УДК 54.05 **Химические науки**

Иванов Кирилл Сергеевич, *студент 4 курса, Педагогический факультет*
Ставропольский государственный педагогический институт
Россия, г. Ставрополь
Гончаров Артем Сергеевич, *студент 4 курса, Педагогический факультет*
Ставропольский государственный педагогический институт
Россия, г. Ставрополь

ЭФФЕКТИВНЫЕ СПОСОБЫ АФФИНАЖА СЕРЕБРА ИЗ ЧИСЛА ДОСТУПНЫХ РЕАГЕНТОВ

Annotation: This article is devoted to the study of the features of the methods of silver refining in a laboratory and a small factory, a small enterprise. The relevance of the topic lies in the need for a more detailed study of the methods of obtaining silver from available materials. The practical significance is due to the possibility of using the materials of the article for effective refining outside of special means and equipment of a large plant. The result of the study was the definition of basic and mixed methods of silver refining at minimal cost.

Keywords: silver, gold, chlorine, oxide, refining, method, reduction.

Аннотация: Настоящая статья посвящена изучению особенностей способов аффинажа серебра в условиях лаборатории и небольшого завода, малого предприятия. Актуальность темы заключается в необходимости более детального изучения способов получения серебра из доступных материалов. Практическая значимость обусловлена возможностью использования материалов статьи для эффективного аффинажа вне специальных средств и оборудования крупного завода. Результатом исследования стало определение базовых и смешанных способов аффинажа серебра при минимальных затратах.

Ключевые слова: серебро, золото, хлор, оксид, аффинаж, способ, восстановление.

The demand for refining technology is due to the possibility of improving the measures and methods for obtaining high-purity silver. Traditionally, silver refining is usually subdivided into four main methods: 1) the method of cupelling; 2) chlorine refining; 3) electrolytic refining; 4) chemical refining. Like the refining of gold, the refining of silver is of value, first of all, for obtaining a mass of precious metals for industrial, economic and aesthetic purposes.

The cupellation method is used when a silver alloy with a low fineness. This method is based on the property of lead melted with silver. Lead is oxidized in air, separating from the metal together with impurities. Gold, platinum and other metals of the platinum family are not separated. These metals remain alloyed with silver. A furnace with an assay crucible is used. The furnace is covered with porous limestone clay (SiO_2 + R_2O_3), which absorbs Pb_2O_3 (evaporates from the alloy under the influence of air flow). After the completion of oxidation and the transition of lead to oxide, the surface of the alloy takes on an iridescent color [1].

Chlorine refining is equally popular. This method is based on the fact that base metals and silver are more easily oxidized by chlorine than gold. Chlorine gas is passed through molten metal (blister gold). Chlorine primarily reacts with base metals and silver. Chlorine is the last to react with gold and PT group metals. The formed chlorides float to the surface (because they have a lower density). Chlorine refining is a very effective way to get pure silver. Chlorine refining is suitable for small enterprises [5].

The method of electrolytic refining is carried out in forms of sandstone, which contain a solution of $AgNO_3$ (with a content of not more than 50 g/1) and a HNO_3 1.5 g / l. The current density should be 2 A / dm2. In this case, the anodes should be made of contaminated silver, and the cathode – of strips, long pieces of stainless steel [4].

The anodes are placed in canvas bags, which collect insoluble impurities. Silver will precipitate at the cathode in the form of crystals (these crystals are regularly scraped off for efficiency). The electrolyte accumulates copper and must be changed regularly.

It should be noted that traditional silver refining technologies are based on electrochemical processes. The starting materials, for example silver-based alloys, are cast in the form of anodes after remelting and subjected to anodic dissolution in nitric acid electrolytes.

Silver of commercial purity is obtained at the cathode, gold and platinoids form a sludge. At this time, the dissolved impurities (base metals) pass into the electrolyte. As they accumulate, base metals can be deposited on the cathode. This contaminates the cathode silver. Contaminated electrolyte must be removed from the bath and replaced with fresh one [4].

The need for electrolyte regeneration is the main disadvantage of the electrochemical refining method.

In the prototype, silver is obtained by electroextraction. Another solution: silver chloride is precipitated from a pure solution and metallic silver is obtained by chemical reduction directly from the chloride. From this point of view, with comparable dimensions of equipment, its complexity and cost, the recovery of silver from AgCl is more efficient than electroextraction.

The chemical method of refining is rarely used in industry and is used in laboratory practice. Just this method is suitable for obtaining silver from available reagents.

Dry AgCl is mixed with an equal weight of Na_2CO_3 and the mixture is slowly heated in a crucible until melted. At the end of the reaction, molten silver is collected at the bottom.

Zinc, iron or aluminum are added to AgCl. 20% H_2SO_4 or HCl is gradually added to the mixture until the evolution of hydrogen ceases. The resulting gray powder is washed, dried and remelted.

Known methods for obtaining pure silver, including chemical dissolution of the original alloy in nitric acid solutions, precipitation from the resulting solution of silver in the form of chloride. To obtain pure silver, chloride thoroughly washed from impurities is melted with soda. Then the chloride is reduced in solutions using cementation with zinc, metallic iron and other methods. Recently, the use of hydrogen has become popular [2].

In a particular case, AgCl is stirred in a solution containing 15-20% ethyl alcohol. To restore silver, add sugar syrup containing 70-90% sugar. Usually, silver recovery is carried out at a temperature of 50-70 ℃.

The syncretic method (using C_2H_5OH and $C_{12}H_{22}O_{11}$) can be distinguished from the number of available reagents and optimal thermodynamic capabilities.

At atmospheric pressure and moderate temperatures, the activation energy for the reduction of silver from its chloride with alcohol is quite high. The process is practically not going on. Heating a mixture based on alcohol to activate the process is technologically undesirable (1).

1 2AgCl + C_2H_5OH + $3H_2O$ = 1 2Ag + 1 2HCl + $2CO_2$ (1)

The recovery of silver from its chloride with sugar at high rates occurs when the mixture is heated from 50-70 ° C and above.

1 18AgCl + 2C12H22O11 + 37H20 + 1 18Ag + 1 18HCl + 14CO2 + 9CO + C (2)

In an alcohol-containing solution, the curdled precipitate of silver chloride disintegrates into tiny particles. The speed and completeness of silver recovery from such a precipitate is maximally possible.

In addition, the reducing potential of the C_2H_5OH – $C_{12}H_{22}O_{11}$ system is higher than when sugar is used. These circumstances have a positive effect on the heterogeneous process of silver reduction by reaction (2). So, the speed and completeness of silver recovery increases.

Thus, the recovery of silver chloride, based on the use of available reagents, provides a solution to the problem of efficiently obtaining silver at minimal cost or when it is impossible to use suitable equipment. In general, the proposed method of silver refining includes the dissolution of the feedstock, purification of solutions from impurities, precipitation of silver chloride and its reduction treatment in C_2H_5OH – $C_{12}H_{22}O_{11}$ solution. Further it is possible isoplzovat HNO_3.

The recovery treatment of silver chloride is carried out with a portionwise addition of sugar to an alcoholic solution, or rather sugar syrup with a water content of 10-30%. A syrup with a lower water content requires overheating, which is undesirable in this case. The use of a more diluted syrup increases the volume of circulating solutions and is accompanied by a decrease in the rate of reduction treatment.

The silver chloride recovery temperature must be maintained in the range of 50-70 °C. High temperatures, as already noted, cause intense distillation of alcohol. The reduction of silver according to the proposed method is accompanied by the release of gaseous carbon dioxide (oxide) (2).

At elevated temperatures, the process rates and gas evolution are excessive, solutions and AgCl emissions are possible.

The method of refining silver, including dissolving the feedstock in HNO3 in the presence of ammonium ions, stepwise separation of impurities from the solution and obtaining pure silver differs in a group of aspects. First of all, an HCl solution (with a residual silver content of 3 g / l) is added to the purified solution [4; 5].

The silver is then reduced by stirring in an aqueous alcohol solution and adding sugar. This is how you get metallic silver. The rest of the stock solution is used to dissolve the feedstock. The solution, which is obtained after the dissolution of silver, must be directed to the precipitation of chloride.

The method of refining silver, including dissolving the feedstock in HNO_3 in the presence of ammonium ions, stepwise separation of impurities from the solution and obtaining pure silver differs in a group of aspects. First of all, an HCl solution (with a residual silver content of 3 g/l) is added to the purified solution.

The silver is then reduced by stirring in an aqueous alcohol solution and adding sugar. This is how you get metallic silver. The rest of the stock solution is used to dissolve the feedstock. The solution, which is obtained after the dissolution of silver, must be directed to the precipitation of chloride.

Conclusions. So, we analyzed the main methods of refining silver. During the research, typical methods of refining, its types and directions were shown. In addition, we have proposed several syncretic methods for refining silver. All of these methods are suitable for refining in a laboratory or small business.

Библиографический список:

1. Eriksson R. Experimental determinations of concentration fields in the copper and silver refining systems using probe-beam deflection // Electrochimica Acta. 1995. T. 40. № 6. C. 725-732.
2. Ibragimov R.M., Bernyaev O.G., Kazakov S.A., Skopov G.V. Processing of the silver–zinc crust of the product of refining of raw lead in a copper-smelting converter // Metallurgist. 2019. T. 63. № 5-6. C. 529-533.
3. Khlebnikov A.I. Modern industrial experience of application of vacuum silver distillation for separation of gold-silver alloy // Non-Ferrous Metals. 2014. № 2. C. 25-28.
4. Lebed A.B., Shpoltakova I.A., Mal'Tsev G.I., Zaikov Yu.P., Potapov A.M. Physicochemical investigation of anodic processes involved in silver electrowinning in refining technology // Russian Journal of Inorganic Chemistry. 2013. T. 58. № 4. C. 427-431.
5. Polygalov S.E., Mastugin S.A., Shadrina E.A. To the problem of reducing the amount of harmful emissions when refining silver // Solid State Phenomena. 2018. T. 284. C. 877-881.