



Separation Techniques of Lithium Isotopes by Ion Exchange Method and Monitoring by ICP-MS

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1. Introduction

Lithium is an alkali metal, the lightest of the existing metals, with a specific mass of 0.534 g/cm³. Its atomic number is 3 and molecular weight is 6.94. It only has a +1 oxidation state. Natural lithium is composed of two stable isotopes, ⁶Li (Lithium-6) with an atomic weight of 6.015 and ⁷Li (Lithium-7) with an atomic weight of 7.017. The isotopic abundances are on average 7.53% for ⁶Li and 92.47% for ⁷Li which leads to a ⁶Li/⁷Li isotopic ratio of 0.081.

In Brazil, Spodumene is one of the most important ores for obtaining lithium. This ore has the basic chemical formula LiAlSi₂O₆. After the various processing and purification steps, the resulting product has lost almost all of the Al and Si, but maintains a significant amount of Na, Ca and other alkaline and alkaline earth elements from the process of obtaining lithium hydroxide LiOH. Lithium-7 is a product used to regulate the water's pH of the primary circuit system of power nuclear reactors. And Lithium-6 is used for the secondary production of so-called thermonuclear devices, and is used as fuel in nuclear fusion reactors.

CBL – Companhia Brasileira de Lítio, a 100% brasilian company, which explores a lithium mineral, spodumene, and has been producing its chemical lithium derivatives since 1991. CBL's difficulties were immense, mainly because it was an underground mine, whose reserves are located in the northeast region of Minas Gerais - Vale do Rio Jequitinhonha, one of the most deprived in the country. Forty years later, the situation is quite different from that experienced in the late 1980s, when CBL was effectively implemented. At the moment, both Araçuaí/Itinga, where the Mine and the Ore Processing Unit are located, and Divisa Alegre, where the Chemical Plant was built, are development hubs in the region. Its commercial and financial office is located in Sao Paulo. CBL considers it relevant to show the strategic aspect of Lithium, that it can meet the needs of the Brazilian nuclear sector.

In 2020, CBL made a partnership with Institute of Energy Research and Nuclear – IPEN to develop technology for isotopic separation of ⁷Li in relation to ⁶Li and consequently the enrichment of ⁷Li by ion exchange technique, which have been carried out at IPEN for decades [Abrão, 1995].

The main target of this development will be the nationalization of production know-how, based on innovation, currently dependent on the international market, and encouraging the national industry to produce equipment and inputs with high added value on a commercial scale, and developing state-of-the-art technology, in addition to the training of human resources in the area for Brazil.

The aim of this work is present the status of development of this project between CBL-IPEN and some results obtained through analysis via ICP-MS.

2. Methodology

Lithium isotopes have very similar chemical and physical properties, consequently isotopic separation is very complex, requiring the development of specific processes. The ion exchange chromatographic was applied for purification of LiOH and isotopic separation and enrichment of ⁷Li.

Purification method was applied on LiOH obtained from CBL, with purity of approximately 54%. Three columns filled with IRC 748 resin and a fourth column filled with 1-x8 resin. Different solutions were tested for elution.

For isotopic separation four columns were filled with synthetic resins, and the solution of LiCl was

percolated. Elution with Calcium acetate was carried out using peristaltic pumps through the others three columns.

Periodically an aliquot was collected for analysis of Li concentration and isotopic ratio of ${}^6\text{Li}/{}^7\text{Li}$.

3. Results and Discussion

ICP-MS is a technique that allows the identification of isotopes of the same element. The ICP-MS generates a graph, where on the y axis, it represents the signal intensity of the ions (counts per second - cps) and on the x axis, it represents the mass/charge ratio (m/z) of the ions. Therefore, in analytical development, the first step is to ensure that the ICP-MS system is identifying the ratio for the natural abundance of lithium.

The purification process was efficiency with HCl elution at concentration of 0.5M, which 99.95% of purity was achieved.

Figure 1 shows the results of the ${}^7\text{Li}$ isotopic enrichment process through the Ion Exchange column.

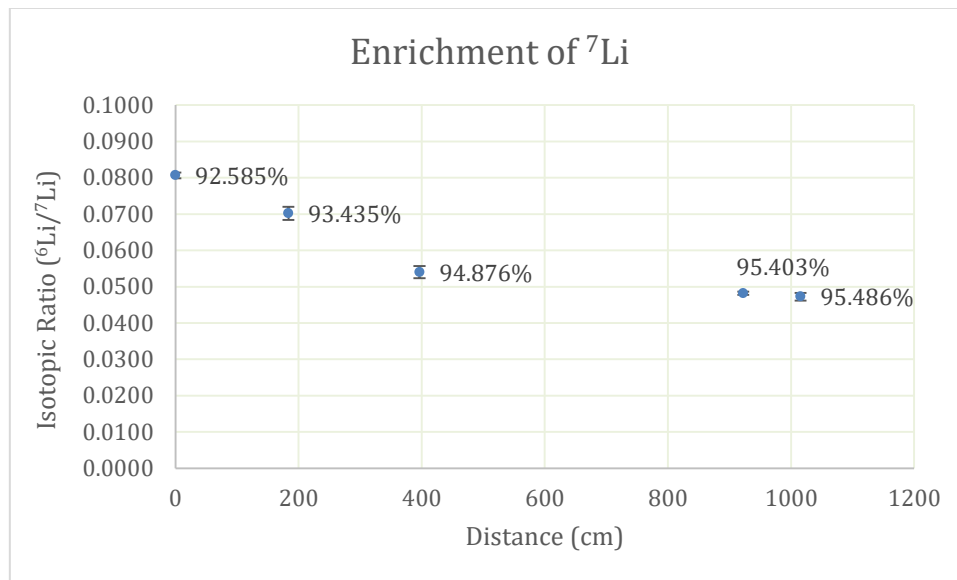


Figure 1: Enrichment of ${}^7\text{Li}$.

It is observed that in this stage an isotopic enrichment of ${}^7\text{Li}$ was obtained by 95.49%, thus, the final objective has not yet been achieved. Given this result, the intention is to continue, that is, to extend the ${}^7\text{Li}$ enrichment stage.

4. Conclusions

The values obtained so far in the development of the project can be seen. In purification stage, the final result was a lithium purity of 99.99%.

In isotopic separation stage, enrichment of 95.49% has so far been achieved, taking 92.5% natural ${}^7\text{Li}$ as a reference. In the next stage, the final objective is to achieve a ${}^7\text{Li}$ enrichment of 99.95%. We are improving our results and working to achieve the final objective of this stage.

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