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**INVESTIGATIONS OF PYROMETALLURGICAL AND ELECTROLYTIC
CLEANING PROCESSES OF BISMUTH CONNECTIONS AND SURVEY
OF NEW TECHNOLOGIES FOR PROCESSING OF VISIBLE DROSSES
RECEIVED AFTER RAINING OF BLACK LEAD WITH MINERAL
WASTE DISPOSAL**

Abstract. The article presents a literature review and possible ways of obtaining high purity bismuth of the Vu000, Vio0000 grades with a combination of pyrometallurgical and electrolytic cleaning schemes using simple equipment that ensures its competitiveness at cost and simplicity of technical solutions. The technology of obtaining bismuth is a unique connection with this, it is not fully disclosed. The results of the study show the high purity of the product obtained, the work on the selection of the electrolyte composition, the preparation of the anodes and the electrolytic refining of bismuth and the processing of the technology regimes are completed.

Key words: bismuth grade Bi000, impurities, electrolysis, refining, waste.

Bismuth is a very rare and rather scattered element. According to various estimates, the average content (clarke) of a given element in the earth's crust is from $9 \cdot 10^{-7}\%$ to $2 \cdot 10^{-5}\%$ by mass, which means that per ton of the material of the earth's crust there are only 0.2 grams of bismuth [1- 3]. By the prevalence in the bowels of our planet, bismuth occupies the seventy-first place. Its less than silver, less than many elements of the rare and scattered - thallium, indium, cadmium. Today, this element is necessary for every country with a highly developed industry. Over the past decades, the demand and the price of this metal have risen sharply, as electronics and nuclear power have added to such traditional consumers of bismuth (primarily high-purity brands) as metallurgy, pharmaceuticals and the chemical industry [4-6].

Currently, the main producers of high purity bismuth are China (up to 70%), Russia, Bolivia, Peru, Mexico, Australia and the USA [7].

In the Republic of Kazakhstan during the Soviet period, the main producers of bismuth metal were lead-zinc and copper-smelting industries, since in the process of processing of basic metals, it was required to clean the bismuth that was present without fail. The ordinary bismuth grades were produced, which were sent mainly to Russia, where the brands of higher purity were produced, mainly by the method of repeated recrystallization, by the vacuum distillation method, the main disadvantages of which were low productivity, the complexity of the process and the use of expensive equipment. It was for these years that the main research was devoted to developing technologies for further purification of bismuth to the highest purification grades. One of the main producers of bismuth in the Republic of Kazakhstan until 2011 was the corporation "Yuzhpolimetall", which produced bismuth of certain brands of high purity. A small amount of bismuth of ordinary grades produces lead-zinc production of the corporation "Kazzinc".

The program for the development of the mining and metallurgical industry provides for an increase in processing of the main types of mined raw materials for obtaining products with high added value and,

ultimately, the creation of metallurgical industries and subsequent redistribution, ensuring the development of high-tech industries and exports. In Kazakhstan, the main source of bismuth production of ordinary grades is lead-copper production, in the technological process of which, redistribution from bismuth to bismuth-containing drosses is envisaged, electrolytically processed to produce bismuth sludge, smelting it to rough bismuth and purging of impurities to B1 grades, Be2, Bu0, and B00. The most pure in content impurities in the process of such redistribution is Bio. Bismuth grades B000, B0000 are obtained by zone recrystallization in an inert gas atmosphere, by a vacuum distillation method. These methods are not characterized by high productivity and do not give a high extraction of bismuth into the final product.

The scientific novelty of the work is to obtain high purity bismuth of the brands Vi000, Vio0000 with a combination of pyrometallurgical and electrolytic cleaning schemes on simple equipment, which ensures its competitiveness at cost and simplicity of technical solutions.

At present, we have preliminary results of studies on the production of Bi000 bismuth with a pyrometallurgical method, including a phased purification from the impurity impurities. The purification regimes, the characteristics of the main equipment have been worked out, which are the novelty of this study. The next step is to obtain Bio0000 by electrolytic refining of B000 in electrolyzers with solid anodes. There are preliminary positive results on the composition of the electrolyte, the preparation of anodes, the electrolytic refining of bismuth, the melting of cathode metal, the nomenclature and the technological strapping of the main equipment. This method completely has a scientific novelty.

The starting materials for the production of bismuth with a content of the main substance 99.999% and 99.9999% (B000 and B0000) can be the ordinary bismuth brands Bio and BvOO, obtained during the electrolytic processing of bismuth dyes from the refining of leaded lead. The technology of pyrometallurgical purification consists of 1) removal of lead impurities, special additives having a close affinity for lead 2) carrying out desulfurization operation - removal of silver, nickel and copper 3) removal of cadmium, thallium and residual lead content 4) qualitative refining - removal of chlorides. This stage allows the above impurities to be removed to the content specified in GOST 10998 for 99.999% purity bismuth (B000). The mode parameters and additives used contain novelty. The technology of the second stage provides for the electrolytic refining of Bi000 bismuth in electrolyzers with solid anodes. The technology is based on the anodic dissolution of Bi000 bismuth and the deposition of dendrites on a portable titanium cathode. The composition of the electrolyte, the regime parameters of the process have scientific novelty. The technology consists of the following stages: 1. Preparation of anodes - melting of Bi000 bismuth, intercalation of the reagent for fine cleaning from the residual quantity of suspended impurities in the form of sulphides, bottling of the anodes in the form of blocks. 2. Preparation of electrolyte 3. Carrying out electrolysis 4. Stripping of cathode metal 5. Washing of dendrites 6. Melting of cathode metal 7. Filling of metal.

The equipment used in the process must be made of inert materials to prevent contamination by impurities of the guest metals - titanium, graphite of special purity. Reagents used for cleaning should have a mark not lower than "hh" / or "och".

There are no analogues of the proposed production in the RK and the CIS countries. The competitiveness of the proposed bismuth production of the brands Vi000, Bio0000 at the cost and simplicity of technical solutions will allow us to compete only with the main producer - China [8-15].

All existing technologies are based on pyro- or hydrometallurgical cleaning methods, which do not allow achieving the required purity. The method of purification of bismuth [16] does not allow to purify from Te and Ag to the required content, the method of vacuum distillation of bismuth [17] allows to significantly reduce the lead content in bismuth, but this method is effective only for pre-purified bismuth and is used only at the finishing stages of bismuth refining and in small volumes. A hydrometallurgical method for processing bismuth-containing materials to produce bismuth powder [18] is known, B000, however, the disadvantages of this method is the complexity of the process, the use of expensive and complex in composition reagents.

The purpose of this article is to show the possibility of organizing an experimental production of bismuth production of the brands Vi000, Vi0000, and attracting investments for the commercialization of

products of the developed technology. The commercial attractiveness of the technology is the steadily increasing demand for high purity bismuth, the scope of which is expanding due to the development of such high-tech industries as the semiconductor industry, the development of nuclear power [19-23]. The cost of high-grade bismuth reaches \$ 100 per kilogram. World production currently amounts to about 10,000 tons per year [24-29]. The proposed production of bismuth in the case of commercialization of the results of the study will yield more than 200 tons per year. The volume of the market is unlimited.

The spectrum of potential consumers of high purity bismuth is extensive [30-34, 25,10].

1. The pharmaceutical industry has a share that accounts for 45% of world consumption. In Russia and abroad (manufacturers Gist-Brokaades (Netherlands), M / S Elder Pharmaceutical Ltd (India), Torrent Pharmaceuticals (India), Yamanouchi Europe (Japan), Laboratories INC (USA))) used compounds made on the basis of high purity bismuth - basic and average nitrates, basic carbonate, salicylate, tartrate, gallate, tribromophenolate, bismuth citrate. These compounds are used as substances in the synthesis of drugs "Vikalin", "Vicair", "Xeroform", "Dermatol", "Bismoverol", "Bijohinol", "De-Nol", "Tribimol", "Telen", Desmol ", " Pilorid ", etc. As modern studies have shown, bismuth compounds have antitumor activity and can be promising for the treatment of HIV, AIDS and AIDS-related diseases.

2. Metallurgical industry - (production of low-melting alloys with lead, tin, cadmium, in the manufacture of molds for precision casting, dies, marking, assembly and control devices, for improving the machinability of aluminum, cast iron and steel alloys in the manufacture of aircraft and motor vehicles)

3. The chemical industry - as a catalyst in the production of synthetic fibers, etc.

4. Nuclear power - bismuth - a liquid coolant and a cooling agent. A small cross section for the capture of thermal neutrons by bismuth and a significant ability to dissolve uranium, together with a significant boiling point and low aggressiveness to structural materials, make it possible to use bismuth in homogeneous nuclear reactors

5. Electronics - an alloy of 88% Bi and 12% Sb in a magnetic field exhibits an anomalous effect of magnetoresistance; of this alloy, high-speed amplifiers and switches are manufactured. tungstate, stannate-vanadate, silicate and bismuth niobate are part of the high-temperature ferroelectric materials, bismuth ferrite BiFeO_3 in the form of thin films is a promising magnetoelectric material. Bismuth is one of the components of lead-free solders, as well as low-melting solders, used for mounting particularly sensitive microwave components.

6. Ceramic industry - fusible enamels, etc.

The enumeration of all industries where it is possible to use high purity bismuth will take a sufficiently large page volume. Bismuth salts are used in areas very far from each other. This, for example, the production of pearlescent lipstick and the production of paints for road signs.

The proposed technology for the production of high purity bismuth of the brands Vi000, Vi0000 will allow the production of high-tech and export-oriented products with a wide range of applications for such industries as metallurgical (in the form of various alloys), pharmaceutical, chemical, nuclear, semiconductor, etc., will contribute in the implementation of the Program for the Development of the Mining and Metallurgical Industry of the Republic of Kazakhstan, will subsequently allow the production of various high-purity commercial products from bismuth that is, products with high added value, the development of Kazakhstan's scientific potential in the production of ultrapure metals, and the reduction of imports of similar products.

We believe that the main social and economic effect of the implementation of this technology can be attributed first and foremost to the transfer of unique knowledge and great practical experience in setting up the production of ultrapure metals of the main technology developers, young scientists, since even in the Soviet era there were a limited number of such specialists.

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**ВИСМУТТЫҢ ҚОСЫЛЫСТАРЫН ПИРОМЕТАЛЛУРГИЯЛЫҚ ЖӘНЕ ЭЛЕКТРОЛИЗ
АРҚЫЛЫ ТАЗАЛАУДЫ ЗЕРТТЕУ МЕН МИНЕРАЛДЫ ҚАЛДЫҚТЫ УТИЛЬДЕУГЕ
ҚОРҒАСЫННЫҢ РАФИНАЦИЯСЫНАН БӨЛІНЕТІН ВИСМУТТИ ДРОССТАРДАН
ҚАЙТА ӨНДЕУДІҢ ЖАҢА ТЕХНОЛОГИЯЛАРЫН ЖАСАУ**

Аннотация: мақалада Ви000, Ви0000 маркалы висмут алу бойынша әдеби шолу және оны жоғары тазалықта өндіру үшін пирометаллургиялық және электролиттік тазарту схемаларының комбинациясы негізінде техникалық шешімдері оңтайлы мен қарапайым жабдықта бәсекеге қабілеттілігін қамтамасыз ету мақсатында ықтимал әдістері қарастырылады. Висмут алу технологиясы бірегей болғандықтан мақалада толығымен ашылып көрсетілмеген. Зерттеу нәтижелері өнімнің жоғары тазалығын көрсетті, анод пен электролит құрамы анықталды, висмут алудың технологиялық режимдерін айқындалды.

Түйін сөздер: Ви маркалы висмут, қоспа, электролиз, рафинациялау, қалдықтар

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**ИССЛЕДОВАНИЯ ПИРОМЕТАЛЛУРГИЧЕСКОЙ И ЭЛЕКТРОЛИТИЧЕСКОЙ СХЕМ ОЧИСТКИ
СОЕДИНЕНИЙ ВИСМУТА И ИЗЫСКАНИЕ НОВЫХ ТЕХНОЛОГИЙ ПЕРЕРАБОТКИ
ВИСМУТИСТЫХ ДРОССОВ, ПОЛУЧЕННЫХ ПОСЛЕ РАФИНИРОВАНИЯ ЧЕРНОВОГО
СВИНЦА С УТИЛИЗАЦИЕЙ МИНЕРАЛЬНОГО ОТХОДА**

Аннотация. в статье представлены литературный обзор и возможные способы получения висмута высокой чистоты марок Ви000, Ви0000 с сочетанием пирометаллургической и электролитической схем очистки на простом оборудовании, обеспечивающая ее конкурентоспособность по себестоимости и простоте технических решений. Технология получения висмута является уникальной связи с этим оно не раскрыто полностью. Результаты исследования показывают высокую чистоту получаемого продукта, завершены работы по подбору состава электролита, подготовки анодов и проведению электролитного рафинирования висмута и отработка режимов технологии.

Ключевые слова: висмут марки Ви000, примеси, электролиз, рафинирование, отходы.