EAST EUROPEAN JOURNAL OF PHYSICS. 3. 637-642 (2026)
DOI:10.26565/2312-4334-2026-3-59 ISSN 2312-4334

PRODUCING HIGH-PURITY LEAD BY A COMPREHENSIVE REFINING METHOD

Olexii P. Shcherban, Olexandr I. Kondrik, Dmytro O. Solopikhin
National Science Center "Kharkiv Institute of Physics and Technology" N.A.S. of Ukraine,
1 Akademicheskaya St., 61108 Kharkiv, Ukraine
Corresponding Author email: shcherban@kipt.kharkov.ua
Received May 14, 2026; revised July 30, 2025; accepted August 12, 2026

The thermodynamics of redox reactions of the formation of lead oxide and impurity oxides during filtration in an argon atmosphere and Pb distillation under vacuum (~0.5 Pa) was studied. The strength of impurity oxides relative to lead oxide during oxidizing refining and distillation of lead was estimated by the absolute value of the change in Gibbs free energy. A comprehensive distillation refining process of lead was investigated, which includes the stages, such as filtration (oxidizing refining) in an argon atmosphere and lead purification from non-volatile and volatile impurities by evaporation of the metal in a vacuum with condensation of the vapor into a hot liquid phase ($T_{cond} \approx 0.85\ T_{evap}$). Experimental results of the application of a comprehensive process for obtaining high-purity lead of the C000 grade with a total content of majority impurities (in the amount) of 99.9996 mass % are presented.
Keywords: *Lead; Impurity oxides; Lead oxide; Oxygen potential; Gibbs free energy; Lead purification; Oxidizing refining; Filtrtion, Vacuum distillation*

1. INTRODUCTION

High-purity lead is characterized by the three grades: C0000 (99.9999 %, here and below the concentration of elements is given in mass percent), C000 (99.9996 %), C00 (99.9985 %). The majority of impurities are Ag, Cu, Zn, Bi, Sb, Fe, Tl, Hg, Cd, and Ni, with contents of 10-4–10^{-7} %. The above grades of high-purity lead are the product of after purification of lead of lower grades: C0 (99.992 %), C1 (99.985 %), C2 (99.95 %), C3 (99.9 %), which are obtained by processing crude lead, which has the following composition: 96-99 % Pb, 0.05-2.4 % Cu, up to 0.45 % As, 0.6-0.9 % Sb, up to 0.2 % Sn, 0.005-0.07 % Bi, up to 0.6 % Ag [1]. Recently, archaeological lead has attracted particular interest, as it is valued for its low content of the radioactive isotope ^{210}Pb.

High-purity lead (with a basic substance content of 99.99 % and above) is critical in industries where even trace impurities of other metals can affect device accuracy or the stability of chemical reactions, particularly in nuclear physics, semiconductor technology, the production of chemically pure reagents, and scientific applications. High-purity lead serves as a standard reference for complex chemical analyses and spectroscopy. It is widely used as a reliable X-ray and gamma radiation shield, for the manufacture of containers for transporting and storing radioactive substances (isotopes) in medicine and industry, and in batteries for backup power systems where minimal self-discharge and a long service life are required (for example, in space technology or submarine cables). High-purity lead is the basis for precision instrument-making, where it is used to create special alloys and solders, and contact degradation because of impurities that can cause corrosion or resistance changes is unacceptable. Lead is added to special types of glass (e.g., dense flint glass) to increase the refractive index and dispersion of light [2]. High-purity raw material ensures the absence of extraneous color shades and bubbles in telescope and objective lenses. In scientific research (for example, in low-background measurements), special purified archaeological lead with minimal natural radioactive isotopes is used to avoid interfering with highly sensitive sensors. Scintillation crystals of $^{arch}PbWO_4$ and $^{arch}PbMoO_4$ were grown of such lead [3, 4]. Examples of promising applications of low-background experiments using scintillation crystals made of purified archaeological lead can be found in [5-9].

The task of refining the crude alloy is to remove impurities and increase the lead content to standard norms. During refining, noble metals, copper, bismuth, arsenic, antimony, and tin are extracted from lead. At present, most plants use the pyrometallurgical method of lead refining. The fire (pyrometallurgical) method of crude metal refining uses differences in the physical and chemical properties of lead and impurity elements: solubility, melting or boiling point, oxidizing ability or affinity for sulfur, and the ability to form compounds that do not dissolve in the lead melt. During pyrometallurgical refining, impurities are sequentially removed from crude lead in various ways: copper - by liquation and by treating the melt with elemental sulfur; tellurium - by treating the melt with metallic sodium in the presence of caustic soda; arsenic, antimony and tin - by their oxidation; silver and gold - by using metallic zinc; zinc - by oxidation in a lead bath or in an alkaline melt, by vacuuming, and other methods; bismuth is removed with calcium, magnesium, and antimony (in this case, lead is contaminated with these elements); calcium, magnesium, and antimony - by high-quality refining [1].

One method of deep metal refining is vacuum distillation [10, 11]. Distillation is attractive because it can achieve high metal purity with high yield and is environmentally clean. However, simple distillation does not provide the

Cite as: O.P. Shcherban, O.I. Kondrik, D.O. Solopikhin, East Eur. J. Phys. 3, 637 (2026), https://doi.org/10.26565/2312-4334-2026-3-59

required degree of strong removal of separate impurities from lead. A more effective approach to purifying the metal is a comprehensive one.

A feature of lead is that it belongs to fusible metals (T_{melt} = 600.5 K) and is characterized by low vapor pressure at the melting point ($4.3 \cdot 10^{-7}$ Pa) [12]. Analysis of the vapor-pressure dependence on temperature shows that an acceptable rate of lead evaporation in vacuum distillation corresponds to a melt temperature of 1200 ÷ 1250 K. These physical features of lead require new approaches to distillation purification and the development of special devices for their implementation.

In the ISSPMT NSC KIPT, a comprehensive process for lead purification was proposed and a special device for distilling Pb in vacuum was patented. The proposed developments were implemented for the deep purification of archaeological lead [13].

The comprehensive process includes filtration of the initial metal (oxidizing refining) to remove surface contaminants, impurity oxides and lead, various inclusions, followed by vacuum distillation to remove volatile and non-volatile impurities with condensation of metal vapor into the liquid phase at high temperature. This approach has proven effective, but the influence of redox reactions between impurity oxides and lead oxide on impurity behavior during lead filtration and distillation has not been investigated.

The purpose of this work is to study and analyze the thermodynamics of redox reactions of impurity oxides and lead oxide during melting of the initial lead in an inert gas atmosphere and vacuum and its distillation in vacuum, as well as experimental studies of the comprehensive process of the distillation method for obtaining high-purity lead (> 99.9995 %).

2. THERMODYNAMIC ANALYSIS OF REDOX REACTIONS OF IMPURITIES DURING LEAD MELTING AND DISTILLATION

In this work, we carried out a thermodynamic analysis of the oxidation reactions of Pb and the impurities contained in it. We analyzed the content of the following oxygen-active impurities in lead: calcium, sodium, magnesium, arsenic, zinc, silver, iron, copper, tin, antimony, and bismuth. They can be removed from Pb in the form of their stable oxides CaO, Na_2O, MgO, As_2O_3, ZnO, Ag_2O, FeO, CuO, Cu_2O, SnO_2, Sb_2O_3, Bi_2O_3. This removal of impurities can be accomplished by the oxidizing refining of lead which in turn forms with oxygen the stable oxide PbO. The removal of metal impurities from lead in the form of oxides occurs under the condition of greater strength of these oxides compared to the strength of PbO in certain ranges of temperature and pressure changes in the surrounding gas environment. The main characteristic of the strength (stability) of metal impurities oxides MeO is their oxygen potential $\pi_{(MeO)}$, or the decrease in Gibbs free energy ΔG_{MeO} during the formation of oxide compounds. To estimate the strength of metal-impurity oxides in molten lead under atmospheric pressure, the change in standard Gibbs energy, ΔG^0_{MeO}, can be used. The main reaction of oxidizing refining is:

$$\frac{2n}{m}\mathrm{Me} + 2\mathrm{PbO} = \frac{2}{m}\mathrm{Me_nO_m} + \mathrm{Pb}. \quad (1)$$

Here, m and n are indices reflecting the valence ratios of the atoms in the compounds. That is, impurities (Me) replace lead in lead oxide, releasing pure lead, i.e., purifying it.

To compare the oxygen potentials of the formed impurity oxides with each other, the changes in ΔG^0_{MeO} were determined per mole of oxygen, i.e. for reactions that in the general case proceed according to the equation:

$$\frac{2n}{m}\mathrm{Me} + \mathrm{O_2} = \frac{2}{m}\mathrm{Me_nO_m}. \quad (2)$$

In this case, the equilibrium constant of reaction (2) for partial pressures is of the form: $K_p = \frac{a^{2/m}_{Me_nO_m}}{a^{2n/m}_{Me} \cdot (P_{O_2})}$, where a_{Me} and $a_{Me_nO_m}$ – the activity of metal impurities and their oxides, accordingly; P_{O_2} – equilibrium oxygen pressure, which the standard energy change ΔG^o is associated by the relation:

$$\Delta G^o = -RT \cdot \ln K_p = -RT \cdot \ln \frac{1}{(P_{O_2})_{Me_nO_m}} = RT \cdot \ln (P_{O_2})_{Me_nO_m}. \quad (3)$$

At a constant activity of Me_nO_m, which can be taken as unity, the partial pressure of oxygen in the system, which serves as a measure of the strength of the oxide, will be determined by the vapor pressure of the metal being refined in the gas phase. With a decrease in the metal vapor pressure at a constant temperature in the system, the value of $(P_{O_2})_{Me_nO_m}$ increases. That is, a decrease in the metal vapor pressure reduces the strength of the oxide. The vapor pressure of a metal in the gas phase can be reduced using a vacuum. We change the strength of the oxide by reducing the overall pressure in the system. For practical calculations of the effect of vacuum on the strength of oxides, it is convenient to use the change in the standard Gibbs energy corrected for the decrease in pressure from 1 atm., or P = 10^5 Pa. The value of the correction for the transition from the condensed state to the gaseous that with pressure P is determined by the expression (3).

The cases of formation of divalent metal oxide MeO, provided that the boiling point of the metal $T_{boil}(Me)$ is less than the boiling point of the oxide $T_{boil}(MeO)$, and also when $T_{boil}(Me) > T_{boil}(MeO)$ were considered in [14]. With taking into account corresponded stoichiometric coefficients and generalizing the consideration to the case of the formation of an oxide of the M_nO_m type, for the first condition ($T_{boil}(Me_nO_m) > T_{boil}(Me)$, the oxygen potential of the formed oxides Me_nO_m is equal to:

$$\pi^0_{Me_nO_n} = \Delta G^0_{Me_nO_m} - \frac{2n}{m}RT\cdot\ln P \quad (4)$$

In a similar manner and in the case when the boiling point (sublimation) of the oxide $T_{boil}(Me_nO_m)$ is lower than the boiling point of the metal $T_{boil}(Me)$, the correction for reduced pressure is introduced with the opposite sign:

$$\pi^0_{Me_nO_n} = \Delta G^0_{Me_nO_m} + \frac{2}{m}RT\cdot\ln P \quad (5)$$

The detailed description of the model used to calculate the dependences of the change in Gibbs free energy ΔG on temperature and pressure during the formation of impurity oxides in the liquid and vapor phases is also given in [15] with using the example of oxidizing refining in the process of obtaining high-purity tellurium by a comprehensive method.

When transforming to the base 10 logarithm $\ln(x) \approx 2.3026\cdot\lg(x)$ and using the expression for the universal gas constant in joules (R = 8.31 J/mol·K), we have:

$$\pi^0_{Me_nO_n} = \Delta G^0_1 - \frac{2n}{m}19.145T\cdot\lg\left(\frac{P}{1.013\cdot10^5}\right) (T_{boil}(Me_nO_m) > T_{boil}(Me)) \quad (6)$$

$$\pi^0_{Me_nO_n} = \Delta G^0_1 + \frac{2}{m}19.145T\cdot\lg\left(\frac{P}{1.013\cdot10^5}\right) (T_{boil}(Me_nO_m) < T_{boil}(Me)) \quad (7)$$

It was necessary to investigate the influence of atmospheric pressure of the gas medium and vacuum on the strength of oxides in the low-temperature range T = 600 ÷ 1120 K. Calculations of changes in the standard Gibbs energy $\Delta G^0(T)$ and $\Delta G(P, T)$ during the formation of base metal oxide (PbO) and impurity oxides in the liquid and gaseous phases were performed using formulas (6) and (7). The graphs of the obtained dependences are shown in Fig. 1 and Fig. 2. The Ag_2O compound decomposes already at the temperature of ~ 500 K [16], therefore it was not considered.

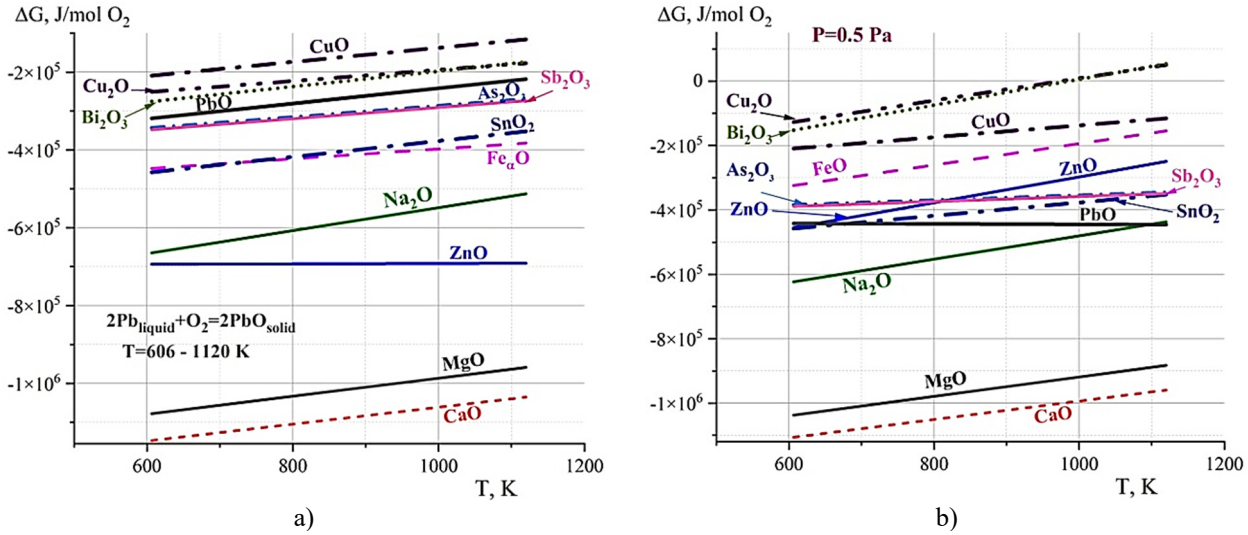


Figure 1. Change in Gibbs potential during the formation of PbO and oxides of impurities Ca, Na, Mg, As, Zn, Fe, Cu, Sn, Sb, Bi in the lead liquid phase during melting in an argon atmosphere, (a) and in a vacuum of 0.5 Pa, (b) in the temperature range of 600 ÷ 1100 K

Analysis of the obtained calculations shows that when melting lead in an argon atmosphere, there are more stable oxides (CaO, MgO, ZnO, Na_2O, $Fe_\alpha O$, SnO_2) in it relative to PbO than when melting in a vacuum (CaO, MgO, Na_2O). The stable oxides concentrate in the lead oxide and are removed from the melt by filtration. As shown in the graphs, as temperature increases, the change in Gibbs potential during oxide formation decreases slightly in absolute value, indicating decreased stability.

Thus, calculations show that a more effective removal of impurities in the form of their oxides by oxidizing refining of molten lead will be carrying out its filtration process in an argon atmosphere and at low temperatures (near the melting temperature of lead in the range of ~ 600 ÷ 650 K).

Fig. 2 shows calculated dependences of the change in the Gibbs potential during the formation of PbO and oxides of impurities in the lead liquid phase in temperature region which includes the temperatures (1200 ÷ 1250) K of the distillation purification process of lead in the vacuum of 0.5 Pa.

It can be seen that at high temperatures, the oxides that are stable relative to PbO and the oxides of the remaining impurities are CaO and MgO, which during the distillation process will collect on the surface of the melt and remain as a residue in the crucible. The formation of metal impurity oxides located above PbO will be difficult, since they have a low absolute change in Gibbs energy and therefore are not stable.

The thermodynamic calculations performed, along with their analysis, were taken into account when planning and carrying out the lead purification process using a comprehensive refining method (oxidizing refining and vacuum distillation).

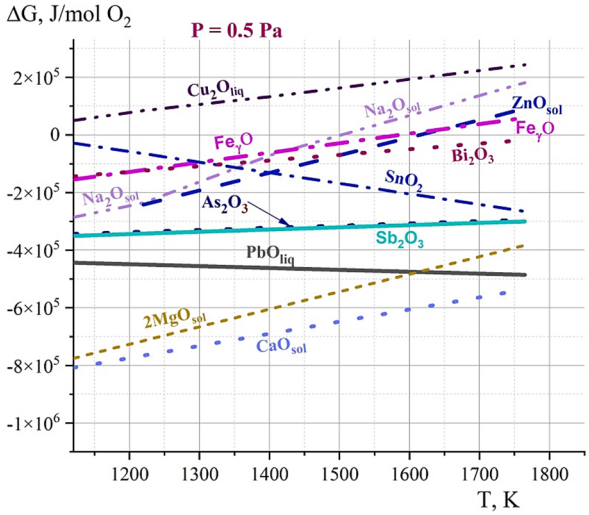


Figure 2. Change in the Gibbs potential during a formation of PbO and oxides of Ca, Na, Mg, As, Zn, Fe, Cu, Sn, Sb, Bi impurities in the lead liquid phase in the vacuum of 0.5 Pa in the high-temperature region of 1120 ÷ 1765 K

3. EXPERIMENTAL STUDIES OF THE COMPREHENSIVE PROCESS OF PRODUCING HIGH-PURITY LEAD BY DISTILLATION METHOD

The distillation method of refining is based on the difference in the composition of the liquid mixture being separated and the vapor formed of it. This difference is estimated by the value of the separation coefficient α. The theoretical foundations of the distillation method of metal purification are presented in [17-19].

The ideal separation coefficient α_i during molecular evaporation is defined as

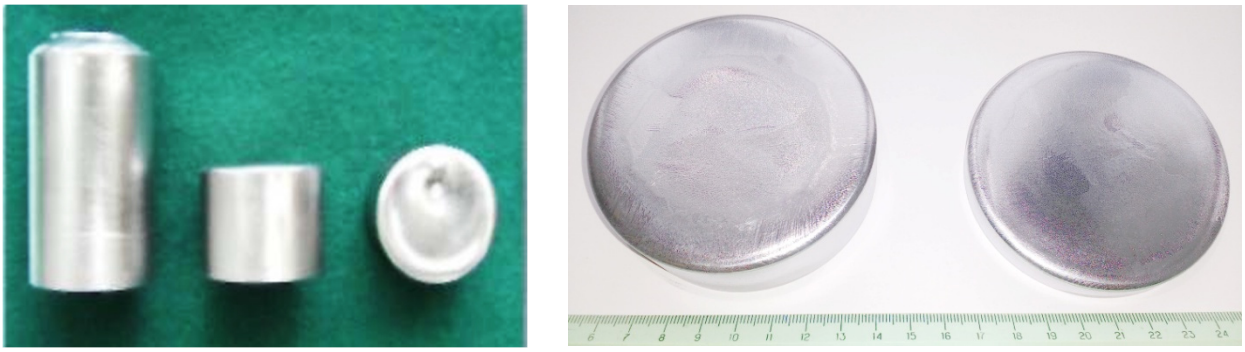
$$\alpha_i = \frac{p_A^0\sqrt{M_B}}{p_B^0\sqrt{M_A}} \tag{8}$$

where p_A^0, p_{AB}^0 - are the vapor pressures of the pure base and impurity components A and B; M_A and M_B are the molecular weights of components A and B, respectively.

Using expression (8), the ideal impurity separation coefficients α_i were calculated at different temperatures, including the lead distillation temperature. By the value of α_i, the impurities in lead can be divided into volatile (Zn, Te, Mg, Sr, Tl, Bi, Ca, Li etc.) with $\alpha_i \sim 10^{-2}$–10^{-5} and non-volatile (Mn, Ag, Al, Ni, Co, Cu, Sn, Si, Cr, Fe, U etc.) with $\alpha_i \sim 10^{2}$–10^{9}. For most impurity elements, α_i differs significantly from 1, suggesting effective purification of lead by vacuum distillation. The values of α_i allow us to estimate the lead refining efficiency of volatile and non-volatile impurities, accounting for the yield of usable lead (losses) [13].

The basic stages of the integrated lead refining process were as follows. The first stage is filtration of liquid lead to remove surface contaminants, oxides of impurities and base metal, various inclusions and partially low-melting metals. The second stage is the distillation of the metal with condensation into a superheated liquid phase to remove volatile and non-volatile impurities.

To implement the integrated method of deep refining, we used a previously developed special device for filtering metals in an argon atmosphere [20] and a special distillation device for distilling Pb in a vacuum [13], the schemes are given in the indicated references, where the processes of filtration and distillation of lead are also described in detail. The filtration and distillation devices were made of high-purity dense graphite (MPG-7 grade) with minimal impurities, characterized by chemical inertness towards lead. Filtration was carried out in a device that combines this process with pouring the metal into measuring ingots. Fig. 3 shows the photos of ingots of filtered lead (a) and distillate (b) of refined lead weighing ~ 1 kg each. If necessary, the lead distillate was also poured into measuring ingots through the filter.



a) b)

Figure 3. Ingots of filtered initial lead (a) and distillation-refined lead (b)

4. RESULTS AND DISCUSSIONS

The initial material for experimental studies of the efficiency of lead purification by the comprehensive method was C0-grade technical lead. The concentration of impurities in it, as well as in that after filtration and distillation, is given in Table 1.

The impurity content in the lead samples was determined by high-resolution laser mass spectrometry. The random error of the analysis results is characterized by the relative standard deviation of 0.15-0.30.

Table 1 lists only the impurity elements regulated by standard norms for impurity content in lead. The purity of the initial lead in terms of the sum of impurities is ~ 99.992 %, which corresponds to the standard C0 grade. Analysis of the results obtained shows that the efficiency of oxidizing refining for individual impurities is 2 - 4 times. The efficiency of the oxidizing refining process can be increased by improving the device for intensifying the redox reactions of impurities in the lead melt, more complete collection of oxides from the surface of the melt, and removal of oxides by filtration.

Table 1. The content of majority impurities in the initial lead, after filtration and distillation in vacuum (distillate)

Impurity	Mass fraction of impurities, no more		
	Initial (C0)	after filtration	distillate (C000)
	$n \cdot 10^{-4}$ %		
Ca	3	1	0.2
Na	5	3	0.1
Mg	2	1	0.3
As	3	2	0.1
Zn	7	5	0.2
Ag	2	1	0.1
Fe	8	2	1
Cu	5	2	0.2
Sn	4	2	1
Sb	6	3	0.3
Bi	35	10	0.4
Pb, %	99.992	99.997	99.9996

If we evaluate the efficiency of distillation purification relative to filtered lead, it ranges from 2 times (Fe, Sn) to 10-30 times (Sb, Na). The low lead purification of Fe and Sn is probably due to the deviation from the ideal behavior of these impurities in lead (non-compliance with ideal separation coefficients). In general, an experimental study on the use of a comprehensive distillation method for lead purification showed that it allows the production of lead C000 grade (99.9996 %) from lead of technical C0 grade (99.992 %), an improvement of almost two orders of magnitude.

The comprehensive process described in this work for obtaining high-purity metals using oxidizing refining was applied to metals such as cadmium and zinc [21].

5. CONCLUSIONS

A thermodynamic analysis of the oxidation reactions of Pb and the impurities Ca, Na, Mg, As, Zn, Fe, Cu, Sn, Sb, Bi present in it during the melting of lead in an argon atmosphere and distillation in a vacuum was carried out. Stable and unstable impurity oxides in relation to the main lead oxide were determined by calculating the change (decrease) in the Gibbs free energy ΔG_{MeO}. These calculations make it possible to determine impurity behavior and plan the choice of technological conditions for the complex lead refining process.

The efficiency of oxidizing refining of lead by filtration of liquid metal according to the scheme of a comprehensive process of distillation purification of lead was investigated. This method reduces the content of major

impurities in the initial lead by 2-4 times. Improving the filtration device can increase the efficiency of the oxidizing refining process.

This paper presents results from experimental investigations of the comprehensive process of distillation refining of lead. Investigations show that the efficiency of this process increases by almost two orders of magnitude (from 99.992 % in the initial material to 99.9996 % in the purified product). The purity of such lead meets the standard norms for high-purity lead of the C000 grade.

ORCID

Olexii P. Shcherban, https://orcid.org/0000-0002-6004-0579; **Olexandr I. Kondrik,** https://orcid.org/0000-0001-9428-4830; **Dmytro O. Solopikhin,** https://orcid.org/0000-0003-1426-8713

REFERENCES

[1] A.M. Verkhovlyuk, A.V. Narivsky, and V.G. Mohylatenko, *Technologies for obtaining metals and alloys for foundry production*, (Vinichenko Publishing House, Kyiv, 2016). (in Ukrainian).
[2] B.C. Jamalaiah, L.R. Moorthy, and H.J. Seo, Journal of Non-Crystalline Solids, **358**(2), 204 (2012). https://doi.org/10.1016/j.jnoncrysol.2011.09.007
[3] S. Nagorny, L. Pattavina, M.B. Kosmyna, B.P. Nazarenko, S. Nisi, L. Pagnanini, S. Pirro, *et al*., Journal of Physics: Conf. Series. **841,** 012025 (2017). https://doi.org/10.1088/1742-6596/841/1/012025
[4] A.G. Yakubovskaya, I.A. Tupitsyna, and A.M. Dubovik, Problems of Atomic Science and Technology. **1**(137), 204, (2022). https://doi.org/10.46813/2022-137-204
[5] L. Pattavina, N. Ferreiro Iachellini, and I. Tamborra, Phys. Rev. D, **102**(6), 063001 (2020). https://doi.org/10.1103/PhysRevD.102.063001
[6] L. Pattavina, N. Iachellini, L. Pagnanini, L. Canonica, E. Celi, M. Clemenza, F. Ferroni, *et al*., J. Cosmol. Astropart. Phys. **10**, 064 (2021). http://dx.doi.org/10.1088/1475-7516/2021/10/064
[7] N.F. Iachellini, L. Pattavina, A.H. Abdelhameed, A. Bento, L. Canonica, F. Danevich, O.M. Dubovik, *et al*., J. Low Temp. Phys. **209**(5–6), 872 (2022). https://doi.org/10.1007/s10909-022-02823-8
[8] J.W. Beeman, G. Benato, C. Bucci, L. Canonica, P. Carniti, E. Celi, M. Clemenza, *et al*., Applied Radiation and Isotopes. **194**, 110704 (2023). https://doi.org/10.1016/j.apradiso.2023.110704
[9] D. Alloni, G. Benato, P. Carniti, M. Cataldo, L. Chen, M. Clemenza, M. Consonni, *et al*., Physical review D**, 111**, 103050 (2025). https://doi.org/10.1103/wcvd-rk1f
[10] V.E. Ivanov, I.I. Papirov, G.F. Tikhinsky, and V.M. Amonenko, *Pure and ultrapure metals*, (Metallurgia, Mscow1965). (in Russian)
[11] V.A. Pazukhin, and A.Ya. Fisher, *Separation and refining of metals in vacuum*, (Moscow: Metallurgy, 1969). (in Russian)
[12] A.N. Nesmeyanov, *Vapor Pressure of Chemical Elements,* (Moscow: Publishing House of the USSR Academy of Sciences, 1961). (in Russian)
[13] R.S. Boiko, V.D. Virich, F.A. Danevich, T. I. Dovbush, G. P. Kovtun, S. S. Nagornyi, S. Nisi, *et al*., Inorganic Materials, **47**(6), 645 (2011). https://doi.org/10.1134/S0020168511060069
[14] E. A. Kazachkov, *Calculations on the theory of metallurgical processes*, (Metallurgy, Moscow, 1988). (in Russian)
[15] O.P. Shcherban, D.O. Solopikhin, and O.I. Kondrik, Polish journal of science, **80**, 39 (2024). https://doi.org/10.5281/zenodo.14176578
[16] I.S. Kulikov, *Thermodynamics of oxides,* Reference, (Metallurgy, Moscow, 1986). (in Russian)
[17] G.G. Devyatyh, and Yu.E. Elliev, *Introduction to the theory of deep cleaning substances*, (Metallurgiya, 1973). (in Russian)
[18] A.I. Belyaev, *Fiziko-himicheskie osnovy ochistki metallov i poluprovodnikovyh materialov*, (Metallurgiya, Moscow, 1973). (in Russian)
[19] G.G. Devyatyh, and Yu.E. Elliev, *Glubokaya ochistka veshchestv*, (Vysshaya shkola, Moscow, 1974). (in Russian)
[20] G.P. Kovtun, and O.P. Shcherban, Patent Ukraine No. 1246, 2002. (in Ukrainian)
[21] O.P. Shcherban, D.O. Solopikhin, O.I. Kondrik, and V.D. Virich, Problems of Atomic Science and Technology **1**(161), 15 (2026). https://doi.org/10.46813/2026-161-015

ОТРИМАННЯ СВИНЦЮ ВИСОКОЇ ЧИСТОТИ КОМПЛЕКСНИМ МЕТОДОМ РАФІНУВАННЯ

Олексій П. Щербань, Олександр І. Кондрик, Дмитро О. Солопіхін

Національний науковий центр «Харківський фізико-технічний інститут» НАН України, вул. Академічна, 1, 61108, Харків, Україна

Досліджено термодинаміку окисно-відновлювальних реакцій утворення оксиду свинцю і оксидів домішок при фільтрації у атмосфері аргону і дистиляції Pb у вакуумі ~ 0,5 Па. По абсолютній величині зміни вільної енергії Гіббса оцінено міцності оксидів домішок по відношенню до оксиду свинцю при окисному рафінуванні і дистиляції свинцю. Досліджено комплексний процес дистиляційного рафінування свинцю, який включає такі етапи як фільтрацію (окисне рафінування) в атмосфері аргону і очистку свинцю від важколетких і легколетких домішок шляхом випаровування металу у вакуумі з конденсацією пару у гарячу рідку фазу ($T_{конд.} \approx 0{,}85\ T_{вип.}$). Наведено експериментальні результати застосування комплексного процесу для отримання свинцю високої чистоти марки С000 з сумарним вмістом основних домішок на рівні 99,9996 мас. %.

Ключові слова: *свинець; оксиди домішок; оксид свинцю; кисневий потенціал; вільна енергія Гіббса; очистка свинцю; окисне рафінування; фільтрація; дистиляція у вакуумі*