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Separation of natural trivalent oxides of arsenic and antimony

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Abstract

It is demonstrated that arsenic oxide can be extracted from materials containing also antimony oxide using a mixed solvent of 1-butanol and n-heptane. The condition is that water generated as a result of esterification is completely removed from the reaction zone as an azeotrope. The ternary liquid system water+n-heptane+1-butanol forms three binary azeotropes and a ternary saddle azeotrope. Hydrolysis of tributyl arsenite gives As_2O_3 with a 90–92% yield. The yield of Sb_2O_3 is almost 100%. The organic heptane+butanol mixture can be used for re-extraction of arsenic (III) from a new portion of the mixture of oxides. Thus, the process is cyclic and economically viable; it does not involve high temperature metal roasting harmful for the environment; energy costs of the process are much lower than those of roasting.

Introduction

As chalcophiles, arsenic and antimony are found in nature mainly as sulfides and other compounds of sulfur [1], [2], [3]. However, they are also found as oxoforms—especially antimony—and frequently together as elementary analogs. Thus, for example Algerian natural senarmontite (antimony ore) contains up to 7% arsenic oxide (As_2O_3), with the content of 20–30% antimony oxide (Sb_2O_3) [4]. Similarly, copper ores desired for their copper are increasingly found to contain higher levels of arsenic and antimony contaminants. While copper smelters are now not emitting arsenic in such amounts as in the past [5], there are problems with arsenic accumulation resulting from human activities for past 100 years or so.

From ores that contain high content of arsenic and antimony (12% or more), those elements are generally extracted by means of oxidizing roasting. Arsenic is usually sublimated between 300 and 600°C as “white arsenic” (arsenic oxide) [2] while for the purpose of full transition of antimony to an oxoform (Sb_2O_3) the material is subjected to an additional roasting above 800°C [3]. However, the pyrometallurgical method of separation alone has failed to ensure the obtaining of prime high-purity products. In their work on selective

leaching of As and Sb contained in anode slimes, Fernández et al. [4] report that although pyrometallurgical and hydrometallurgical processes “dissolve most of the elements present in anode slimes, treatment of the leaching solutions becomes complex, since the separation of the multiple components is difficult”. Notwithstanding the well-developed laboratory methods of separation of these elements [2], [3], such methods still have not found a large-scale application under plant conditions due to a number of technical problems. Moreover and evidently, roasting at the temperatures indicated involves high-energy costs.

The purpose of this work was to develop a new and effective method of separation of arsenic (III) and antimony (III) oxides—applicable also on a large scale and *without* high temperature metal roasting that is costly as well as harmful to the environment.

Section snippets

Experimental

Seven experiments have been conducted in the same manner, with the amounts of starting compounds and the yields of prime products presented in Table 1. The procedure is described as follows (with amounts corresponding to Experiment 1). In the Dean-Stark apparatus and a return condenser provided with a calcium chloride tube, a suspension consisting of 87.5 g (0.3 mole) antimony oxide (III), 19.8 g (0.10 mole) arsenic oxide (III), 53.4 g (0.720 mole) n-butyl alcohol, and 35 ml n-heptane was boiled until …

Results and discussion

It was reported long ago [6] that arsenic oxide can be extracted from mixtures containing compounds of other metals by higher monohydric alcohols of the aliphatic series: $As_2O_3+6ROH \leftrightarrows 2(RO)_3As+3H_2O$ where R is amyl or longer.

Based on this reaction, we attempted to separate arsenic (III) and antimony (III) oxides using amyl and higher alcohols. Our attempts, however, were unsuccessful; antimony oxide was also extracted. Therefore, we have decided to use lower alcohols instead.

We have found that butyl …

Conclusions

Thus, a new method of separation of arsenic (III) and antimony (III) oxides has been developed. Our method is based on the fact that As_2O_3 treated with a mixture of butyl alcohol and heptane is quantitatively dissolved in the organic phase producing tributyl arsenite. Sb_2O_3 quantitatively remains on the reactor bottom. Subsequent hydrolysis of tributyl arsenite produces arsenic oxide.

Arsenic and antimony are considered contaminants in many ores. The method described here provides a solution for …

Acknowledgments

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2019, Transactions of Nonferrous Metals Society of China (English Edition)

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Removal of vanadium (IV) from water solution by sulfated Katira gum-cl-poly (acrylic acid) hydrogel

2019, Colloids and Surfaces A: Physicochemical and Engineering Aspects

> *Citation Excerpt :*
>
> ...Such methods are not useful in a large-scale due to the number of technical problems. Moreover, roasting at the temperature requires high-energy costs [14], adsorption is most effective and economically viable method owing to its high removal efficiency, low cost, ease of operation, and reusability of the adsorbents [15], where inexpensive adsorbents, developed from various industrial and agricultural waste materials are used [16–23]. Recent development of various polymeric materials which are used for the water purification is briefly discussed by Brostow and Lobland [24]....

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2018, Journal of Hazardous Materials

> *Citation Excerpt :*
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> ...Elemental arsenic (As) and antimony (Sb) belong to Group VA of the periodic table, and these two elements can exist together in ore deposits. For example, 7% arsenic oxide and 30% antimony oxide have been detected from the mineral senarmontite [1,2]. Nearly all arsenic and antimony compounds are considerably toxic, especially the inorganic ones [3]....

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Alkaline oxidative pressure leaching of arsenic and antimony bearing dusts

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> ...Under the optimal conditions, the leaching of arsenic and the recovery of antimony reached about 98% and 95%, respectively, but the method was uneconomic due to the large use of Na2S and H2O2. Brostow et al. (2010) developed a new method to separate As2O3 from Sb2O3 using an organic system consisting of 1-butanol and n-heptane in ShellSol D70. Although this process employs recycling and is economically viable, it was applied only in the laboratory, and there are still some problems to be resolved....

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