[3]. Kinoshita, K., Inoue, T., Fusselman, S.P., Grimmett, D.L., Roy, J.J., Gay, R.L., Krueger, C.L., Nabelek, C.R. and Storvick, T.S. (1999). Separation of Uranium and Transuranic Elements from Rare Earth Elements by Means of Multistage Extraction in LiCl-KCl/Bi System. J. Nucl. Sci. Technol., Vol. 36, p. 189-193.

[4]. Spedding, F. and Dahan A. (1965). Rare earth metals, Moscow, Metallurgy, 324 p.

[5]. Yosisuke, H. (1988). Met. Technol. (Tokyo), vol. 58, p. 52.

[6]. Plambeck, J.A. (1976). in: A. J. Bard (Ed.), Encyclopedia of Electrochemistry of the Elements, Volume X Fused Salt Systems, Marcel Dekker, New York.

[7]. Banks, C.V., Heusinkveld, M.R., O'Laughlin, J.W. (1961). Absorption Spectra of the Lanthanides in Fused Lithium Chloride-Potassium Chloride Eutectic. Anal. Chem., Vol. 33, p.1235-1240.

[8]. Johnson, K.E. and Mackenzie, J.R. (1969). Samarium, europium and ytterbium electrode potentials in LiCl-KCl eutectic melt. J. Electrochem. Soc., Vol. 116, p. 1697-1703.

[9]. Ogawa, T. and Minato, K. (2001). Dissolution and formation of nuclear materials in molten media. Pure Appl. Chem., Vol. 73, No. 5, p. 799.

[10]. Franklin, K., Kobayashi, F., Akabori, M., Takano, M., Itoh, A. and Ogawa, T. (1999). A study on the electrode potential of dysprosium metal and dysprosium nitride in LiCl–KCl eutectic salt. Paper presented at the 31st Symposium on Molten Salt Chemistry, 11–12 November 1999, Sendai, Japan.

[11]. Sheng, J., Yamana, H. and Moriyama, H. (2002). Activity coefficients of Dy dissolved in liquid Bi. J. Nucl. Mater., Vol. 301, p. 220.

[12]. Chang, K.G., Ping Lu X.P., Du, Y.Y. and Zhao M.S. (1994). Determination of the apparent standard potential of the Dy/Dy(III) system in the LiCl-KCl eutectic. Chin. J. Chem., Vol. 12, No. 6, p. 509.

[13]. Castrillejoa', Y., Bermejoa, M.R., Barradoa, A.I., Pardoa, R., Barradoa, E. and Martlnez, A.M. (2005). Electrochemical behavior of Dy in LiCl-KCl eutectic melt on W and Al electrodes. Electrochimica Acta, Vol. 50, p. 2047-2057.

[14]. Kushkhov, Kh.B., Vindizheva, M.K., Mukozheva, R.A., Tlenkopachev, M.R. and Nafonova, M.N. (2012). Investigation of lanthanum ions electroreduction on tungsten electrode in halide melts at 823 K. Melts, No.1, p. 1-10.

[15]. Kushkhov, Kh.B., Uzdenova, A.S. and Shogenova, D. L. (2006). Electroreduction of yttrium ions on silver and tungsten electrodes in chloride and chloride-fluoride melts at 823 K. Melts, No. 2, p. 55-64.

[16]. Kushkhov, Kh.B., Zhanikaeva, Z.A. and Chuksin, S. I. (2009). Electroreduction of neodymium ions in chloride melts. Melts, No. 3, p. 50-59.

[17]. Brouwer, G. at al. (1985). A guide to inorganic synthesis. Moscow: Mir, Vol. 4, 447 p.

[18]. Kuznetsov, S.A. and Gaune-Escard, M. (2001). Redox electrochemistry and formal standard redox potentials of the Eu(III)/Eu(II) redox couple in an equimolar mixture of molten NaCl–KCl. Electrochimica Acta, Vol. 46, No. 8, p. 1101-1111.

[19]. Griliches, S.Y. (1987) Electrochemical and chemical polishing, Leningrad: Mashinostroenie, p. 107-128.

[20]. Heyrovský, Y. and Kuta, Y. (1965). Basics polarography, Moscow: Mir, 559 p.

[21]. Stolz, F. (2010). Electroanalytical methods. Theory and practice, Publishing house: Beanom. Knowledge Laboratory, 326 p.

[22]. Jaeger, E. and Zalkind, F. (1977). Methods of electrochemistry measurements. Moscow: Mir, 585 p.

[23]. Delahey, P. (1957). New apparatus and methods in electrochemistry, Moscow, 354 p.

[24]. Beimejo, M.R., Gomez, J., Medina, J., Martinez, A.M. and Castrillejo, Y. (2006). The electrochemistry of gadolinium in the eutectic LiCl–KCl on W and Al electrode. Journal of Electroanalytical Chemistry, Vol. 588, No. 2, p. 253-266.

[25]. Caravaca, C., de Cordoba, G., Tomas, M.J. and Rosado, M. (2007). Electrochemical behavior of gadolinium ion in molten LiCl–KCl eutectic. Journal of Nuclear Materials, Vol. 360, p. 25-31.

[26]. Castrillejo', Y., Bermejo, M.R., Martinez, A.M., Barrado, E. and Diaz Arocas, P. (2007). Application of electrochemical techniques in pirochemical processes - electrochemical behavior of rare earth at W, Cd, Bi and Al electrodes. Journal of Nuclear Materials, Vol. 360, p. 32-42.

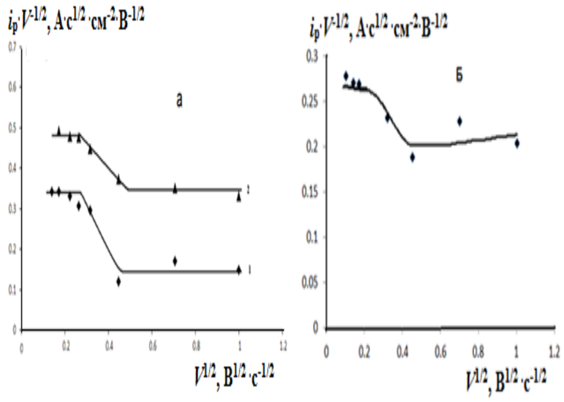


Fig. 9. ip/V1/2 от V1/2 dependence for NaCl–KCl–CsCl–DyCl3 melt, (C(DyCl3)·10-4, mol·cm-3: a) 1 – 3.6; 2 – 5.6; б) 2.0. working electrodes: (a)W and (b) Ag, T = 823 K.

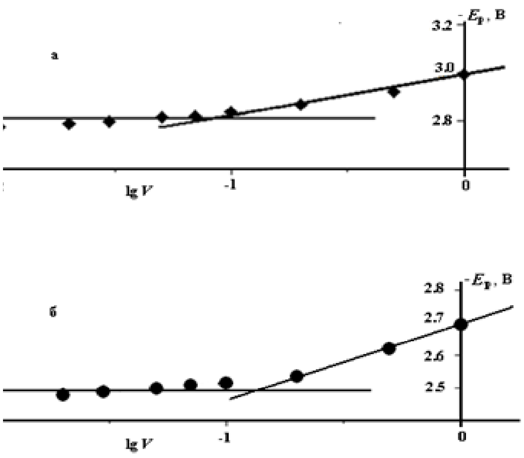


Fig. 10. $E - \lg[i/i_d - i]$ dependence for NaCl–KCl–CsCl–DyCl3 melt , (C(DyCl3)·10-4, mol·cm-3: a) 1 – 5.6 ; b) 3.9 . Working electrodes (a) W and (b) Ag, T = 823 K.

The values of the number of electrons transferred in the electrode process, which was calculated by the well-known diagnostic criteria for the half-width of the peak was close to three at the scan rate up to 0.1 V/s. The increasing of the scan rate higher than 0.1 V s-1 leads to a broadening of wave. Analysis of the half-widths of the peaks for these scan rates by the diagnostic criteria of Matsuda, Ayabe and Delahey [21-23] gives the value $\alpha n\alpha = 0.8 \div 2.4$.

Thus, the electrode process of dysprosium chloride complexes, which was recovered on a tungsten electrode in chloride melts under stationary and non-stationary conditions of polarization to the scan rate 0.1 V/s is limited by the diffusion stage of delivery, and at non-stationary conditions of polarization limited by the rate of charge transfer.

With using data on the structure of rare earth chloride complexes, and in particular, dysprosium, according to which it is exist in pure chloride melts in the form of complex DyCl63-, the electroreduction process can be represented by the following reaction:

$$DyCl_6^{3-} + 3e \leftrightarrow Dy + 6Cl^- \quad (1)$$

We calculated the diffusion coefficient of the DyCl63- complex ions with using the following equation:

$$i_p = 0.446 \frac{F^{3/2}}{R^{1/2} T^{1/2}} n^{3/2} C_{Ox} D_{Ox}^{1/2} V^{1/2} \quad (2)$$

Calculation of ion diffusion coefficient of DyCl63- performed for the scan rate when the value of ip/V½ constantly and the electrode process is reversible (Fig. 9). The diffusion coefficient of dysprosium chloride complex DyCl63- ions is (0.5±0.2)·10-5 cm2/s. These values was in good agreement with early published data [24–26].

## 4. Conclusions

The result of our investigations shows that the electroreduction of dysprosium chloride complexes ions on tungsten and silver electrodes in eutectic KCl–NaCl–CsCl melt occurs in three-electron step at stationary and non-stationary polarization up to 0.1 V/s and it is limited by the diffusion stage, and the higher scan rates lead to the slowness stage charge transfer.

## 5. References

[1]. Nishimura, T., Koyama, T., Iizuka, M. and Tanaka T. (1998). Development of an environmentally benign reprocessing technology – pyrometallurgical reprocessing technology. Prog. Nucl. Energy, Vol. 32, No. 3/4, p. 381-385.

[2]. Laidler, J.J., Battles, J.E., Miller, W.E., Ackerman, J. P. and Carls, E. L. (1997). Development of pyroprocessing technology. Progress in Nuclear Energy, Vol. 31, No. 1-2, p. 131-140.

Our results indicate the diffusion control of process of dysprosium ions electroreduction in molten NaCl–KCl–CsCl at stationary state polarization. At this fact also indicates the value of the ratio $i_d/\mathrm{nFC} = (0.2 \div 0.4)\cdot 10^{-3}\,\mathrm{cm/s}$ for the ions, which characterizes the method of delivery of electroactive species to the electrode surface, the value of which is comparable with the diffusion constant $\chi = \mathrm{D}/\delta$.

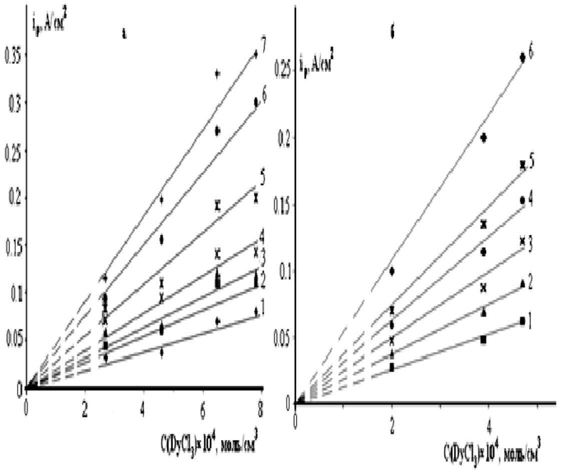
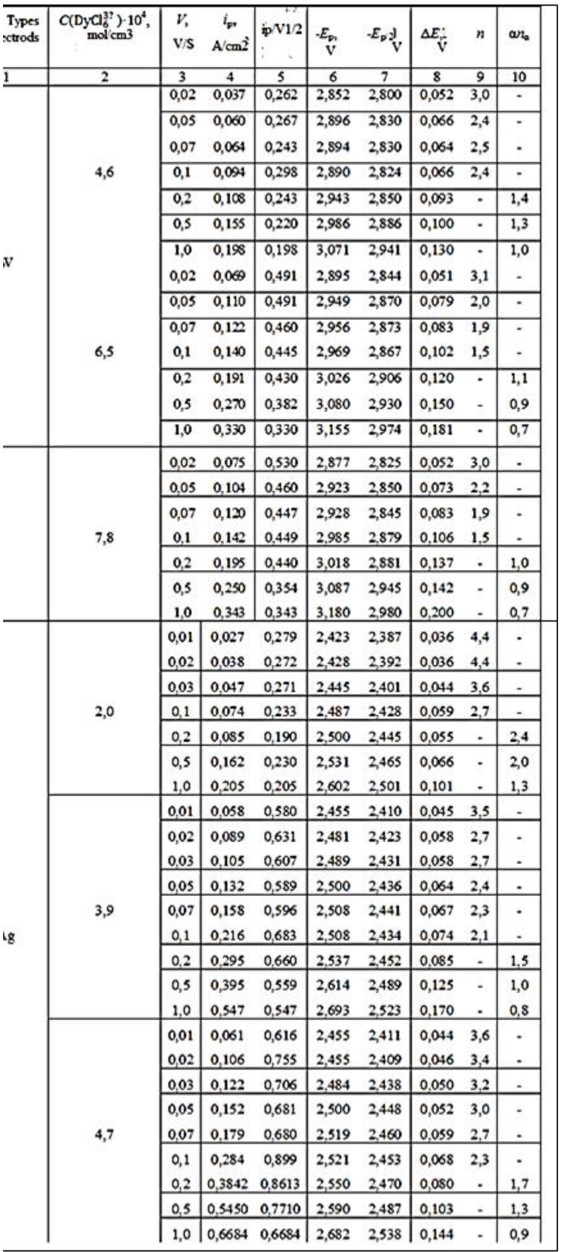


Fig. 8. Electroreduction current – DyCl3 concentration dependence in NaCl–KCl–CsCl–DyCl3 melt.
Scan rate, V/s: a) 1 – 0,02; 2 – 0,05; 3 – 0,07; 4 – 0,1; 5 – 0,2; 6 – 0,5; 7 – 1,0;
b) 1 – 0,01; 2 – 0,02; 3 – 0,03; 4 – 0,05; 5 – 0,07; 6 – 0,1
. Working electrodes: (a) W and (b) Ag , T = 823 K.

The diffusion control of the electrode process is confirmed by the form of current density – scan rate (ip/V1/2 – V1/2) dependence. By the rates of the polarization up 0.07 V/s to 0.2 V/s was observed constancy of the ip/V1/2 – V1/2 ratio (Table 1, Fig. 9).

Table 1

Some electrochemical parameters of DyCl3 electroreduction on the tungsten and silver electrodes
in eutectic NaCl–KCl–CsCl melt, T = 823K



| Types ectrods | $C(\mathrm{DyCl}_6^{3-})\cdot 10^4$, mol/cm3 | $V$, V/S | $i_p$, A/cm2 | ip/V1/2 | $-E_p$, V | $-E_{p/2}$, V | $\Delta E$, V | $n$ | $\alpha n_\alpha$ |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| W | 4,6 | 0,02 | 0,037 | 0,262 | 2,852 | 2,800 | 0,052 | 3,0 | - |
| | | 0,05 | 0,060 | 0,267 | 2,896 | 2,830 | 0,066 | 2,4 | - |
| | | 0,07 | 0,064 | 0,243 | 2,894 | 2,830 | 0,064 | 2,5 | - |
| | | 0,1 | 0,094 | 0,298 | 2,890 | 2,824 | 0,066 | 2,4 | - |
| | | 0,2 | 0,108 | 0,243 | 2,943 | 2,850 | 0,093 | - | 1,4 |
| | | 0,5 | 0,155 | 0,220 | 2,986 | 2,886 | 0,100 | - | 1,3 |
| | | 1,0 | 0,198 | 0,198 | 3,071 | 2,941 | 0,130 | - | 1,0 |
| | 6,5 | 0,02 | 0,069 | 0,491 | 2,895 | 2,844 | 0,051 | 3,1 | - |
| | | 0,05 | 0,110 | 0,491 | 2,949 | 2,870 | 0,079 | 2,0 | - |
| | | 0,07 | 0,122 | 0,460 | 2,956 | 2,873 | 0,083 | 1,9 | - |
| | | 0,1 | 0,140 | 0,445 | 2,969 | 2,867 | 0,102 | 1,5 | - |
| | | 0,2 | 0,191 | 0,430 | 3,026 | 2,906 | 0,120 | - | 1,1 |
| | | 0,5 | 0,270 | 0,382 | 3,080 | 2,930 | 0,150 | - | 0,9 |
| | | 1,0 | 0,330 | 0,330 | 3,155 | 2,974 | 0,181 | - | 0,7 |
| | 7,8 | 0,02 | 0,075 | 0,530 | 2,877 | 2,825 | 0,052 | 3,0 | - |
| | | 0,05 | 0,104 | 0,460 | 2,923 | 2,850 | 0,073 | 2,2 | - |
| | | 0,07 | 0,120 | 0,447 | 2,928 | 2,845 | 0,083 | 1,9 | - |
| | | 0,1 | 0,142 | 0,449 | 2,985 | 2,879 | 0,106 | 1,5 | - |
| | | 0,2 | 0,195 | 0,440 | 3,018 | 2,881 | 0,137 | - | 1,0 |
| | | 0,5 | 0,250 | 0,354 | 3,087 | 2,945 | 0,142 | - | 0,9 |
| | | 1,0 | 0,343 | 0,343 | 3,180 | 2,980 | 0,200 | - | 0,7 |
| g | 2,0 | 0,01 | 0,027 | 0,279 | 2,423 | 2,387 | 0,036 | 4,4 | - |
| | | 0,02 | 0,038 | 0,272 | 2,428 | 2,392 | 0,036 | 4,4 | - |
| | | 0,03 | 0,047 | 0,271 | 2,445 | 2,401 | 0,044 | 3,6 | - |
| | | 0,1 | 0,074 | 0,233 | 2,487 | 2,428 | 0,059 | 2,7 | - |
| | | 0,2 | 0,085 | 0,190 | 2,500 | 2,445 | 0,055 | - | 2,4 |
| | | 0,5 | 0,162 | 0,230 | 2,531 | 2,465 | 0,066 | - | 2,0 |
| | | 1,0 | 0,205 | 0,205 | 2,602 | 2,501 | 0,101 | - | 1,3 |
| | 3,9 | 0,01 | 0,058 | 0,580 | 2,455 | 2,410 | 0,045 | 3,5 | - |
| | | 0,02 | 0,089 | 0,631 | 2,481 | 2,423 | 0,058 | 2,7 | - |
| | | 0,03 | 0,105 | 0,607 | 2,489 | 2,431 | 0,058 | 2,7 | - |
| | | 0,05 | 0,132 | 0,589 | 2,500 | 2,436 | 0,064 | 2,4 | - |
| | | 0,07 | 0,158 | 0,596 | 2,508 | 2,441 | 0,067 | 2,3 | - |
| | | 0,1 | 0,216 | 0,683 | 2,508 | 2,434 | 0,074 | 2,1 | - |
| | | 0,2 | 0,295 | 0,660 | 2,537 | 2,452 | 0,085 | - | 1,5 |
| | | 0,5 | 0,395 | 0,559 | 2,614 | 2,489 | 0,125 | - | 1,0 |
| | | 1,0 | 0,547 | 0,547 | 2,693 | 2,523 | 0,170 | - | 0,8 |
| | 4,7 | 0,01 | 0,061 | 0,616 | 2,455 | 2,411 | 0,044 | 3,6 | - |
| | | 0,02 | 0,106 | 0,755 | 2,455 | 2,409 | 0,046 | 3,4 | - |
| | | 0,03 | 0,122 | 0,706 | 2,484 | 2,438 | 0,050 | 3,2 | - |
| | | 0,05 | 0,152 | 0,681 | 2,500 | 2,448 | 0,052 | 3,0 | - |
| | | 0,07 | 0,179 | 0,680 | 2,519 | 2,460 | 0,059 | 2,7 | - |
| | | 0,1 | 0,284 | 0,899 | 2,521 | 2,453 | 0,068 | 2,3 | - |
| | | 0,2 | 0,3842 | 0,8613 | 2,550 | 2,470 | 0,080 | - | 1,7 |
| | | 0,5 | 0,5450 | 0,7710 | 2,590 | 2,487 | 0,103 | - | 1,3 |
| | | 1,0 | 0,6684 | 0,6684 | 2,682 | 2,538 | 0,144 | - | 0,9 |

The slope of the $\mathrm{E} - \lg[i/i_d - i]$ dependence is given the value of electron number n = 3 (Fig. 10).

For determine of the electrons number, which transferred in the electrode process, the analysis of stationary state current-voltage curves was made by the Heyrovsky-Ilkovich equation [20].

rate, V/s: 1 – 0,01; 2 – 0,02; 3 – 0,05; 4 – 0,07; 5 – 0,1; 6 – 0,2; 7 – 0,5; 8 – 1,0; 9 – 2,0. C(DyCl3) = 5.6·10-4 mol/cm3, working electrode: W, T = 823 K.

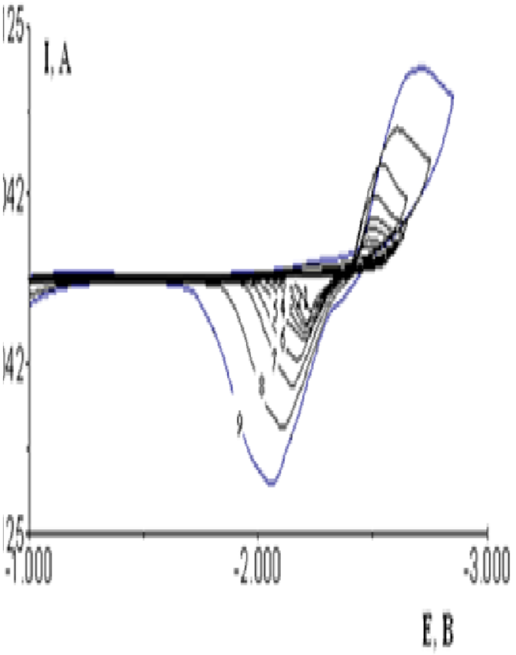


Fig. 5. Cyclic voltammograms of NaCl–KCl–CsCl–DyCl3 melt at different scan rate, V/s: 1 – 0,01; 2 – 0,02; 3 – 0,03; 4 – 0,05; 5 – 0,07; 6 – 0,1; 7 – 0,2; 8 – 0,5; 9 – 1,0. C(DyCl3) = 3.9·10-4 mol/cm3, working electrode: Ag, T = 823 K.

Cyclic voltammograms at different return potentials presented in (Fig 6 and 7) for the process of dysprosium ions electroreduction. They allow to correlate the wave of cathodic reduction and wave of anodic oxidation. If we would limit the value of the polarization potential to -2.85 and -2.63 V, than the anode loop there was only one wave of cathodic dissolution cycle – lanthanide metal.

This picture can be explained by the proximity of the recovery potential of complex chloride ions of dysprosium with recovery potentials of alkali metals.

To establish the nature and mechanism of the electrode process of complex dysprosium ions electroreduction in chloride melts we calculated the current density, the potential peak and half-peak, half width of the peak at different concentrations of DyCl3 and scan rates by well-known diagnostic criteria.

Limiting current electroreduction of dysprosium ions are in direct proportion increases with increasing concentration of dysprosium chloride in melt (Fig. 8 ).

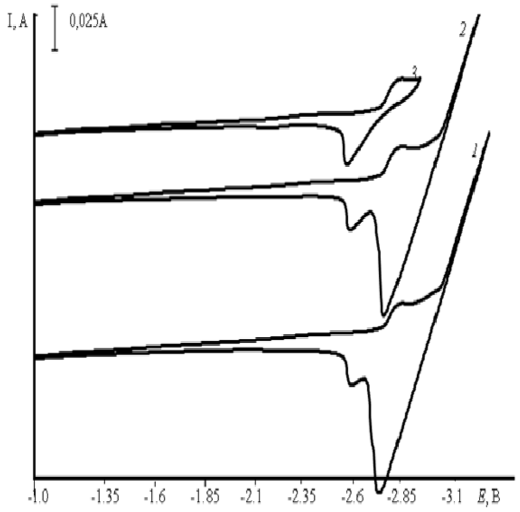


Fig. 6. Cyclic voltammograms of NaCl–KCl–CsCl–DyCl3 melt at different return potentials, V: 1–(-3.35); 2–(-3.25); 3–(-2.85), scan rate = 0.07 V/s. C(DyCl3) = 5.6·10-4 mol/cm3, working electrode: W, T = 823 K.

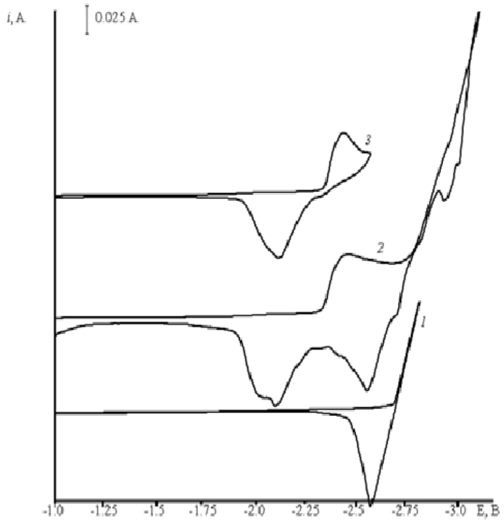


Fig. 7. Cyclic voltammograms of NaCl–KCl–CsCl–DyCl3 melt at different return potentials, V: 1–( NaCl-KCl-CsCl); 2–(-3.22); 3–(-2.63), scan rate = 0.1 V/s. C(DyCl3) = 3.9·10-4 mol/cm3, working electrode: Ag, T = 823 K.

of the depolarizer concentration leads to the increase of height of electroreduction wave (Fig. 2 and 3) .

We studied the influence of scan rate on the process of dysprosium ions electroreduction. The voltammograms (Fig. 4 and 5) were taken as in stationary and non-stationary polarization (0.01 V/s ≤ V ≤ 2.0 V/s) and (0.01 V/s ≤ V ≤ 1.0 V/s) respectively . The change of scan rate from stationary to non-stationary doesn't give the appearance of diffusion peak on current-voltage curves . This picture can be explained by the proximity of the reduce potential of complex dysprosium chloride ions and discharge potentials of alkali metals. It should also be noted that the height of the anodic wave of the current-voltage curves increases with increasing concentration of the depolarizer in the melt (Fig. 4 and 5).

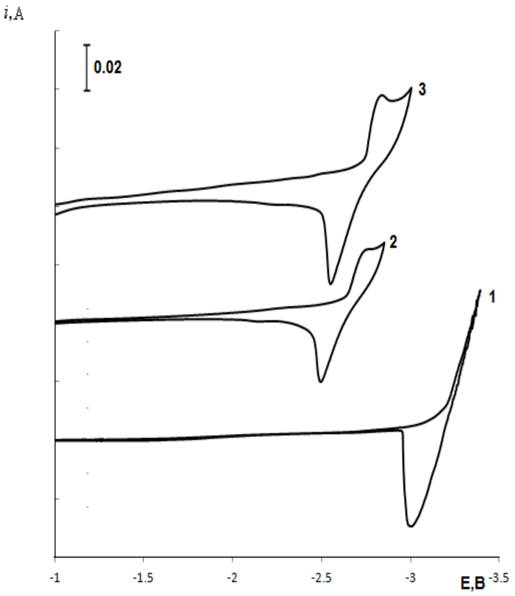


Fig. 2. Cyclic voltammogramms of NaCl–KCl– CsCl – DyCl3 melt at 823K. C(DyCl3)·104, mol/cm3: 1– 0 , 2–3.6, 3–5.6. Working electrode: W, scan rate = 0.1 V/s.

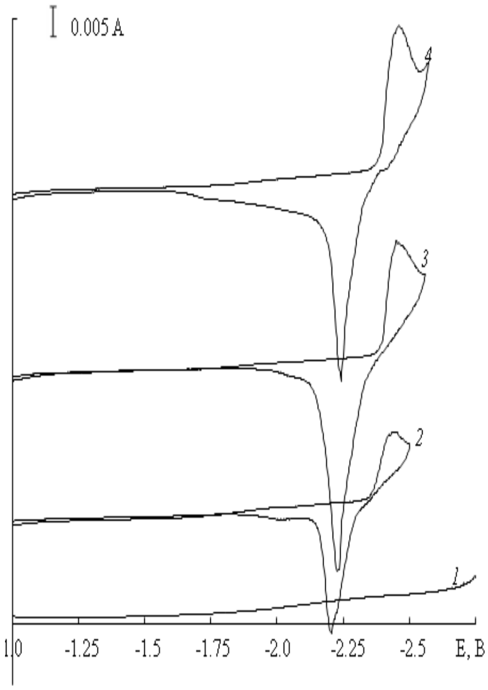


Fig. 3. Cyclic voltammograms of NaCl–KCl– CsCl–DyCl3 melt at 823K. C(DyCl3)·10-4, mol/cm3: 1– 0 , 2–2.0, 3–3.9, 4– 4.7. Working electrode: Ag, scan rate = 0.01 V/s.

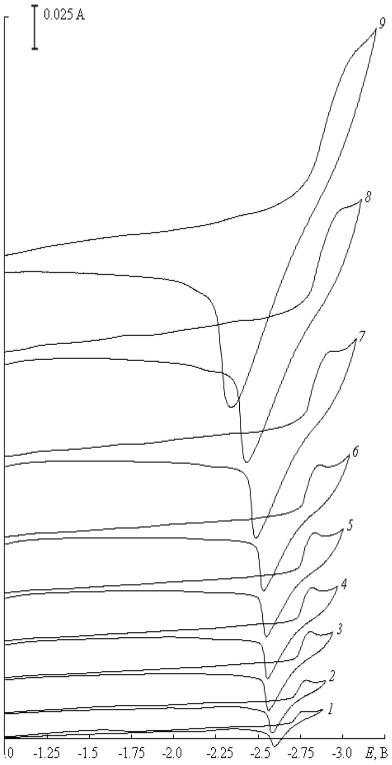


Fig. 4. Cyclic voltammograms of NaCl–KCl–CsCl–DyCl3 melt at different scan

Anhydrous dysprosium chloride is very hygroscopic compound. Anhydrous trichloride was prepared from hexahydrate DyCl3·6H2O by the known method [17], where the dehydrating agent was the ammonium chloride. All operations with anhydrous chlorides were carried out in glovebox mBraun Labstar 50 in the argon atmosphere. Experiments were carried out in a hermetic quartz cell (Fig. 1) under the argon atmosphere, purified from traces of moisture and oxygen, which is necessary in order to obtain reliable results.

In three-electrode cell, the working electrode was the tungsten (∅ = 1.0 mm) and silver needle electrodes. As the reference electrode we used quasireversible glassy carbon rod electrode. The using of glassy-carbon quasi- electrode help as to avoid the using of oxygen-diaphragms. Oxide ceramics are not compatible with the halide melts containing rare earth ions.

Glassy- carbon quasi- stationary reference electrode, apparently, is a compromise electrode, and is determined by the redox potentials are established with the participation of the various components of the molten salts. Therefore, its parameters depends on the melt composition and temperature. Glass-carbon quasi- stationary reference electrode was used in our researches [17], and previously by the authors [18] in chloride and chloride-fluoride melts. The anode was the glass- carbon crucible, which was the container for melt at the same time.

Electroreduction of dysprosium ions was investigated by cyclic voltammetry at scan rate from 0.01 to 1.0V/s. The current-voltage dependence was obtained by the electrochemical complex Autolab PGSTAT30 (Ecochemic, Holland), which was paired with the computer. Eutectic mixture of NaCl–KCl–CsCl was used by solvent. It was prepared from previously recrystallized and dried under vacuum at 423–472 K chloride followed by melting in the argon atmosphere. The electrodes for experiments were mechanically cleaned by the fine sandpaper, and then were polished [19].

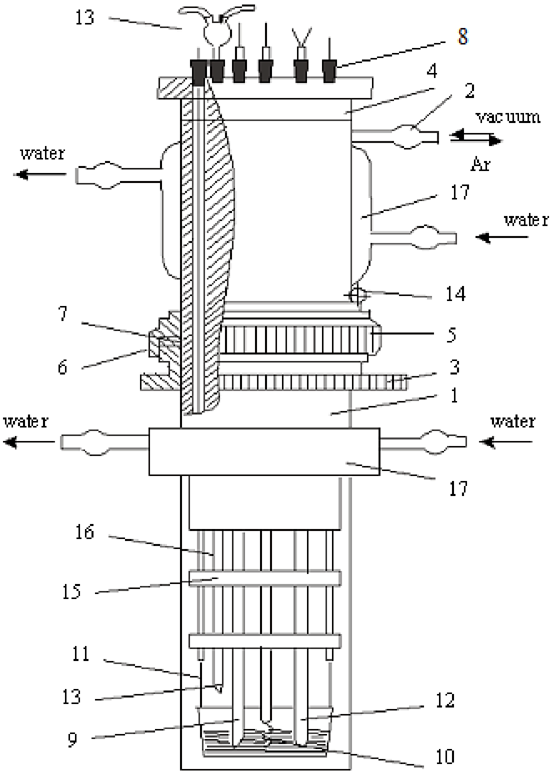


Fig. 1. Scheme of high temperature electrochemical quartz cell. 1–quartz body, 2–union for degassing of the cell, 3–ring threaded, 4–PTFE bushing, 5–steel clamping nut, 6–vacuum rubber ring, 7–ring PTFE, 8– tube from the vacuum rubber, 9–indicate electrode, 10–reference electrode, 11– current leads wire to the anode, 12–thermocouple, 13–boot device, 14–circlip, 15–serpentine washers, 16–porcelain tube, 17–cooling casing.

## 3. Results and discussion

The cyclic voltammograms of dysprosium ions electroreduction process on a tungsten and silver electrodes in NaCl–KCl–CsCl melt shows in Fig. 2 and 3 respectively.

The absence of any waves on the background curve (fig. 2 - 3, curves 1) and low residual current at relatively high negative potentials lead to the conclusion about purity of the background electrolyte. At the concentration of dysprosium trichlorides in the melt about 1.0·10-4 mol/cm3 the electroreduction wave appears on the voltammograms at potentials (-2.6 ÷ -2.9) and ( -2.4 ÷ -2.6 ) V respectively relative quasi-reversible glass -carbon electrode. As seen from the cyclic voltammograms, the increasing

## 1. Introduction

Understanding of the chemical and electrochemical behavior of lanthanide ions in chloride melts was an important task in view of the significant role of pyrochemical processes for the development of a new generation of nuclear reactors for transmutation of plutonium and neptunium processing, improved pyrochemical processing technologies of highly radioactive waste [1-3] and getting clean rare earth metals and various compounds based on them.

A promising way of getting rare earth metals and in particular dysprosium, as well as alloys and its compounds are the electrolysis of molten salts. For the development of an electrochemical method of their reducing it is necessary to have reliable information on the electrochemical behavior of complexes formed by REM ions in halide melts and joint electroreduction lanthanides with the components that make up the alloy and synthesized compounds.

There is some information in literature which dedicate to the study of chemical and electrochemical behavior of dysprosium ions in halide and halide-oxide melts. So, Spedding F. and A. Dahan [4] for the electrochemical production of rare earth metals used molten fluoride system (REM – lithium fluoride – alkali metal fluoride). As for Iosisuke H. [5], he proposed the fluoride-oxide electrolyte for production of high melting point REM (Gd, Sm, Dy, Y).

According Plembek [6], in the eutectic LiCl–KCl melt the metal dysprosium slowly reacts with the melt, forming a solid pale purple melt containing dysprosium in one form or another. In [7] was indicates that the dysprosium ion Dy3+ stable in molten LiCl–KCl, and the authors [8, 9] noted the possibility of formation of Dy3+ and Dy2+ ions.

The possibility of Dy2+ ions existence was also indicated in [10], where the solid metal dysprosium immersed in molten LiCl–KCl–DyCl3. Obtaining of DyCl2 was by the reaction 2DyCl3+Dy↔3DyCl2. However, dichloride dysprosium disproportionate in melt into the metal dysprosium and dysprosium trichloride. Cheng et al [11] explained the formation of the "metallic mist" over the melt by the disproportionation of DyCl2 in the melt. Other way, the authors [12] pointed that the process of Dy3+ ions electroreduction in chloride melts occurs in three-electron reversible reaction.

More detail investigation of the electrochemical behavior of dysprosium ions in eutectic LiCl–KCl melt on tungsten and aluminum electrodes was studied in [13]. The mechanism of Dy3+ ions electroreduction in LiCl–KCl melt was proposed by using various electrochemical methods (voltammetry, chronopotentiometry, square-wave voltammetry). The authors [13] suggested that Dy0 electrodeposition on inert tungsten electrode was in two very closely spaced electrochemical steps: Dy3++1e→Dy2+ and Dy2++2e→Dy0. Electroreduction of Dy3+ ions on the aluminum electrode proceeded by single-stage with the formation of sustainable Dy-Al alloy.

During the studying of rare-earth ions electroreduction [14–16] showed that tungsten is the most indifferent electrode material.

Thus, analysis of published data on the electrochemical behavior of dysprosium ions in chloride melts shows: the first, there are few works and limited information on this issue, and secondly, the available information is often inconsistent and there is no consensus on the mechanism of REM ions electroreduction in chloride melts, and thirdly, most of the studies carried out on the background of a low-temperature LiCl–KCl melt; fourthly, as for dysprosium, if corrosion of metal dysprosium in molten LiCl–KCl–DyCl3 with produced Dy2+ ions is no doubt, that the mechanism, according to the electroreduction of Dy3+ ions on the inert electrode in two very close cathode stage insufficiently substantiated and require further research.

Thus, based on studies conducted earlier by various authors, in this paper we tried to eliminate the alloy effect and identify the true mechanism of the electrode process and studied the electrochemical behavior of chloride complexes of dysprosium on tungsten and silver electrodes in eutectic NaCl–KCl–CsCl melt.

## 2. Experimental

The initial reagent for dysprosium chloride was dysprosium oxide Dy2O3. Oxide was converted into dysprosium chloride hexahydrate with help of hydrochloric acid, followed by decantation with distilled water and double-distilled water and dried in an oven.

# The Electroreduction of Dysprosium ions in Eutectic NaCl –KCl – CsCl Melt at 823K

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## ملخص البحث

## Abstract

The mechanism of dysprosium chloride complexes electroreduction on the tungsten and silver electrodes in NaCl–KCl – CsCl melt at 823 K has been studied by linear and cyclic voltammetry. Some kinetic parameters of processes were calculated. It was shown that the tungsten electrode was indifferent to dysprosium, which were reduced on the surface. We found that the discharge mechanism of dysprosium chloride complexes was described by three-electron step when the steady-state conditions of polarization were limited by the mass transfer stage. The conditions of nonstationary polarization made the slowness of charge transfer stage. The diffusion coefficient was calculated for $DyCl_6^{3+}$ ions diffusion coefficient was $(0.50 \pm 0.2)\cdot 10^{-5}$ $cm^2/s$

**Key Words:** Molten Chlorides, Dysprosium trichloride, Electroreduction mechanism, Tungsten and Silver electrodes, Linear and Cyclic voltammetry, Diffusion coefficient