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AFFINAGE OF INDIUM

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Traditional and new technologies of affinage of indium from the degree of cleanness of rough metal to the high-clean state: chemical (including, method of disproportionation of more subzero chlorides), electrochemical (including, reactionary and thin-layer electrolysis, amalgam affinage), vacuum-thermal distillation, electrotransfer are considered.

Keywords: indium, affinage, acidization, vacuum-thermal distillation, electrolytic affinage, crystallization methods, electrotransfer.

The basic sources for receipt of indium are served intermediate foods as zinc and leaden productions. The main source of secondary indium serves as recycling bits of targets of dusting, used for creation conducting layers of ITO (indium-tin-oxide). A height of stake for cheaper indium, got by recycling, is the important factor of pricing, retentive a price advance on an indium [1].

A draft indium is got from intermediates zinc (wastes of affinage of zinc, sublinates of veldts- or fuming-processes, copper-cadmium cakes) and leaden (dusts of the restoration melting, veldts-oxides and wastes of affinage of lead) productions. They are processed by sulphuric acid and from solutions, after cleaning from zinc, copper and cadmium, a draft indium isolate by cementation or electrolysis. Depending on content of admixtures in initial solution a draft metal contains 96-99 % indium.

Melting the got cementation of indium sponge under the layer of alfeli results in cleaning of indium from the admixtures of aluminium, zinc, lead and tin, and melting under the layer of glycerin allows to reduce content of admixtures for zinc, iron, thallium and cadmium, possessing large affinity to the chlorine, than indium, to $1.6 \cdot 10^{-4}$ % [2]. Melting under the layer of glycerin, containing the iodide of potassium, use for cleaning of indium from thallium and cadmium.

At extraction of indium from secondary raw material (wastes of leaden-tin alloys) can be used one of chemical methods is extraction, in this case extraction of indium by salt fusion of chlorous zinc [3].

The method of chemical transport reactions (in his interpretation of the deep cleaning of metals through their subconnections) is used and as it applies to an indium. So, in-process [4] the process of cleaning of monochloride of indium *InCl* the area melting from the admixtures of *Fe*, *Ni* and *Cu* is researched. The cleared monochloride can be used for the receipt of high-purity indium by the method of disproportionation.

At processing of wastes of indiumcontain connections of type of $A^{III}B^{V}$ used the exchange reactions of higher chloride of indium $InCl_3$ with *InAs* or *InSb* in fusible

eutectics: $Li(Na,K)Cl + nZnCl_2 + mNH_4Cl$ with formation of monochloride of indium [5].

Electrolysis with liquid bipolar electrodes used for the selection of metallic indium. An electrolyte on the basis of fusible eutectic here is in the reserved cycle: it is satiated by the monochloride of indium and impoverished by an indium which is electrolytically besieged as a draft metal (99.9-99.99 % *In*). After two-phase successive reprecipitation in an aquatic electrolyte got the high-purity indium (content of admixtures at the level of $1 \cdot 10^{-4}$-$1 \cdot 10^{-5}$ %).

High-clean indium powders open new possibilities for the use of indium at a technique. Among the different methods for receipt of metallic powders of indium a preference gives oneself up to the method of disproportionation of more subzero chlorides of indium, to allowing to influence on the sizes of particles of the got powder and substantially to promote the cleanness of metal [6].

Indium with a cleanness $5N^+$ can be got an electrodeposition from bath, prepared by dissolution of indium cleanness 99.9 % in dilute sulphuric acid [7].

The process of amalgam affinage consists in the electrolytic selection of indium on a mercury cathode with formation of amalgam, anodic decomposition of amalgam and besieging of the cleared indium on a cathode. At anodic decomposition of amalgam an indium clears up from next elements: *Mn, Zn, Ga, Fe, Ni, Co, Cu, Bi, Pb, Sn, As, Sb, Be*, id est, combining cathode and anodic processes, it is possible to clean an indium from the large number of trace-elements. As an electrolyte use dilute acids (sulphuric or hydrochloric). The receipt of amalgam and her decomposition usually combine in one electrolyzer with a bipolar mercury electrode. An amalgam method provides cleaning of indium to the degree of cleanness $5N^5$. After an amalgam affinage an indium contains the admixture of mercury which is deleted by melting in a vacuum inevitably.

The plant tests of affinage of indium by the method of vacuum-thermal treatment (temperature 900 °C, remaining pressure is 0.13-1.3 Pa, self-control of 10 hour) showed [8], that a draft indium at these parameters of process can be purged from admixtures to the level of requirements, produced to the indium of brand of In-000 (sum of admixtures - less than $8 \cdot 10^{-4}$ %).

It is offered a method and device for the receipt of indium cleanness 6N by the method of a vacuum distillation in patent [9]. Metal with cleanness 99.99 % loaded in crucible, located in overhead part of furnace, and heated him in a vacuum 0.01 Pa to the temperature 1250 °C. An indium evaporates and condenses on the internal surface of pipe and flows down in crucible, located in the underbody of stove.

The indium of the highest cleanness (7N) was got the method of electromigration in a liquid metal [10], which is based on the directed motion of admixtures at imposition on a molten metal mutually perpendicular electric and magnetic fields. Thus content of nickel and tin in the indium goes down in 10 times, coppers - in 3 times.

Crystallizational methods (area melting and growing of single-crystals on Chokhralsky) are carry out the deep cleaning of indium from the admixtures of copper, nickel and silver, at which coefficients of distribution in an indium less 0,1.

Conclusion. For pre-cleaning of indium from admixtures apply an acidization. For the deep cleaning use the method of chemical transport reactions, vacuum-thermal distillation, electrochemical, crystallizational methods, and also reactionary and lowlayer electrolysis and electromigration.

LIST OF LITERATURE

1. Наумов, А. В. О современном состоянии рынка индия [Текст] / А.В. Наумов, М.А. Наумова // Цветная металлургия. – 2012. – № 4. – С. 57-61.
2. Колобов, Г. А. Рафинирование галлия и индия [Текст] / Г. А. Колобов, В. В. Павлов, Ю. В. Мосейко // Теория и практика металлургии. – 2013. – № 3-4 (92-93). – С. 62-67.
3. Дьяков, В. Е. Исследование экстракции индия расплавом солей из металлических отходов [Текст] / В. Е. Дьяков // Известия вузов. Цветная металлургия. – 2012. – № 4. – С. 30-34.
4. Лебедев, В. В. Поведение примесей в процессе очистки монохлорида индия зонной плавкой [Текст] / В. В. Лебедев, В. П. Фомин // Металлургия : научные труды Запорожской государственной инженерной академии. – Запорожье : ЗГИА, 2000. – Вып. 3. – С. 34-36.
5. Козин, В. Ф. Разработка эффективных способов переработки вторичного сырья на основе соединений $A^{III}B^{V}$ [Текст] / В. Ф. Козин, И. А. Шека, А. А. Омельчук / X конференция по химии высокочистых веществ. – Нижний Новгород : ИХВВ РАН, 1995. – С. 232-233.
6. Физико-химический метод получения индиевого порошка высокой чистоты [Текст] / Л .А. Казанбаев, П. А. Козлов, В. Л. Кубасов, С. А. Загребин // Цветные металлы. – 2003. – № 1. – С. 33-35.
7. Zhou, Zhi-hua. Preparation of high-purity indium by electrorefining [Text] / Zhi-hua Zhou, Hong-bing Mo, Dong-ming Zeng // Trans. Nonferrous Metals Soc. China. – 2004. – 14. – N 3. – P. 637-640.
8. Вакуум-термическое рафинирование индия [Текст] / Л. А. Казанбаев, П. А. Козлов, В. Л. Кубасов, С. А. Загребин // Цветные металлы. – 2003. – № 1. – С. 36-38.
9. Method and apparatus for enhanced purification of high-purity metals [Text] : pat. 6932852 USA : МПК7 C 21 C 7/10. Tayama K., Hodozuka T., заявитель и патентообладатель. – Dowa Mining Co., Ltd. – № 10/613545; заявл. 02.07.2003; опубл. 23.08.2005.
10. Трунин, Е. Б. Получение индия и галлия высокой чистоты методом электропереноса в магнитном поле [Текст] / Е. Б. Трунин, О. Е. Трунина // Неорганические материалы. – 2003. – № 8. – С. 936-939.