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Lead and bromide precipitation from aqueous acidic solutions. Potential exploitation in industrial applications

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Abstract

Precipitation of lead and bromide, followed by careful crystallization, is usually discussed when the production or synthesis of lead bromide is involved. However, there are numerous issues, especially concerning the precipitation of lead bromide hydroxide (Pb(OH)Br) and its derivatives in the neutral pH range (6.5–8), that has not been discussed in detail. The importance of the additional research needed for this issue can be justified by the fact that similar pH values can be observed in natural waters. The obtained data suggest that lead bromide hydroxide would be the major solid phase of the resulting precipitate when lead and bromide exist in an aqueous solution in a proper stoichiometry and in the pH range 4.5–8 irrelevantly from the background solution (i.e. acetates or nitrates) or the methodology of precipitation (i.e. mixture of the respective synthetic salts or titration of a concentrated industrial acidic solution containing lead and bromide). The latter was additionally supported by the fact that lead bromide hydroxide was recorded as the end product of a titration which included also ions other than lead and bromide suggesting that, even in the presence of inhibitors in low concentrations, lead bromide hydroxide would be quantitatively precipitated. Additionally, in terms of application, direct precipitation can be certainly examined as a potential treatment option for small scale hydrometallurgical procedures, although the appropriate purification stage cannot be avoided. The obtained results also verified that when the methodology of limited acid demand

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would be initially applied for the selective leaching of constituents (lead and bromide here) from industrial hazardous solid wastes, then the precipitation of the resulting aqueous solution (leachate) would be possible and feasible. Furthermore, dissolution experiments of synthetic lead bromide hydroxide proved that although the nature of the chemical bonds limits its dissolution in water, its solubility is high enough to be characterized as a toxic pollutant, whereas in acidic environments all the respective compounds of the Pb(OH)X where X the respective halogen, would be highly soluble. Also, certain other characterization data, such as SEM, FT-IR and XRD as well as solubility issues of the synthetic Pb(OH)Br are presented.

Keywords: Precipitation; Hydroxy salts; Lead; Bromide; Pb(OH)Br; Titration

1. Introduction

Precipitation processes could be directly used for the treatment of aqueous solutions containing toxic metals. Some of the most common inorganic pollutants (such as heavy metals) can be treated in this way [1]. To this purpose, numerous additives forming rather insoluble solid phases can be used. The most important among them are the hydroxides of alkali and alkali earth metals, such as NaOH, KOH, $Ca(OH)_2$, sulfides, phosphates and carbonates. A brief description of the specific treatment technology can be found elsewhere [2]. On the other hand, precipitation, followed by crystallization in certain occasions, is an important stage in hydrometallurgical procedures. It must be noted that generally the temperatures adopted in hydrometallurgical processes are higher than room temperatures. Certain products obtained from precipitation processes in small or larger scale applications were previously discussed [3]. Additional laboratory studies, concerning lead recovery from aqueous solutions obtained from hydrometallurgical processes suggested the use of certain other precipitation reagents, such as sodium poly-sulfate [4]. Furthermore, toxic metals existing in aqueous solutions may be also removed/recovered by the use, among others, of certain sorbents or flocculants. When the pH values vary, however, especially close to neutral or alkaline, precipitation is always involved. Its extent is not always obvious due to parallel reactions occurring simultaneously regarding the presence of other aqueous ions or interactions with the newly formed solid phases.

In this study, precipitation of lead and bromide in the pH range 4.5–8.5 is examined. To this purpose, two different experimental conditions were adopted. According to the first one, aqueous solutions containing high concentrations of lead and bromide as well as other impurities were titrated at room temperature using NaOH and KOH (1 M) solutions. The specific solutions were obtained from a hydrometallurgical procedure (also at room temperature) previously applied to an industrial toxic solid waste for the selective recovery of lead and bromide. The main aim of this procedure was the recovery and recycling of existing constituents (i.e. lead and bromide) and the examination of other issues such as the role of inhibitors in the case the specific procedure is to be examined as a stage of a hydrometallurgical treatment process. According to the second procedure, lead bromide hydroxide was synthesized using the appropriate aqueous solutions following the experimental conditions proposed in a previous study [5]. The specific procedure leads to the formation of a polycrystalline material. In more recent studies, laurionite lead type compounds (Pb(OH)X where X denotes the halogen) were synthesized and discussed, whereas improved experimental modifications resulted in the formation of monocrystals [6–8]. Detailed information concerning the relative structural data can be found in the previously mentioned literature and the respective data can be correlated with other similar compounds. Cer-