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ENVIROCHEM2023

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4-7. jun 2023. godine, KLADOVO, SRBIJA

KNJIGA IZVODA

BOOK OF ABSTRACTS

ENVIROCHEM2023
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9. simpozijum

Hemija i zaštita životne sredine

EnviroChem2023

sa međunarodnim učešćem

9th Symposium

Chemistry and Environmental Protection

EnviroChem2023

with international participation

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Jarosite sludge - utilization and valuable metals recovery applyingroasting-leachingprocess

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During the conventional roast–leach–electrolysis (RLE) zinc production process, precipitation of the jarosite-type compounds is widely used to remove iron and other metal impurities from the solution. Above mentioned compounds, with the general formula $MFe_3(SO_4)_2(OH)_6$, (M^+=NH_4, Na, K, Ag, etc.), in addition to iron, contain a high concentration of Pb, Cd, Cr, As, Zn, In, Ga, Ge as metal oxides and/or sulfates [1]. Consequently, jarosite is considered hazardous yet valuable waste [2]. In addition, every year around 6-7 million tonnes of jarosite waste is generated globally [3]. Due to large waste volumes and its chemical characteristics, jarosite requires a lot of storage space and monitoring. Unfortunately, this type of waste is often landfilled causing serious environmental problems and irreversible metal and value losses. Hence, an urgent solution for both managing and utilization/recycling is required, to face needs regarding ecological demands and circular economy goals.

In this paper, jarosite sludge, as a specific type of hazardous industrial waste, is used to investigate transformation to the targeted compounds through the comprehensive thermodynamic analysis and experimental roasting process tests. The roasting was conducted to transform iron into insoluble hematite (Fe_2O_3), valuable metals (Zn, Cu, and In) into water-soluble sulfates, and to keep Pb in the form of water-insoluble anglesite ($PbSO_4$). The solid residue obtained after roasting was used in leaching tests to further evaluate the efficiency of the targeted phase transformations.

Theoretical considerations of chemical reactions and phase thermodynamics were performed using the HSC Chemistry v.9.2.3 software [4] to define potential chemical reactions, examine the feasibility of the target transformations, and set the limiting reaction parameters. Further, in the first part of the experimental work, the influence of the roasting process and reaction parameters on the transformation of jarosite sludge phases into target compounds was investigated. This included variations in the reaction time, temperature, and furnace atmosphere influence. The leaching conditions were kept constant (temperature of 25 °C, during 60 min, and solid to liquid ratio of 1/5) to determine the efficiency of phase transformations in the samples obtained by roasting. Changes in the chemical and mineralogical composition and microstructure were analyzed using different analytical methods, including XRD and SEM analysis.

According to the obtained results of the roasting process, it was determined that the phase transformation of jarosite sludge compounds into targeted insoluble hematite and water-soluble sulfates occurs at 730 °C, the time required is 60 min in the air (oxidizing) atmosphere of 1-2 [dm^3/h]/kg of the input material, which is in accordance with the results of the theoretical indications. Also, it is experimentally confirmed that the introduction of sulfate into the roasting atmosphere leads to the incomplete transformation of jarosite and the formation of the unwanted $Fe_2(SO_4)_3$. Leaching results of the sample obtained by the abovementioned optimal roasting conditions show that only 4.5 % of Fe is leached while the rest remains as solid targeted hematite. Also, more than 75 % of In and more than 90 % of other targeted metals (Cu and Zn) are leached, indicating the high efficiency of the roasting process. Phase transformation was confirmed by SEM analysis, showing that hexagonal crystals of jarosite, dominating in the starting material, were completely replaced with the globular microstructure of Fe_2O_3, in the roasted samples. SEM analysis of the leaching residue also confirmed the absence of the water-soluble sulfates and the presence of the anglesite as water-insoluble sulfate. The phase composition of the samples is confirmed by XRD analysis.

This research shows that the proposed process enables the recycling of jarosite through metal transformation and further utilization. The obtained products can be used in industry, while the metal ions can be selectively separated from the sulfate solution and returned to the production streams. This approach contributes to the utilization of jarosite, as hazardous waste, in order to obtain valuable metals, and generally reduces the negative environmental impact by decreasing the amount of disposed waste and reducing the need for primary exploitation.

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