines using different types of adsorbents: inorganic ion exchangers, such as spinel-type manganese oxide, of the aluminum compound demonstrate extremely high selectivity for lithium extraction from sea water [16-19]. Such materials have high adsorption capacity; in alkali media (pH ~8) lithium had concentration 400 times higher.

Studies [20] on lithium adsorption on different titanium oxides demonstrated that the structure of Li_2TiO_3 obtained from anatase turned out to be more suitable for lithium extraction than that obtained from rutile. In the paper [21] for lithium adsorption they use activated carbon as an adsorbent.

Lithium adsorption using aluminum salt as an adsorbent ($AlCl_3 \cdot 6H_2O$) was performed at the temperatures of 10 to 30°C. The temperature above 30°C did not have any effect on lithium sorption on $Al(OH)_3$, which proved that the process is taking place through physical adsorption [22]. The maximum adsorption capacity at pH 9 made up 123 mg/g.

Sorbents obtained on the basis of double compounds of aluminum and lithium $LiCl \cdot 2Al(OH)_3 \cdot mH_2O$ and stable in brines with low pH level have high rates [23-26]. A distinctive feature of the suggested sorbent is its selectivity, since lithium cannot be replaced by any other element in this compound.

Thus, publications analysis has shown that the problem of lithium extraction from natural brines is relevant. It should be noted that studies are mostly performed at the laboratory level.

The purpose of our work is to choose the most effective sorption method of lithium extraction in the process of natural brine processing in the static conditions using either ion-exchange resins or inorganic sorbents.

Research methodology.

Reagents: saline acid HCl high grade, GOST 3118-77; sodium hydroxide NaOH high grade, GOST 4328-77; aqueous ammonia NH_4OH ultrahigh purity, GOST 24147-80; carbon dioxide in cylinders with 100% concentration; crystalline sodium thiosulfate $Na_2S_2O_3 \cdot 5H_2O$, analytic grade, GOST 27068-86; potassium hypermanganate 0.1 N, titration standard, TU 6-09-2540-72; aluminum hydroxide $Al(OH)_3$ analytic grade, GOST 11841-76; manganese dioxide MnO_2 high purity, GOST 4470-79; titanium dioxide TiO_2 grade P-03, GOST **9808-84, and** activated carbon Goldcarb 207C (Altyntau-Kokshetau).

Ionite preparation. Cation exchange resins are produced by the industry in the sodium form. To perform the research cationites were preliminarily transferred to the hydrogen form. Ionite was cleaned from synthesis products and transferred to N-form using the saline acid solution [27]. A definite volume of each ionite previously swollen in distilled water was loaded into the glass columns. Then 5% solution of HCl was flowing through each column at a rate of 3 specific volumes per hour to equal acid concentration at entry and exit. Ionites were washed from acid using distilled water to pH = 6 - 7. Prepared ionites were dried at 50°C to the constant weight.

Sorbent preparation. For the sorbent synthesis they used a pressure tight thermostatically-controlled cell with the capacity of 2 dm^3 equipped with a mechanical stirrer 'OST basic' making a fixed number of rotations – 500 rpm. The constant temperature was maintained using a circulation bath LOIP LT-200. For the purpose of aluminate solution carbonization CO_2 was fed through the flowmeter from the cylinders to the distributor placed in the cell. The mixture of titanium dioxide and sodium hydroxide powders was matured in a muffle furnace type SNOL 7.2/1300 for 1 h at 650°C. Synthesized sorbents were washed with distilled water to pH=6 – 7 and dried at 105°C to the constant weight.

Experimental method. Sorption was performed in static conditions at a temperature of 25±5°C. For the purpose of sorption using ion-exchange resins 1 g of each cationite in N-form were placed into the dry flasks with the capacity of 0.5 dm^3, 0.2 dm^3 of brine was added, and it was placed onto the mixer. Cationites contact with brine was maintained for 28 days.

For the purpose of sorption using inorganic sorbents 10 g of each sorbent were placed into the dry flasks for 2 dm^3, 1 dm^3 of brine was added, and it was placed onto the mixer. Sorbents contact with brine was maintained for 4 days. Solutions were separated from sorbents using vacuum filtration.

Analysis methods. Natural brines and solutions after sorption were analysed for lithium content. The quantitative content of lithium in the sorbent was determined based on the difference of their content in the original brine and solution after sorption.

Lithium determination was performed by the method of atomic-emission spectroscopy as per NSAM 320Г-90 using a double beam atomic-emission spectrometer Agilent 240FS/AA equipped with an automatic monochromator and control of slit width setting in the flame 'acetylene – air'. The X-ray phase analysis was made using a diffractometer D8 ADVANCE BRUKER AXS GmbH, (Germany) emission of Cu–K_α, data base PDF-2 of the International Center for Diffraction Data ICDD (USA).

Results and discussion. Static sorption was performed using natural brine composed of (g/dm^3): Na 30.49; Cl^- 58.2; Ca 5.37; Mg 1.29 and K 0.68. Concentration of Li was 8.24 mg/dm^3. pH of the source brine was 7.

Ion exchange method of lithium extraction from natural brines on synthetic sorbents. Characteristics of ionites used for studying lithium extraction from brines by sorption are shown in table 1.

Table 1 – Characteristics of Cationites

Ionite Name	Ionogenic Group	Physical Structure
CU-2-8	Sulfonic acid $–SO_3H$	Gel-like strong-acid ionite
Purolite C100	Sulfonic acid $–SO_3H$	Gel-like strong-acid ionite
Purolite C160S	Sulfonic acid $–SO_3H$	Macroporous strong-acid ionite
Purolite S940	Amino phosphonic acid $–NHCH_2PO(OH)_2$	Macroporous chelating ionite
Amberlite IR 120	Sulfonic acid $–SO_3H$	Gel-like strong-acid ionite
CYBBER CRX 210	Iminodiacetic acid $–CH_2N(CH_2COOH)_2$	Macroporous chelating ionite
CYBBER CRX 300	Aminomethylphosphonic acid $–NHCH_2PO(OH)_2$	Macroporous weak-acid ionite

As is clear from table 1, we used strong-acid, weak-acid and chelating cationites with a gel-like and macroporous structure as sorbents of the following functional groups: $–SO_3H$; $–NHCH_2PO(OH)_2$ and $–CH_2N(CH_2COOH)_2$. Ionites have varying selectivity with respect to lithium ion. Carbonaceous and phosphoric-acid cationites, i.e. Purolite S940, CYBBER CRX 210, and CYBBER CRX 300, are more preferable for lithium extraction from brines. However, testing ionites with sulphonic-acid group was of interest for getting fuller information and comparative evaluation. It was established that CU-2-8 was the only sulphocationite that resulted in minor lithium extraction of 0.49%. The sorption results might have been affected by such factors as medium pH, temperature, structure of the resins, and other. Therefore, sorption of lithium from natural brines using cation exchange resins is ineffective.

For lithium extraction from natural brines by sorption, inorganic sorbents can be used along with ion-exchange resins. Such inorganic sorbents as aluminum hydroxide, titanium and manganese oxides were synthesized provisionally for the study.

Synthesis of Aluminum Hydroxide $Al(OH)_3$. At the first stage, a commercial chemical reagent - aluminum hydroxide was leached using NaOH solution under the following conditions maintained: concentration of NaOH was 285 g/dm^3, the solid to liquid phase ratio was 1:3, temperature was 98°C, and duration was 5 hours. The produced filtered aluminate solution was carbonized with carbon dioxide. Carbonization was performed in polythermal regime with decrease of temperature from 70 to 60°C. Carbon dioxide was flowing through the entire solution volume for 6 hours with constant pulp stirring. Then precipitate of $Al(OH)_3$ was separated from the stock solution by filtering, elutriated and dried. The X-ray phase analysis of precipitate confirmed production of aluminum hydroxide represented by two phases: gibbsite and bayerite (figure 1).

Synthesis of Titanium Dioxide TiO_2. To produce hydrated titanium oxide, a mixture of powdered TiO_2 and NaOH was pestled in an agate mortar at a w/w proportion of 1:1.5. Then, the mixture was transferred to alundum pot and kept in a muffle furnace at 650°C for 1 hour to enable a reaction with production of the alloy Na_2TiO_3. After alloy cooling, we added HCl (1:1) in drops:

$$Na_2TiO_3 + 6HCl \rightarrow 2NaCl\downarrow + TiCl_4 + 3H_2O$$

SADX'HJGHLThen, after filtering, we added strong solution of ammonia NH_3 in drops tothe resulted filtrate, during the procedure white gas NH_4Cl evolved and hydrated titanium oxide was formed:

$$TiCl_4 + 3H_2O + 4NH_3 \rightarrow 4NH_4Cl\uparrow + TiO_2{\cdot}nH_2O$$

The X-ray phase analysis of obtained $TiO_2{\cdot}nH_2O$ after washing and drying showed that its major phases were hydrated acid oxide $Ti_4H_2O_9{\cdot}1.9H_2O$, anatase TiO_2 and brookite TiO_2.

Synthesis of Manganese Oxide MnO. To synthetize manganese oxide, we added 3.125% $Na_2S_2O_3$ solution to 0.1 N $KMnO_4$ solution slowly in drops while stirring. This allowed getting a dark-cherry precipitate from the solution. The X-ray phase analysis of the precipitate showed that its major phases were pyrochroite $MnO{\cdot}H_2O$ and hydrated manganese oxide $Mn_7O_{13}{\cdot}5H_2O$ (figure 2).

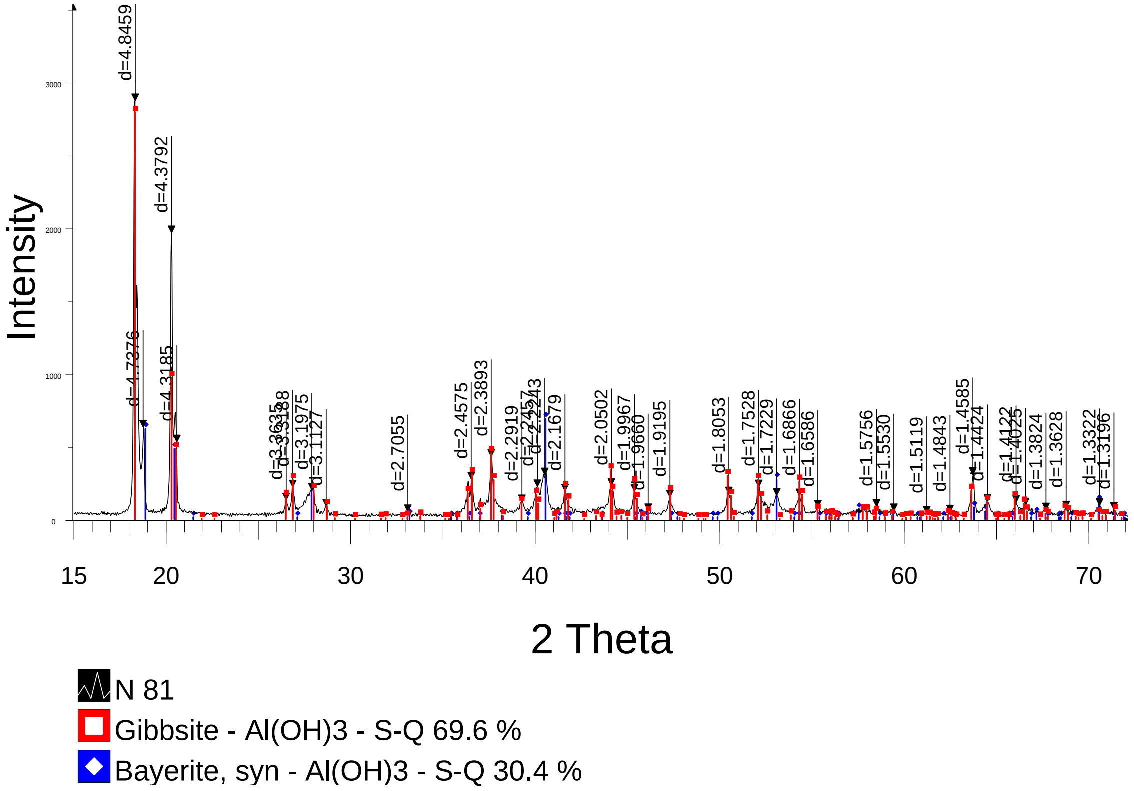

Figure 1 – Diffraction Pattern of Synthesized Aluminum Hydroxide

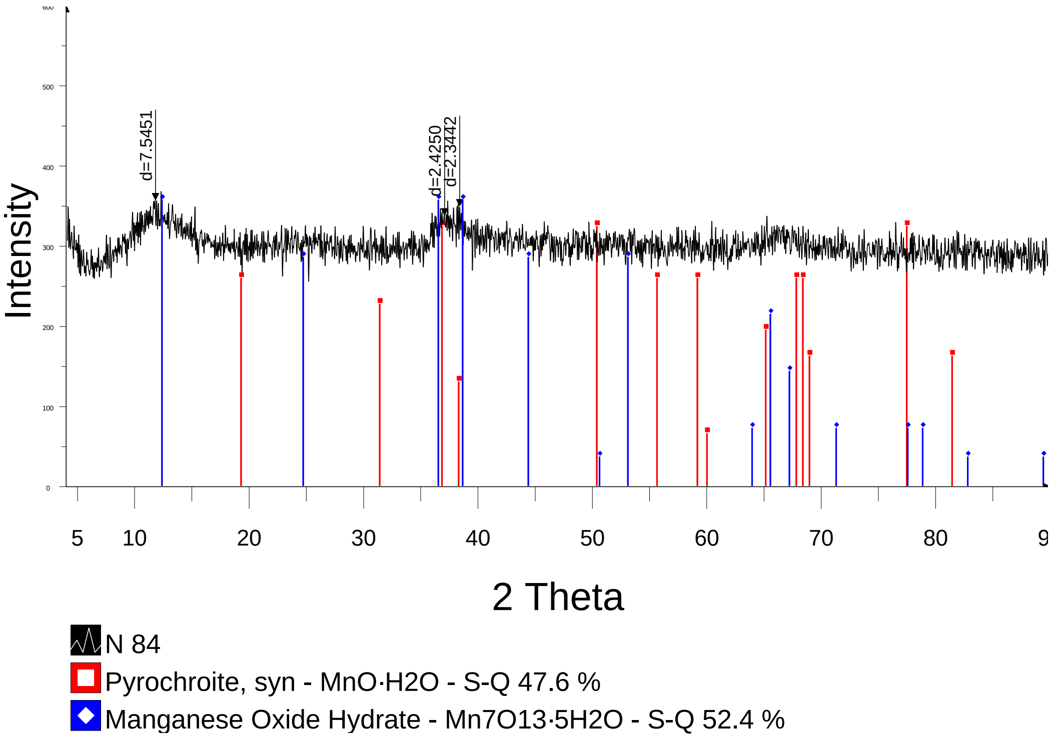

Figure 2 – Diffraction Pattern of Hydrated Manganese Oxide

Lithium Extraction from Natural Brines Using Inorganic Sorbents. Testingof the sorption method for processing brines was investigated using two types of inorganic sorbents: 1) commercial chemical reagents: aluminum hydroxide, titanium and manganese oxides, and activated carbon; 2) sorbents synthesized in laboratory settings. Results of the experiments are presented in table 2.

Table 2 – Sorption of Lithium from Natural Brines Using Inorganic Sorbents

Sorbent	Lithium extraction by sorbent, %	
	Commercial reagent	Synthesized sample
Aluminum hydroxide	21.87	9.13
Titanium oxide	–	–
Manganese oxide	7.85	20.11
Activated carbon	0.97	

As table 2 shows, the highest results of lithium sorption from brines were obtained with commercial aluminum hydroxide used as sorbent, the extraction rate made up 21.87%. The rate of lithium extraction from manganese oxide brine was lower and made up 7.85%. The rate of sorption by activated carbon made up merely 0.97%. Titanium oxide didn’t sorb lithium from brine.

The rate of lithium sorption from brines using synthesized sorbents - aluminum hydroxide and hydrated manganese oxide made up 9.13% and 20.11%, respectively. The lithium sorption rates decreased 2.4 times when synthesized aluminum hydroxide was used due to bayerite phase in the synthesized sorbent, according to the X-ray phase analysis results (figure 1). Commercial aluminum hydroxide was entirely represented by a gibbsite phase, which might have a favourable effect on the sorption results. When synthesized manganese oxide was used, the lithium sorption rates were higher than in the previous series of experiments. The phase composition of commercial manganese oxide also differed from the synthesized sorbent. It contained manganese oxide Mn_2O_3, manganese nsutite $Mn_{1.60}Mn_{0.32}O_{3.10}(OH)_{0.90}$ and hydrated manganese oxide $1.48MnO\cdot 0.15H_2O$. Another factor that might have an effect on the lithium sorption rates was different phase compositions of the sorbents. As the X-ray phase analysis showed, the initial compounds of inorganic sorbents have changed a little after they had been used for lithium sorption due to low rates of lithium sorbed.

Therefore, sorption with the use of inorganic sorbents such as commercial aluminum hydroxide and hydrated manganese oxide may be appropriate for lithium extraction from natural brines.

Conclusion. There is a growing interest to lithium all over the world. Currently, our country does not perform any systematic studies on lithium extraction. Therefore, Kazakhstan, which has lithium resources in natural and saline lake brines, should investigate its raw material sources and develop a technology for Li extraction from such sources. However, composition of natural brines in our country (with an average Li concentration being 0.007-0.012 g/dm^3) differs significantly from those in other countries (0.1 g/dm^3 Li and higher), and the existing technologies cannot be applied to our natural sources. That’s why to involve natural sources of Kazakhstan into the global lithium production new solutions must be found for the effective processing thereof.

It was established that sorption of lithium from natural brines using synthetized ion-exchange resins is ineffective. CU-2-8 was the only ionite resulted in a minor lithium extraction rate (0.49%).

The highest rates were achieved with a commercial reagent aluminum hydroxide (among inorganic sorbents) used as a sorbent (the lithium extraction rate made up 21.87%), and with a synthesized sorbent, hydrated manganese oxide, where the extraction rate reached 20.11%. Differences in the phase compositions of sorbents might have influenced the lithium sorption rates. That was a static sorption, i.e. a one-stage process. In practice, sorption is performed in dynamic conditions, which is more effective as the sorbent is continuously in contact with new portions of the solution flown through it. Therefore, dynamic sorption process may allow increasing the rates of lithium extraction on a sorbent from natural brines to 65-70%.

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ҚАЗАҚСТАННЫҢ ГИДРОМИНЕРАЛДЫ ЛИТИЙЛЫ ШИКІЗАТЫН СОРБЦИЯЛЫҚ ТӘСІЛДЕРІМЕН ҚАЙТА ӨҢДЕУЫ

Аннотация. Қазіргі әлемдегі жоғары технологиялар литий (Li) басты компоненті болып табылады. Оның өндірісі үшін Қазақстан қажетті әлеуетке ие. Литийді алу үшін ең тартымды шикізатары табиғи тұзды ертітінділер және тұзды көлдер рапы болып табылады. Құрамында литийі бар гидроминералды шикізатын қайта өңдеу саласында, үйлестіру кеңесінің шешімі мақсатында, жаңа технологиялық шешімдерді тарту, зерттеу және іздеу маңызды және өзекті ғылыми-техникалық міндет болып табылады. Мақалада органикалық шайырлармен және органикалық емес сорбенттермен литий сорбциясының әдеби деректер бойынша талдаулар жүргізілді. Әдетте, литийді сорбциялау үшін көбінесе катионоалмастырғыш шайырлары, протонды сияқты, сондай-ақ натрий нысандарында пайдаланылады. Олардың қатарына кіреді таралған катионит КУ-2-8 немесе оның аналогтары. Зерттеуде бейорганикалық сорбенттер қатарындағы, құрамында литийі бар ерітінділерден литийді сорбциямен алуы бойынша, көбінесе марганец, титан және алюминий қосылыстар негізінде пайдаланылады.Табиғи тұзды ертітінділерден біз литийді алу үшін, статикалық жағдайда, сорбциямен ионалмастырғыш шайырларды: КУ-2-8, С100 Purolite, Purolite C160S, Purolite S940, Amberlite IR 120, CYBBER CRX 210 және CYBBER CRX 300 қолдана отырып, жүргізілді. Көрсетілгендей, бұл литий, іс жүзінде ионитерге отырмайды. Шамалы литийді сульфокатионитте КУ-2-8 алуы, бар болғаны 0,49 % құрайды. Табиғи тұзды ертітінділерді қайта өңдеу бойынша, бейорганикалық сорбенттерді (коммерциялық реагенттер түрінде): алюминий гидроксидін, титан оксиді мен марганецті және белсендірілген көмірді қолдана отырып зерттеулер орындалды. Сонымен қатар, осындай бейорганикалық сорбенттер: алюминий гидроксиді, гидратталған титан оксиді және марганец синтезделген. Аса жоғары көрсеткіштер– коммерциялық реагент, алюминий гидроксидін сорбент ретінде пайдаланған кезде орын алуы анықталды, бұл ретте литийді алу 21,87 % құрады, сондай-ақ синтезделген сорбентте – гидратталған марганец оксиді, Li алу 20,11 % құрады. Тұзды ертітінділерден литийді алу үшін, сорбенттер ретінде алюминий және/немесе марганец пайдалана отырып, бейорганикалық сорбенттермен, сорбция тәсілі таңдалды.

Түйін сөздер: литий, табиғи тұзды ертітінділер, сорбция, ионалмастырғыш шайыр, бейорганикалық сорбенттер, синтез, алу.

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СОРБЦИОННЫЕ СПОСОБЫ ПЕРЕРАБОТКИ ГИДРОМИНЕРАЛЬНОГО ЛИТИЕВОГО СЫРЬЯ КАЗАХСТАНА

Аннотация. В современном мире высоких технологий литий (Li) является ключевым компонентом. Казахстан обладает необходимым потенциалом для его производства. Наиболее привлекательным сырьем для извлечения лития являются природные рассолы и рапы соляных озер. Исследование и поиск новых технологических решений с целью вовлечения в сферу переработки литийсодержащего гидроминерального сырья является важной и актуальной научно-технической задачей.В статье проведен анализ литературных данных по сорбции лития органическими смолами и неорганическими сорбентами. Как правило, для сорбции лития используются по большей части катионообменные смолы как в протонированной, так и натриевой формах. В их число входит распространенный катионит КУ-2-8 или его аналоги. В исследованиях по сорбционному извлечению лития из литийсодержащих растворов из числа неорганических сорбентов преимущественно используются соединения на основе марганца, титана и алюминия. Нами для извлечения лития из природных рассолов в статических условиях проведена сорбция с применением ионообменных смол: КУ-2-8, Purolite C100, Purolite C160S, Purolite S940, Amberlite IR 120, CYBBER CRX 210 и CYBBER CRX 300. Показано, что литий практически не сорбируется на ионитах. Незначительное извлечение лития имеет место на сульфокатионите КУ-2-8 и составляет 0,49 %. Выполнены исследования по переработке природных рассолов с применением неорганических сорбентов (в виде коммерческих реагентов): гидроксида алюминия, оксидов титана и марганца, и активированного угля. Кроме того, синтезированы такие неорганические сорбенты как гидроксид алюминия, гидратированные оксиды титана и марганца. Установлено, что наиболее высокие показатели имели место при использовании в качестве сорбента – коммерческого реагента гидроксида алюминия, при этом извлечение лития составило 21,87 %, а также на синтезированном сорбенте – гидратированном оксиде марганца, где извлечение Li достигло 20,11 %.Для извлечения лития из рассолов выбран способ сорбции неорганическими сорбентами с использованием в качестве сорбентов соединений алюминия и/или марганца.

Ключевые слова: литий, природные рассолы, сорбция, ионообменные смолы, неорганические сорбенты, синтез, извлечение.

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