



**MINING AND METALLURGY
INSTITUTE BOR**

and



**TEHNICAL FACULTY BOR,
UNIVERSITY OF BELGRADE**



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**International October
Conference**

**55th International October Conference
on Mining and Metallurgy**

PROCEEDINGS

**Editor:
Ana Kostov**

**15 – 17 October 2024
Hotel “Đerdap” Kladovo, Serbia**



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LEACHING OF FLOTATION TAILINGS WITH A SULFURIC ACID AND AN IONIC LIQUID IN THE PRESENCE OF HYDROGEN PEROXIDE

Dragana Marilović^{1a}, Grozdanka Bogdanović^{1b}

¹Technical Faculty Bor, University of Belgrade, V.J. 12, 19210 Bor, Serbia

^{1a} dmarilovic@tfbor.bg.ac.rs, <https://orcid.org/0000-0001-8301-750X>;

^{1b} gbogdanovic@tfbor.bg.ac.rs, <https://orcid.org/0000-0002-1013-4075>

Abstract

This study focuses on leaching of flotation tailings with sulphuric acid (H₂SO₄) and ionic liquid 1-butyl-3-methyl-imidazolium hydrogen sulfate ([bmim]HSO₄) in the presence of hydrogen peroxide (H₂O₂). Reagent concentrations of 0.01 mol/dm³ and 0.05 mol/dm³ in the presence of 0.1 mol/dm³ H₂O₂ were tested. When leaching with sulphuric acid in the presence of oxidants, the leaching degree of copper was 80.85% (for 0.01 mol/dm³) and 82.24 (for 0.05 mol/dm³). When flotation tailings were leached in an ionic liquid solution with the same concentrations in the presence of oxidants, the leaching degree of copper was 72.56% and 83.14 % for 0.01 and 0.05 mol/dm³, respectively. The results showed that the maximum dissolution of iron of 3.65% in the presence of hydrogen peroxide was attained with 0.05 mol/dm³ H₂SO₄ after 120 min of the reaction and 1 % in the 0.05 mol/dm³ solution of the ionic liquid [bmim]HSO₄ after 120 min of the reaction.

Keywords: flotation tailings, copper, ionic liquid, sulphuric acid

1. INTRODUCTION

Flotation tailings represent waste material generated during the flotation process, and their proper management and storage are crucial for minimizing negative environmental impacts. The flotation tailings pond of the Bor Copper Mine is a major ecological problem not only for the city of Bor, but also for the surrounding soils and rivers. Recent studies have shown that the mining industry produces around 10 billion tons of tailings every year, and this figure is expected to double by 2035. The biggest problem is the dissolution of toxic elements and the acid mine drainage waters that is produced. The recovery of precious metals and other metals from the tailings adds potential value to this raw material [1].

The application of hydrometallurgical operations is possible for raw materials that have a low metal content or a complex composition. The right choice of reagents is important for a successful process. Sulphuric acid is used as one of the most common reagents for leaching copper from flotation tailings [2]. On the other hand, ionic liquids are recognized as green reagents due to their characteristics such as viscosity, thermal stability, negligible volatility, non-toxicity and high conductivity [3].

This paper presents the comparative results of flotation tailings leaching with sulphuric acid (H₂SO₄) and the ionic liquid 1-butyl-3-methyl imidazolium hydrogen sulfate ([bmim]HSO₄) in the presence of hydrogen peroxide (H₂O₂).

2. EXPERIMENTAL

Main elements contained in flotation tailings are copper and iron. Samples with the following chemical composition were used for the experiments:

Table 1. Chemical composition of the flotation tailings

Element	Cu	Cu _{ox}	Fe	Zn	Pb	S	SiO ₂	Fe ₃ O ₄	MgO	CaO	As _{ppm}
%	0.13	0.09	4.22	0.01	0.01	4.70	60.02	0.03	0.48	3.50	13.24

The leaching experiments were done in a sulfuric acid solution (H₂SO₄) and an ionic liquid solution 1-butyl-3-methyl-imidazolium hydrogen sulfate ([bmim]HSO₄) in the presence of hydrogen peroxide (H₂O₂). A 600 cm³ glass reactor with a magnetic stirrer was used. After setting the working parameters, 10 g of the tailings was added to 200 ml of a solution of a certain concentration. The stirring speed was 400 rpm. At regular time intervals (5, 10, 15, 30, 60, 90 and 120 minutes) 1 ml of the solution was taken and filtered. The diluted solution was analysed for copper and iron using an ICP-OES and multiparameter photometer.

3. RESULTS AND DISCUSSION

Reagent concentrations of 0.01 mol/dm³ and 0.05 mol/dm³ without hydrogen peroxide were tested and the results are presented in previous studies [4]. At a reagent concentration of 0.01 mol/dm³, the copper leaching degree was 71.05 and 72.57% for sulfuric acid and ionic liquid, respectively. At the higher tested concentration of 0.05 mol/dm³, the copper leaching degree was 76.59% for the sulfuric acid solution and 77.10% for the ionic liquid solution.

Figure 1 shows the results of the flotation tailings leaching at a concentration of 0.01 mol/dm³ sulfuric acid and the ionic liquid [bmim]HSO₄ as reagents in the presence of 0.1 mol/dm³ hydrogen peroxide.

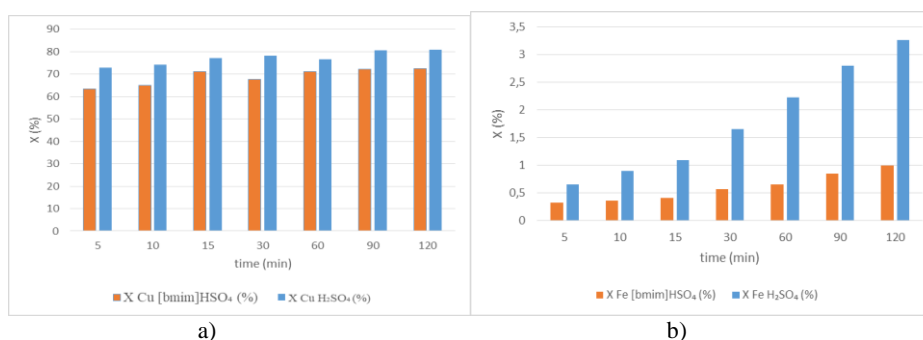


Figure 1. Leaching degree of copper (a) and iron (b) in 0.01 mol/dm³ solution of sulfuric acid H₂SO₄ and 0.01 mol/dm³ solution of the ionic liquid [bmim]HSO₄ in the presence of 0.1 mol/dm³ H₂O₂

The results show that when leaching with sulfuric acid and in the presence of H₂O₂, the copper leaching degree was 80.85%, while the iron leaching degree was 3.27%. Compared to the results without hydrogen peroxide, the copper leaching degree increased for 9.8% and iron leaching increased for 2.5 % in the presence of H₂O₂.

When flotation tailings were leached in [bmim]HSO₄ solution of the same concentration, in the presence of oxidant the copper leaching degree was 72.56 as in the experiments performed without hydrogen peroxide, while the iron leaching was 1%. Under these conditions, hydrogen peroxide had a negligible effect in both tested systems. At lower

initial concentrations of sulphuric acid, it is first consumed in the leaching of calcium, magnesium and other alkali metals [5].

With increasing reagent concentration (0.05 mol/dm^3), the copper leaching degree in the sulphuric acid solution was 82.24% and the leaching of iron was 3.65%. When flotation tailings was leached with an ionic liquid solution with the same concentrations and in the presence of $0.1 \text{ mol/dm}^3 \text{ H}_2\text{O}_2$, the copper leaching degree was 83.14% and iron 1%. It can be observed that with an increase in the concentration of the reagent, the copper leaching degree in the sulfuric acid solution increased by 2%, while it was about 10% higher in the ionic liquid solution. It can also be concluded that with the addition of peroxide, the copper leaching degree increased in both tested systems at a higher concentration. Since the solubility of oxygen in $[\text{bmim}]\text{HSO}_4$ is similar to that in water, a higher concentration of the ionic liquid can lead to a higher degree of oxidation and better dissolution of the metal [6].

The small amount of leached Fe can be attributed to reprecipitation, as $\text{Fe}(\text{OH})_3$ is precipitated below a pH value of 2 [7]. As most of the iron is present in the form of pyrite, this could be one of the reasons for the low leaching degree under the conditions investigated.

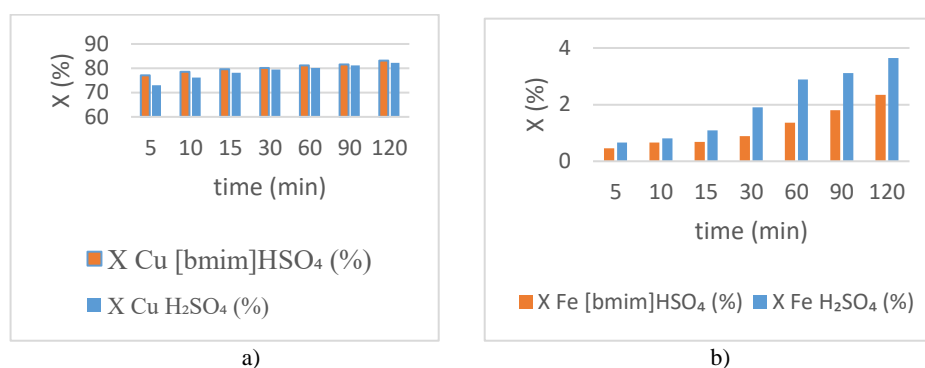


Figure 2. Leaching degree of copper (a) and iron (b) in 0.05 mol/dm^3 solution of sulfuric acid H_2SO_4 and 0.05 mol/dm^3 solution of the ionic liquid $[\text{bmim}]\text{HSO}_4$ in presence of $0.1 \text{ mol/dm}^3 \text{ H}_2\text{O}_2$

These results indicate that hydrogen peroxide has a slight effect for the leaching process of flotation tailings under these conditions. A greater influence of hydrogen peroxide can also be observed at the higher acid ionic liquid concentration tested. Considering the copper oxide content in the initial sample, it can be assumed that all copper was dissolved in the form of easily leachable oxides and the part of the copper sulphide form. The strong influence of hydrogen peroxide on sulfide oxidation by increasing the ore's dissolution was reported by Habashi [8]. He explained that in H_2O_2 solution the sulphide partially converts into elemental sulphur and subsequently to sulfate, which other authors also proved [9-11]. Elemental sulfur at the particle surfaces reducing the leaching rate in the final stage of the reaction [12].

4. CONCLUSION

In the paper, the leaching of copper and iron in aqueous solutions of sulfuric acid and the ionic liquid $[\text{bmim}]\text{HSO}_4$ in the presence of oxidant was studied. The results showed that at reagent concentration of 0.01 mol/dm^3 in the presence of oxidising agents, the leaching degree of was 80.85 % and 72.56 % for sulfuric acid and ionic liquid, respectively. At the



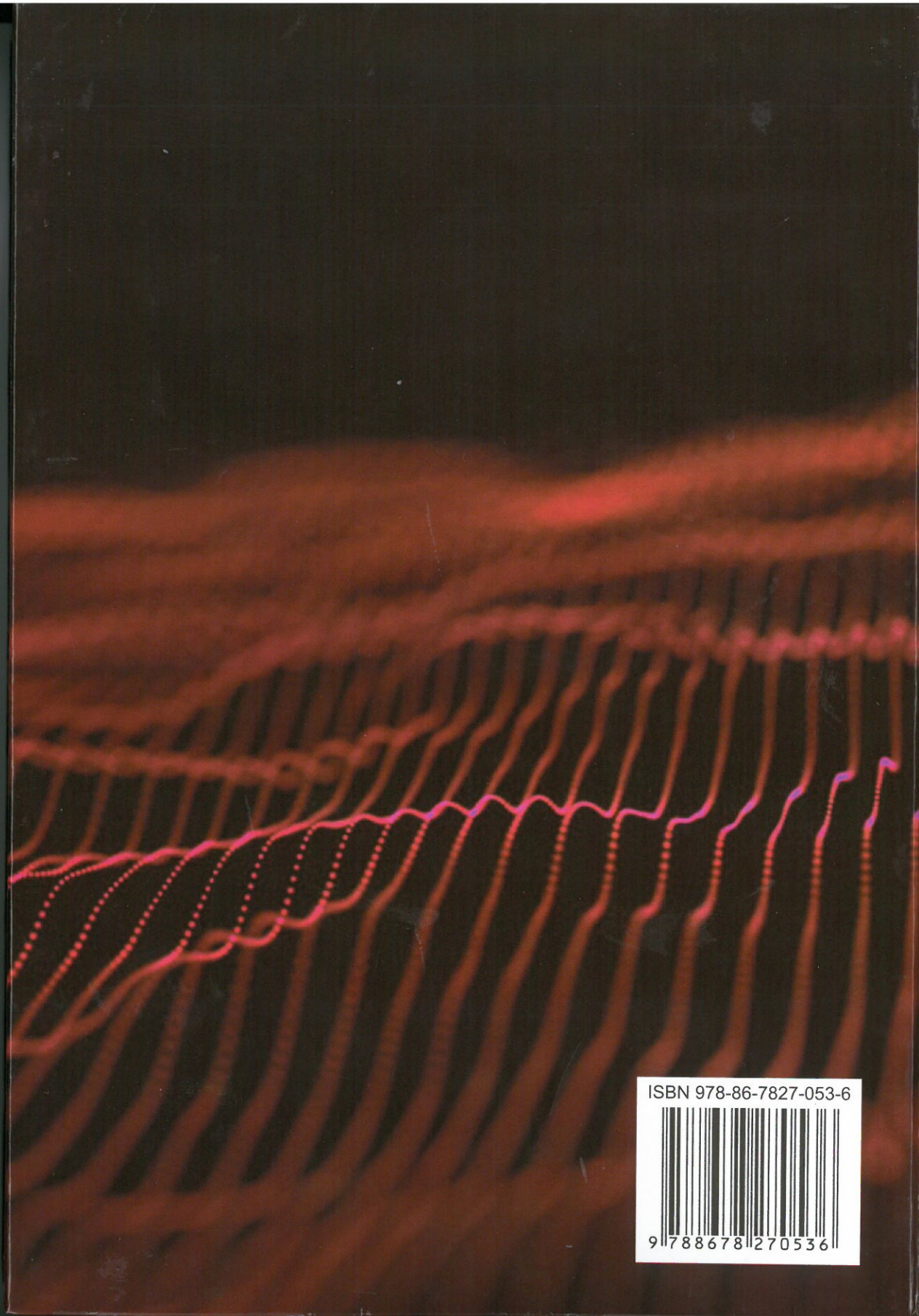
higher tested concentration of 0.05 mol/dm³ the copper leaching degree was 82.24 % for the sulfuric acid solution and 83.14 % for the ionic liquid solution. When used as a leaching agent in aqueous solution, ionic liquids provide better results than leaching with sulphuric acid at the higher reagents concentration tested. For both investigated systems, the copper leaching degree was less than 90% after 120 min of leaching. Further studies with higher concentrations of hydrogen peroxide are required.

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