The 56th International October Conference on Mining and Metallurgy
22-25 October 2025, Bor Lake, Bor, Serbia
www.ioc.tfbor.bg.ac.rs

DOI: 10.5937/IOC25308C *Original scientific paper*

OVERVIEW OF METHODS FOR BOR SEPARATION

Vesna Conić, Milos Janošević, Dragan Milanović, Ivana Jovanović, Daniela Urošević, Mile Bugarin

Mining and Metallurgy Institute Bor, Alberta Ajnštajna 1, 19210 Bor, Serbia
vesna.conic@irmbor.co.rs, 0000-0002-4268-3626
milos.janosevic@irmbor.co.rs, 0000-0002-0818-1235
dragan.milanovic@irmbor.co.rs, 0000-0002-5589-9127
ivana.jovanovic@irmbor.co.rs, 0000-0002-7450-6632
daniela.urosevic@irmbor.co.rs, 0000-0003-3490-7834
mile.bugarin@irmbor.co.rs, 0000-0002-6992-5154

Abstract

The paper presents the research on the selective extraction of boron and lithium from clay lithium resources-ore. Two options for separating B from Li showed good results. The first option was the application of a two-stage leaching of Li ore using H_2SO_4, where 95 % B and 8.31 % Li were recovered in the first phase, while 85 % Li and 4 % B were recovered in the second phase. The second option was the leaching of Li ore using 30 g/L Na_2CO_3, where the leaching was 85.20 % B and 1.33 % Li. The applied procedures achieved satisfactory selectivity of B from Li.

This work may provide guidelines for the selective extraction of lithium and boron from clayey lithium resources-ore in the future.

Keywords: *Clay-type Li resources-ore, Selective extraction, Sodium carbonate, Sulfuric acid*

1. INTRODUCTION

Lithium is the lightest known metal and is widely used in ceramics, glass, aluminum and pharmaceuticals [1,2]. Global consumption of lithium battery products has been reported to have increased by more than 20% per year over the past few years, indicating a strong demand for lithium [3]. As a result of the increased demand for lithium, the price of lithium salts has increased significantly. Nearly 50% of the lithium produced worldwide comes from lithium solutions, which are found almost exclusively in South America, which could lead to a monopoly. Chloride metallurgy is emerging as an alternative process, which has been shown to be more efficient and cheaper to extract. However, such a process is complicated and requires corrosion-resistant equipment [4−6]. The huge growth in demand for lithium batteries used in hybrid and fully electric cars over the next century has raised great concerns about the future availability of lithium. For this reason, to meet the growing demand for lithium, lithium mineral raw materials could be a valuable resource. To meet the growing demand, in recent years, more and more researchers have been working on the treatment of lithium-bearing minerals, including spodumene, lepidolite, zinnwaldite, and petalite. Various methods have been developed to obtain lithium from lithium ores [7−9]. The precipitation of boron from leaching solutions has been presented in many papers[10−12]. If, in addition to boron, lithium also leach, losses of lithium would be inevitable during boron precipitation.

For selective separation of boron from lithium ore, obtained from lithium Europe ore through participation in the EU project Li4Life (GA 101137932), in this paper the possibility of selective boron leaching using H_2SO_4 in one case and Na_2CO_3 in the other case is shown. From this direct separation boron from lithium, almost no leaching of lithium occurred.

2. EXPERIMENTAL

Many experiments on the separation of B from Li have been performed, and only representative ones are shown in the paper. Boron leaching experiments from lithium ore were performed at the laboratory level using 100 g of lithium ore in each experiment. The goal was to leach boron with avoiding lithium leaching in order to achieve selectivity of boron over lithium and minimize Li losses.

2.1 Two stage leaching using H_2SO_4

The leaching was carried out in two stages, in which the first stage used H_2SO_4 with a concentration of 8.8 %, and the solid residue after the first stage was subjected to a second stage of leaching using sulphuric acid with a concentration of 6.6 %. The temperature in the first stage of leaching was 25 °C, while in the second stage it was increased to 80 °C. The leaching time for each stage was 3 h, and the phase ratio S:L=1:4 (w/v).The conditions and results are presented in the Table 1.

Table 1. Conditions and results of leaching Li ore using H_2SO_4

	H_2SO_4, %	Temp., °C	Leach. Time, h	Phase ratio, (w/v)	Recovery, %	
					Li	B
I stage	8.8	25	3	S:L=1:4	8.31	95.00
II stage	6.6	80	3	S:L=1:4	85.00	4.00
Solid residue					6.69	0.65

From the Table 1, it can be concluded that two-stage leaching in H_2SO_4 of different concentrations at different temperatures can provide a certain selectivity Li from B. The higher leaching of Li in the second stage reflects:

- failure to rinse the solid residue after the first leaching stage, whereby the acid from the first leaching stage remain and an additional amount of acid is added to it in the second stage

- the leaching time is extended 3 h + 3 h

- the leaching temperature is increased from 25 °C to 80 °C in comparison with leaching in I stage leaching.

Based on the results obtained, it can be concluded that using 8.8 % sulfuric acid in the first stage of leaching of Li ore achieves 95 % B leaching, while using 6.6 % sulfuric acid in the second stage of leaching of the solid residue obtained from the first stage of leaching achieves 85 % Li leaching. From the above data, the selectivity of B from Li can be achieved.

2.2 Leaching using Na_2CO_3

Leaching was carried out using Na_2CO_3 concentrations of 25 g/L and 30 g/L on a temperature of 85 – 95 °C, at a leaching time of 3.5 h and a phase ratio of S:L=1:4 (w/v). The conditions and results are presented in the Table 2.

Table 2. Conditions and results of leaching Li ore using Na_2CO_3

	Na_2CO_3, g/L	Temp., °C	Leach. Time, h	Phase ratio	Recovery	
					Li, %	B, %
1.	25	80 – 95	3.5	S:L=1:4	0.44	61.68
2.	30	80 – 95	3.5	S:L=1:4	1.33	85.20

From Table 2, it can be concluded that in the first experiment, good selectivity of B from Li was achieved but the B leaching was low, while in the second experiment, significant B leaching was achieved with ensuring very high selectivity B from Li.

3. CONCLUSION

Selective leaching with H_2SO_4 was carried out under the following conditions: (8.8 % H_2SO_4, 25 °C, 3 h, S:L=1:4 (w/v)) and wit Na_2CO_3 under the conditions (30 g/L Na_2CO_3, 80 – 95 °C, 3.5h, S:L=1:4 (w/v)). It is possible to achieve B selectivity from Li in favor of a high B leaching recovery, 95 % and 85.20 % respectively, and a low Li leaching recovery, 8.31 % and 1.33 % respectively.

Based on the results obtained, it can be concluded that B from Li selectivity can be achieved using the above H_2SO_4 and Na_2CO_3 as leaching agents.

From the results of selective leaching, it can be seen that by applying leaching with Na_2CO_3 the losses are unknown and amount to 1.33% and that the leaching of B is satisfactory and is 85%. The advantages of leaching with Na_2CO_3 are reflected in the following:

1. Borax is obtained directly

Sodium carbonate selectively reacts with borates, forming the sodium borate salt, borax ($Na_2B_4O_7 \cdot 10H_2O$), which is readily soluble and a commercially valuable product.

2. There is less dissolution of unwanted components (eg iron, aluminum), which facilitates subsequent separation.

3. Less corrosivity

In comparison with strong acids (eg H_2SO_4, HCl), Na_2CO_3 solution is less corrosive to equipment, which reduces maintenance costs and extends the life of the plant.

4. More environmentally friendly

Alkaline solutions are less hazardous to handle and have a lower risk of contamination in case of leakage. Neutralization of waste water is simpler and cheaper than with acidic waste water.

5. Easier reagent regeneration

Na_2CO_3 can be partially regenerated from waste solutions, which reduces operating costs.

After the success of the process of selective leaching and separation of B from Li, the solid residue will be further treat with a more ecologically and economically acceptable bioleaching process in order to leach Li. In this sense, the idea of mixing sulphide ore raw material to the primary sample of Li clay ore will be implemented, considering that the characterization of the clay ore showed the presence of traces of sulphide ore mass, which provides the basis for the possibility of a bioleaching process, i.e. the first in string adaptation proces of the *At.Ferrooxidans* and *At. Thiooxidans* microbes to this mixed ores raw materials.

ACKNOWLEDGEMENT

This paper has been developed under the framework of Li4Life project (Grant Agreement n° 101137932), and all results can be found on its official website [13] and social channels [14].

Funded by the European Union

Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor CINEA can be held responsible for them

REFERENCES

[1] A. Ebensperger, P. Maxwell, C. Moscoso, Resour. Policy, 30 (3) (2005) 218−231.

[2] R. Ferro, R. Pipoli The future of lithium. Mining intelligence series [EB/OL]. http://www.salareslithium.com/i/pdf/Media/Lithium_ 2010_BNA.pdf.

[3] H. Wang, K. Huang, S. Liu, J. Power Sources., 196 (2) (2011) 788−792.

[4] P.K. Jena, F. Barbosa, I.C. Vasconcelos, Hydrometallurgy, 52 (2) (1999) 111−122.

[5] E.A Brocchi, F.J. Moura, Miner. Eng., 21 (2) (2008) 150−156.

[6] H.U. Tian-xi, Y.U. Jian-guo, The Chinese Journal of Process Engineering, 10 (4) (2010) 701−705. (in Chinese)

[7] A. Büyükburç, D. Maslioglu, M.S. Ugur Bilici, G. Köksal, Miner. Eng., 19 (5) (2006) 515−517.

[8] B.F.R. Haus, Miner. Eng., 23 (8) (2010) 659−661.

[9] S. You-run., Rare Metals and Cemented Carbides of China, 143 (2000) 22−26. (in Chinese)

[10] A. Erdem Yilmaz, R. Boncukcuo, S. Bayar, B. Ali Fil, M. Muhtar Kocakerim, Korean J. Chem. Eng., 29 (10) (2012) 1382-1387.

[11] J. Wang, J. Wang, J. Zhu, J. Zhou, H. Gu, Journal of Guangdong Non-ferrous Metals of China, 4 (2) (1994) 107−112. (in Chinese)

[12] A. Büyükburç, D. Maslioglu, M.S. Ugur Bilici, G. Köksal, Miner. Eng., 19 (5) (2006) 515−517.

[13] https://li4life.eu/

[14] https://www.linkedin.com/company/li4life-eu-project https://x.com/li4LIFEProject