

ANNOTATION

for the dissertation work on the topic "Creation of highly selective modern sorbents for scandium extraction from technological solutions" for the degree of Doctor of Philosophy (PhD) in the specialty 8D05301 - "Chemistry" by Khimersen Khuangul

Research topic: «Creation of highly selective modern sorbents for scandium extraction from technological solutions»

The purpose of the study is to:

Creation of selective ion exchangers and interpolymer systems for scandium ions based on acidic and basic functional cross-linked polymers and development of a scientific and practical basis for the extraction of scandium from technological solutions.

Research objectives:

1. Study of the initial electrochemical and volumetric gravimetric properties of weakly acidic cation exchangers Lewatit CNP LF and strong base anion exchangers AV-17-8. Creation of interpolymer systems Lewatit CNP LF:AB-17-8 in various molar ratios (X:Y).
2. Study of the influence of the initial states of polymers on the electrochemical properties of processed interpolymer systems in an aqueous environment.
3. Study of the sorption process of scandium ions from aqueous solutions with Lewatit CNP LF:AB-17-8 interpolymer systems with different molar ratios.
4. Creation of a scientific and experimental method for the selective sorption of scandium and lutetium ions from rare earth metal concentrates.

Research methods:

theoretical: a review of the literature on the distribution of scandium in nature, its use and methods of extracting scandium from various minerals, analysis, comparison and formulation of problems of scientific and theoretical research.

empirical: conductometry, gravimetry, photolorimetry, inductively coupled plasma atomic emission spectroscopy, scanning electron microscope, energy dispersive X-ray spectroscopy, IR spectroscopy, thermogravimetry and differential scanning calorimetry.

The main provisions (proven scientific hypotheses and other conclusions that are new knowledge) submitted for defense

1. Changing the initial state of one component of the interpolymer system changes the electrochemical behavior of ion exchangers and interpolymer systems. It has been proven that when studying the physicochemical and sorption properties of ion exchangers in interpolymer systems, it is necessary to take into account the initial state of the components. The degree of modification of the functional groups of ion exchangers contained in the process of mutual activation of IP systems was determined by potentiometric titration: the degree of modification of the cation exchanger (Lewatit CNP LF) is 20%, the degree of modification of the anion exchanger (AB-17-8) is 60%.

2. By determining the optimal ratio (X:Y) of the interpolymer system, the sorption properties of acidic and basic ion exchangers can be increased. The Lewatit CNP LF:AB-17-8 interpolymer system showed the highest sorption of scandium ions after 24 hours in the following molar ratios: 5,6:0,4 (73%); 5,2:0,8 (58,3%); 5:1 (56,86%); and the degree of sorption for individual Lewatit CNP LF (6:0) is 35%, for individual AB-17-8 (0:6) is 23%.

3. It has been established that with an increase in the amount of one polymer in the interpolymer pair, the degree of binding of the second polymer to the metal ion increases. Lewatit CNP LF has a degree of binding of 4.16 mg/mol in a ratio of 6:0, and when the amount of anion exchanger AB-17-8 increases 5 times, the degree of binding of the cation exchanger increases to 11.14 mg/mol in a ratio of 1:5. Using the Lewatit CNP LF:AB-17-8 interpolymer system, it is possible to separate scandium in solution from lutetium. $K_d(6:0)_{Lu}=0,508$ МЛ/МГ; $K_d(6:0)_{Sc}=1,044$ ml/mg; $K_d(5:1)_{Lu}=0,575$ ml/mg; $K_d(5:1)_{Sc}=0,993$ ml/mg. Partition coefficient $\beta_{Sc/Lu}=2,055$.

4. A method has been determined for the optimal separation of Lu^{3+} ions from Sc^{3+} ions using Amberlite IR 120:AB-17-8 interpolymer systems based on a strong acid cation exchanger and a strongly basic anion exchanger. In all ratios of IP systems Amberlite IR 120:AB-17-8, the partition coefficient of lutetium ions is higher compared to scandium. In molar ratio 1:5 $K_{dLu}=4,185$ ml/mg, $K_{dSc}=1,1474$ ml/mg. Maximum partition coefficient $\beta_{Sc/Lu}=11,77$.

Justification of the novelty and significance of the results obtained and their compliance with the directions of scientific development or government programs:

1. For the first time, interpolymer systems were created based on industrial ion exchangers Lewatit CNP LF, AB-17-8 and the electrochemical properties of the resulting IP systems were studied.

2. For the first time, the influence of the initial states of polymers on the process of mutual activation of Lewatit CNP LF:AB-17-8 systems was studied and an assumption was made about the conditions under which the sorption process occurs at a high level.

3. New data have been obtained on the process of sorption of scandium ions from aqueous solutions of functional polymers with different molar ratios.

4. As a result of studying the sorption of IP systems Lewatit CNP LF:AB-17-8 and Amberlite IR120:AB-17-8, a method for separating scandium from lutetium ions was determined by changing the molar ratios of these IP systems.

The dissertation work was carried out within the framework of state grant funding under the program “Development of modern methods for the isolation and extraction of rare earth metals from concentrates and technological solutions of sulfuric acid leaching” (AP14870002, 2022-2024) at the JSC “Institute of Chemical Sciences named after. A.B. Bekturov”, in the laboratory of synthesis and physico-chemistry of polymers.

Description of the doctoral student's contribution to the preparation of each publication:

The main results of the dissertation research were published in 12 publications, including: *2 articles in international scientific journals included in the Scopus scientometric database (Polymers, percentile 76, Q1 u Polymer Bulletin, percentile 69, Q2)*

1. Enhanced Sorption of Europium and Scandium Ions from Nitrate Solutions by Remotely Activated Ion Exchangers. *Polymers*. – 2023. – 15. – P. 1194-1209 (Khimersen Kh. 65%, co-authors Imangazy A. M., Jumadilov T.K., Bayshibekov A.)

2. Remote interaction effect of industrial ion exchangers on the electrochemical and sorption equilibrium in scandium sulfate solution. *Polymer Bulletin*. – 2024. – 81. – P. 2023–2041. (Khimersen K. 70%, co-authors Jumadilov T.K., Imangazy A.M., Haponiuk J.T.)

4 articles published in publications recommended by the Committee for quality assurance in the field of Science and higher education of the MSHE of the Republic of Kazakhstan:

1. Adsorption methods for the extraction and separation of rare earth elements. Review. *Complex Use of Mineral Resources*. – 2021. – №3 (318). – C.12-23 (Khimersen K. 80%, co-authors Jumadilov T., Totkhuskyzy B., Haponiuk J.)

2. Impact of neodymium and scandium ionic radii on sorption dynamics of amberlite IR120 and AB-17-8 remote interaction. *Chemical Journal of Kazakhstan*. – 2021. – 4(76). – P. 26–41. (Khimersen Kh. 60%, co-authors Jumadilov T.K., Kondaurov R.G., Imangazy A.M.)

3. Features of the scandium ions interaction with the interpolymer system Lewatit CNP LF (H⁺) - AB-17-8 (OH⁻) system. *Chemical Journal of Kazakhstan*. – 2023. – 2(82). – P. 109-117. (Khimersen Kh. 70%, co-authors Jumadilov T.K., Mukatayeva Zh. S., Korganbayeva Zh.K., Haponiuk J., Imangazy A.)

4. Features of extraction of lutetium and scandium ions by the interpolymer systems Lewatit CNP LF-AB-17-8. *Chemical Journal of Kazakhstan*. – 2023. – 4(84). – P. 74-84. (Khimersen Kh. 70%, co-authors Jumadilov T.K., Haponiuk J.)

In the materials of international scientific and practical conferences, including the far and near abroad, 6 articles were published:

1. Создание принципиально новой технологии группового извлечения ионов редкоземельных металлов из продуктовых растворов металлургии. Trends, prospects and innovative approaches to the development of chemical science, production and education in the context of globalization: Materials of the International Scientific Conference. – Almaty. – 2021. – P. 91-105. (Khimersen Kh. 40%, co-authors Jumadilov T.K., Kondaurov R.G., Imangazy A.M.)

2. Особенности создания новых селективных макромолекулярных систем по отношению к ионам неодима, рения и скандия. Trends, prospects and innovative approaches to the development of chemical science, production and education in the context of globalization: Materials of the International

Scientific Conference. – Almaty. – 2021. – P. 106-120. (Khimersen Kh. 40%, co-authors Jumadilov T.K., Kondaurov R.G., Imangazy A.M.)

3. Разработка технологии селективной сорбции ионов металлов полимерами с «молекулярными отпечатками». 84th Scientific and Technical Conference dedicated to the 90th anniversary of BSTU and the Day of Belarusian Science: Materials of the International Scientific Conference. – Minsk. – 2020. – P. 282-283. (Khimersen Kh. 40%, co-authors Jumadilov T.K., Imangazy A.M., Kondaurov R.G.)

4. Selectivity of the interpolymer system based on industrial ionites CNP LF® and AB-17-8 to scandium ions. Modern problems of polymer science. Uzbek-Kazakh Symposium: Collection of abstracts. – Tashkent. – 2022. – P. 42-43. (Khimersen Kh. 90%, co-author Jumadilov T.K.)

1 article was published in the publication Advanced Polymer Structures by the foreign publishing house Apple Academic Press:

Influence of Initial States on the Electrochemical Behavior of Industrial Ionites in the Interpolymer System Lewatit CNPLF-AB-17-8. Advanced Polymer Structures. AAP press. 2023, P. 83-95. Chapter 7. (Khimersen Kh. 70%, co-authors Jumadilov T.K., Haponiuk J.)

1 patent for the Utility model of the Republic of Kazakhstan received:

Method for extracting scandium from pregnant solutions. Utility model patent. № 6583, 29.10.2021

Structure and scope of work.

The dissertation work consists of standard sections: normative references, notations and abbreviations, introduction, literature review, experimental part, experimental results and their discussion, list of references and appendix.