

Research On Uranium Recovery From Uranium-Containing Products

Kenzhaliyev B. K., Dosymbayeva Z. D, Berkinbayeva A.N, Suleimenov E. N, Sharipov R. KH, Zheksembiyeva B. T

Abstract— The processes of uranium extraction from uranium-bearing ores using oxidizers and catalysts, uranium sorption from productive solutions on Purolite A500 anionite have been studied. Comparative studies was carried out on leaching of uranium from ores using traditional oxidizing agents: ammonium nitrate, sodium peroxoborate (FGP), iron (III) and using the catalyst "M-1" including manganese, cobalt, nickel, iron in total 0,3 g / dm³, a paramagnetic catalyst based on iron - "PM". When using the catalyst "M-1" after 12 hours of the experiment, uranium extraction was 86 mg / dm³.

Investigations have been carried out on uranium extraction from the productive leaching solutions in the presence of the M-1 catalyst on the ion exchange anion exchangers Purolite A500 and Ambersep-920 to select the optimum sorbent to maximize the recovery of the useful component from the solution. The possibility of using Purolite A500 and Ambersep-920 anion exchangers for extracting uranium from leach solutions is shown. It has been established that the sorption and capacitance characteristics of Purolite A500 and 2-Ambersep-920 sorbents are approximately equal.

Index Terms— catalyst, leaching, extraction ratio, sorption, uranium

I. INTRODUCTION

According to the reserves of natural uranium, Kazakhstan is the second largest in the world and the leading position in its production. The methods of processing uranium ores used on an industrial scale do not provide the necessary indices of uranium extraction. Therefore, it is necessary to study more efficient technologies for obtaining uranium. In recent years, the increasing attention of researchers from far and near abroad has been devoted to the problems of the effectiveness of uranium mining technology [1 - 3]. The main problem to the increase of uranium mining is the conversion of uranium (IV) to a soluble state in underground leaching using existing technologies. The tetravalent uranium does not give soluble complexes and does not pass into the solution, so it must be oxidized to a hexavalent state. If there is poorly soluble in dilute sulfuric acid solutions in the leachable ores of tetravalent uranium, the addition of an oxidizing agent to intensify the uranium dissolution process is required. To

Kenzhaliyev B. K., JSC "Institute of Metallurgy of Ore Benefication", 29/133, Shevchenko and Valikhanov str. corner Almaty, 050010, Kazakhstan

Dosymbayeva Z. D., JSC Kazakh-British Technical University, 59 Tole bi Str., Almaty city, 050000, Kazakhstan (KBTU)

Berkinbayeva A.N., JSC Kazakh-British Technical University, 59 Tole bi Str., Almaty city, 050000, Kazakhstan (KBTU)

Suleimenov E. N., JSC Kazakh-British Technical University, 59 Tole bi Str., Almaty city, 050000, Kazakhstan (KBTU)

Sharipov R. KH., JSC Kazakh-British Technical University, 59 Tole bi Str., Almaty city, 050000, Kazakhstan (KBTU)

Zheksembiyeva B. T., Kazakh State Women's Pedagogical University, 99 Ayteke bi Str., Almaty city, 050000, Kazakhstan

increase the extraction of uranium, sulfuric acid is used in a mixture with oxidizing agents - ammonium nitrate, pyrolusite, sodium peroxoborate, hydrogen peroxide, with ferric salts and other oxidizing agents [4 - 6].

An analysis of the scientific and technical literature of recent years has shown that the use of oxidizers is one of the main directions for increasing the extraction of uranium from the difficult-to-hide ores. In the world practice, the following methods was well studied and used: mechanical methods (ore crushing, agglomeration, etc.), physical (electric shock, magnetic fields, etc.), biological (application of bacteria) and chemical (using oxidants, active additives and Etc.) intensification of the leaching process [7, 8]. The effectiveness of these methods ultimately reduces to a reduction in the processing time of the ore mass and an increase in the recovery of the useful component. However, these methods of intensification are mainly reduced to the use of expensive oxidizing agents, such as potassium permanganate (KMnO₄). Currently, the amount of oxidants used for uranium PGE is very limited. In most developed countries with strict environmental legislation, hydrogen peroxide or compressed oxygen injected directly into the wells is used as oxidants [9]. The experiments showed that the stabilized hydrogen peroxide in the formation completely decomposes into water and oxygen in just a few hours, while the duration of filtration of BP through the formation is weeks or months. Therefore, in particular, studies of the effect of oxidants on the conversion of uranium to soluble form and on the process of leaching of difficult-to-hide uranium-bearing ores are of great interest. In this connection, we carried out studies on the effect of catalysts on the process of sulfuric acid leaching of uranium ores.

One of the most effective ways of extracting uranium from the leaching solution obtained during the leaching of uranium ores is the sorption of uranium on the complexing ionite and subsequent desorption with various solutions. Ion exchange processes occupy an important place in nuclear technology. In addition to using uranium to extract uranium from solutions obtained during the leaching of uranium ores, ion exchange processes are also used for complete desalination of water at nuclear power plants, for capturing radioactive isotopes from the waste water of nuclear enterprises [10].

At present, modern uranium ion exchangers Ambersep-920 and Purolite A-500U, Amberlite IRA910, PuroliteS920, PuroliteS924 are being used to extract uranium from technological solutions. In [11], the use of anionite sorbents from Russia (Rossion-5, Rossion-12 and AM-2B) at the mining and metallurgical plant of Kazakhstan for the sorption of uranium from process solutions is described. In addition, this company is working to find more efficient organic sorbents brand Purolite.

II. RESULTS AND DISCUSSION

Comparative studies of uranium leaching from uranium deposits (whose main mineral is coffinite - not less than 95%) were carried out using an oxidizing catalyst of "M-1" complex containing manganese, cobalt, nickel, iron and paramagnetic iron-based catalyst "PM": [12, 13]. Preliminary studies of the catalyst "M-1" were given in [14, 15]. Experiments on uranium leaching from uranium-bearing ores were carried out under the following conditions: the volume of the solution was 1000 ml, sample weight - 250 g, the temperature - 25 ° C, and the time was 12-48 hours. The results of the studies on leaching of uranium from cores in agitation mode using traditional oxidizing agents: ammonium nitrate, sodium peroxoborate (FGP), iron (III) and using the catalysts "M-1" and "PM" are given in Table 1.

Table 1 – Results of research on sulfuric acid leaching of uranium

Solutions	pH	Redox, MV	U, mg / dm ³	Acid consumption (C _{H2SO4} = 5,0 G / dm ³), g / g of uranium
The catalyst "M-1"	2,00	408	86,0	9,7
PM catalyst	1,78	314,0	31,0	38,7
A solution of ferric iron	1,18	350,0	55,0	12,20
Ammonium nitrate	1,28	252,0	50,52	15,95
Sodium peroxoborate	0,88	450,0	39,2	33,7

From the data presented, it can be seen that in the case of using traditional oxidants, an increase in uranium extraction was observed. The extraction of uranium reaches 55.0 mg / dm³ when using a solution of ferric iron, and the consumption of acid is less than with the use of other oxidants. The use of the PM catalyst does not contribute to increasing the extraction of uranium. The maximum uranium content in the leach solution using the "PM" catalyst was 31 mg / dm³ after 12 hours of the experiment. The use of the M-1 catalyst leads to an increase in the leaching of uranium from the ore. In this case, unlike traditional oxidants, there is a tendency for further uranium recovery to increase with time, leaching processes and a decrease in acid consumption. This indicates an increase in uranium extraction by sulfuric acid leaching from sparingly soluble uranium-containing ores in the presence of the M-1 catalyst and the possibility of its almost complete extraction with increasing process time.

Thus, for future studies on the sorption of uranium from leach solutions using the catalyst "M-1", the anion exchangers were chosen: the strongly basic macroporous anionite Purolite A500 based on the styrenedivinybenzene matrix and macroporous strongly basic anionite Ambersep 920U based on cross-linked polystyrene, which is effectively used in uranium-producing plants. For the sorption of uranium, solutions were used after uranium leaching in the presence and with the use of the catalyst "M-1", with the highest uranium content. The content of uranium in solutions is 86.0 mg/l.

Investigations were carried out on extraction of uranium from the productive solutions on the ion exchange anion exchangers Purolite A500 and Ambersep-920 in order to select the optimum sorbent to maximize the recovery of the

useful component from the solution. Experiments were conducted on the influence of the contact time of the resin with the solution on the sorption of uranium on ion exchange resins Purolite A500 and Ambersep-920. The results of the experiment are shown in Fig. 1

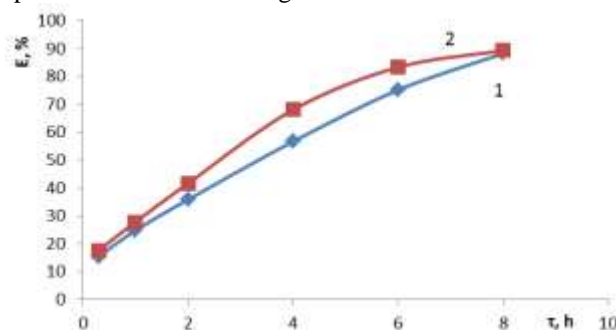


Figure 1 - Extraction of uranium depending on contact time on anion exchangers: 1- Purolite A500; 2 - Ambersep-920

Figure 1 shows that the uranium sorption rate increases rapidly with increasing contact time, and then reaches the saturation point at ~ 480 min., while the Purolite A500 resin reaches a full saturation rate more slowly than the Ambersep-920. The degree of uranium extraction on Purolite A500 anionite reaches 88.3%, Ambersep - 920 - 89.1%.

Figure 2 shows the oxidation-reduction potential (ORP) of solutions in the process of uranium sorption on Purolite A500 and Ambersep-920 anion exchangers depending on the phase contact time (τ, h).

As can be seen in Figure 2, the oxidation-reduction potential (ORP) in both processes increases from 0.42 to 0.45 and 0.43 to 0.47 V for up to 4 hours, then decreases monotonically

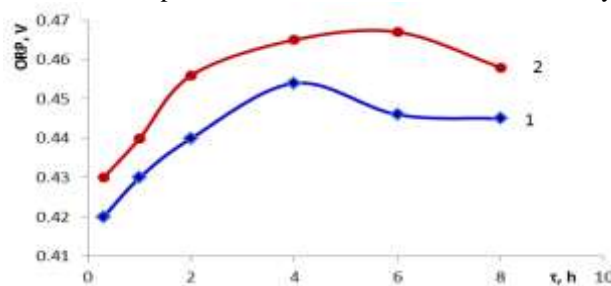


Figure 2 - Dependence of ORP on the contact time of the solution with anion exchangers: 1 - Purolite A500; 2 - Ambersep-920

In the study, the solution volume, uranium concentration, pH and sorption time were kept constant, while the amount of resin varied from 0.25 to 2.0 g / l. The results are shown in Figure 3. An integral factor determining the effectiveness of sorption, as well as the effectiveness of the use of ion exchange resin is the ratio of ion exchange resin and solution. It should be noted that the choice of the ratio of the amount of resin and the volume of the solution affects the degree of recovery. We have studied sorption of uranium at different ratios of resin to solution under static conditions.

As shown in Fig. 3, with the increase in the amount of resin, the extraction of uranium on two anion exchangers increases. Both anion exchangers reach a maximum uranium extraction value of 90.3 - 92.9% at 2.0 g / l. On the other hand, an increase in the amount of anion exchanger results in an increase in the unsaturated portions of the resin phase. This can be the reason for the reduction in the sorption of uranium per unit weight of the sorbent. The increase in the recovery

rate, due to the increase in the amount of sorbent, may be due to an increase in the surface area of the adsorption centers. Comparing the sorption and capacitance characteristics of the Purolite A500 and 2-Ambersep-920 sorbents, it can be seen that the properties of the resins are approximately equal.

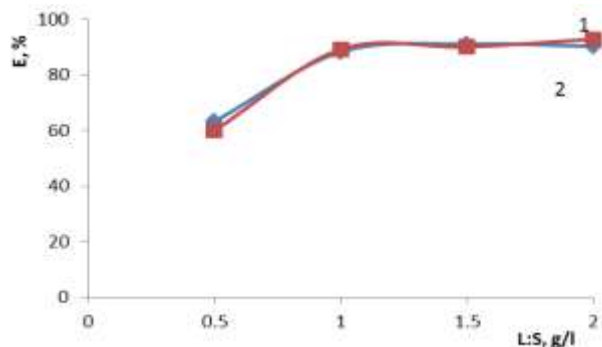


Figure 3 - Uranium content depending on the ratio of resin to solution volume on anion exchangers: 1- Purolite A500; 2 - Ambersep-920

Figure 4 shows that the oxidation-reduction potential (ORP) of solutions during the sorption of uranium on Purolite A500 and Ambersep-920 anionites increases with the volume ratio of anionite and solution (L: S)

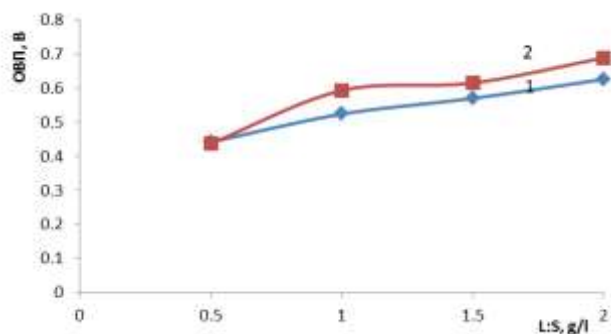


Figure 4 - Dependence of ORP on the ratio of solution to anion exchanger (S:L) at sorption on anion exchangers: 1 - Purolite A500; 2 - Ambersep-920

The conducted experiments on the sorption of uranium from leach solutions using a catalyst indicate the possibility of using Purolite A500 and Ambersep-920 anion exchangers for sorption of uranium.

To determine the optimal parameters for extracting uranium from solutions using anion exchangers, additional studies are needed.

III. CONCLUSION

Using the M-1 catalyst, there was a tendency for further uranium recovery with increasing leaching time. This indicates an increase in uranium extraction by sulfuric acid leaching from sparingly soluble uranium-bearing ores in the presence of the M-1 catalyst and the possibility of practically maximizing its recovery with increasing process time.

The conducted experiments on uranium sorption from leach solutions using the "M-1" catalyst indicate the possibility of using Purolite A500 and Ambersep-920 anionite for the isolation of uranium. The degree of sorption of uranium on the anionite Purolite A500 reaches 88.3%, Ambersep - 920 -

89.1% with increasing contact time. With the increase in the amount of resin, the extraction of uranium on two anion exchangers increases. Both anion exchangers reach a maximum uranium extraction value of 90.3 - 92.9% at 2.0 g / l. It has been established that the sorption and capacitance characteristics of Purolite A500 and 2-Ambersep-920 sorbents are approximately equal.

ACKNOWLEDGEMENTS

This manuscript reports data obtained in the course of a research carried out with the financial support from the Ministry of Education and Science of the Republic of Kazakhstan (№ 85, February 27, 2017).

REFERENCES

- [1] M.I.Pownceby, C.Johnson Geometallurgy of Australian uranium deposits // Ore Geology Reviews, Volume 56, January 2014, Pages 25-44
- [2] R.Ram, F.A. Charalambous, S.Mc Master, M.I. Pownceby, J.Tardio, S.K. Bhargava. Chemical and micro-structural characterisation studies on natural uraninite and associated gangue minerals // *Minerals Engineering*, Volume 45, May 2013, Pages 159-169
- [3] Z. Lunt, D. Boshoff, P. Boylett, M. & El-Ansary Uranium extraction : the key process drivers // Journal of the Southern African Institute of Mining and Metallurgy, Volume 107, Issue 7, Jul 2007, p. 419 - 426
- [4] N.G. Malukhin, S.V. Markelov, Kh.R. Baymurzayev, Kinetics of the formation of solutions in the leaching of uranium from carbonate-sulfide-containing ores // Scientific and technical journal Gorny Vestnik of Uzbekistan. - 2013. - No.3 (54).
- [5] Sabriye (Doyurum) Yusan, Sema (Akyil) Erenturk. Sorption behaviors of uranium (VI) ions on α -FeOOH // Desalination. - 2011. - Vol. 269. - P. 58 - 66.
- [6] Fang-Li Fan, Zhi Qin, Jing Bai, Wei-Dong Rong, Fu-You Fan, Wei Tian, Xiao-Lei Wu, Yang Wang, Liang Zhao, Rapid removal of uranium from aqueous solutions using magnetic Fe₃O₄@SiO₂ composite particles // Journal of Environmental Radioactivity. - 2012. - Vol. 106. - P. 40 - 46.
- [7] VENTER, R. and BOYLETT, M. The evaluation of various oxidants used in acid leaching of uranium. // Hydrometallurgy Conference 2009, The Southern African Institute of Mining and Metallurgy, 2009.
- [8] Qingliang Wang; Guanzhou Qiu Study on bacteria domestication and application of heap leaching in uranium mine // 2011 International Conference on Remote Sensing, Environment and Transportation Engineering, Nanjing, China, 24-26 June, 2011
- [9] V.G. Litvinenko, V.M. Lizunkin, A.A. Morozov, Intensification of heap leaching technology for poor uranium raw materials of the Streltsov ore field // Mining information-analytical bulletin. - 2005. - No. 3. - P. 272-275.
- [10] M.I. Fazlullina, Underground and heap leaching of uranium, gold and other metals. // Izdatel Publishing House "Ore and Metals". - 2005. - Вып. 2. - Т. 1. - 407 p.
- [11] E.V. Salmnikova, M.L. Mursalimova, A.V. Stryapkov, Methods of concentration and separation of trace elements: a textbook. - Orenburg: GOUOGU, 2005. - 157 p.
- [12] N. Zhalgasuly, N.K. Tusupbaev, T.D. Karmanov, N.S. Umirbekova, A.O. Abdikulova, Influence of the paramagnetic material on the oxidability of the ion sulfide and ferrous iron // Proceedings of the V International Scientific and Practical Conference Zhetykar - 2010.
- [13] 13. N.K. Tusupbaev, N.S. Umirbekova, L.V. Semushkina, Influence of various forms of iron on the oxidation of the sulfite ion // KIMS, 2010.
- [14] Patent USA. Method of catalytic oxidation of U⁺⁴ to U⁺⁶ using a catalyst Muhamedzhan-1 /Aibassov Y., Aibassova S., Aibassov G., Aibassov Zh., Aibassov M., Abenov B. /, # 2013-104698, May 2, 2013.
- [15] E. Zh. Aibassov, A. A. Baiguzhin, Zh. S. Umirkulova and G. K. Serikbaeva, Catalytic oxidation of u⁴⁺ to u⁶⁺ by oxygen in the Presence of a catalyst "Muhamedzhan-1" // J. Chem. Chem. Eng. - 2013. - Vol. 7. - P. 81-83