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Isotopic Enrichment of Lithium-6 for Thermoluminescent Dosimeter Application

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1. Introduction

Extracted from the mineral spodumene, the element lithium naturally possesses two stable isotopes: ^{7}Li (approximately 92.6%) and ^{6}Li (approximately 7.4%)[1]. These isotopes have various applications, ranging from the pharmaceutical industry to electrochemistry[2]. It is estimated that due to their high efficiency and environmental reasons, the global production of lithium-ion batteries reached 700 million units in 2004[3]. In the nuclear field, the isotopes ^{6}Li and ^{7}Li behave differently. In Brazil, ^{7}Li is widely used in reactors of Nuclear Power Plant, at Angra dos Reis (RJ), as a coolant because this isotope has negligible cross-sections for absorbing thermal neutrons[4]. On the other hand, the presence of ^{6}Li can decrease the reactor's efficiency, as this isotope has high cross-sections, absorbing thermal neutrons and providing large amounts of energy. For this reason, it is highly applied in the thermonuclear field[5]. ^{6}Li can also be used for tritium production through neutron bombardment in a fusion nuclear reactor[5]. Moreover, ^{6}Li also has an application in radiation dosimeters due to its thermoluminescent capability. A thermoluminescent dosimeter is a device used to measure doses of ionizing radiation received, through the light emitted by a thermoluminescent crystal in the detector[6]. In this regard, the radiationsensitive crystal used for this type of dosimeter is lithium fluoride, where the ^{6}Li isotope is sensitive to thermal neutrons[6]. In the LiF crystal lattice, there are traps that keep the electrons trapped after alpha radiation. Upon heating the crystal, these electrons are released, and light is emitted, making it possible to measure the received radiation[1,6]. Therefore, LiF chips are commonly enriched with ^{6}Li for the efficiency of the dosimeter detector[1]. Thus, this work aims to present a new technology for lithium purification in the national soil, seeking Brazilian independence regarding the acquisition of this element, through the isotopic separation of ^{6}Li and ^{7}Li for their respective applications in the industry.

2. Methodology

For the enrichment of ^{6}Li, 4 acrylic columns with a diameter of 13mm and a length of 100mm were used. Both were filled up to a height of 92.4mm with AG 50W X16 resin. The first column was saturated with LiCl to form a Lithium band, and 0.15M calcium acetate was used to displace this band by approximately 1015.5 cm. After that, 10ml samples were collected, corresponding to 10mm of the band. In these samples, pH, electrical conductivity, concentration through ICP-OES, and isotopic ratio by ICP-MS were measured.

3. Results and Discussion

Finally, as a result, 74 representative samples of the formed Li band were obtained. There was a separation between the lithium isotopes and an enrichment of 10.12% of ^{6}Li was achieved. At the bottom of the band, an abundance of 95.86% of ^{7}Li was detected. Using the results of electrical conductivity and concentration, a correlation coefficient of 0.97 was calculated, indicating linearity between the two parameters. Between conductivity and pH, a correlation coefficient of 0.87 was obtained, indicating linearity between these two parameters as well. Conductivity was the parameter chosen to detect the presence of Li in the samples analyzed in the ICP-MS, as seen in figure 1.

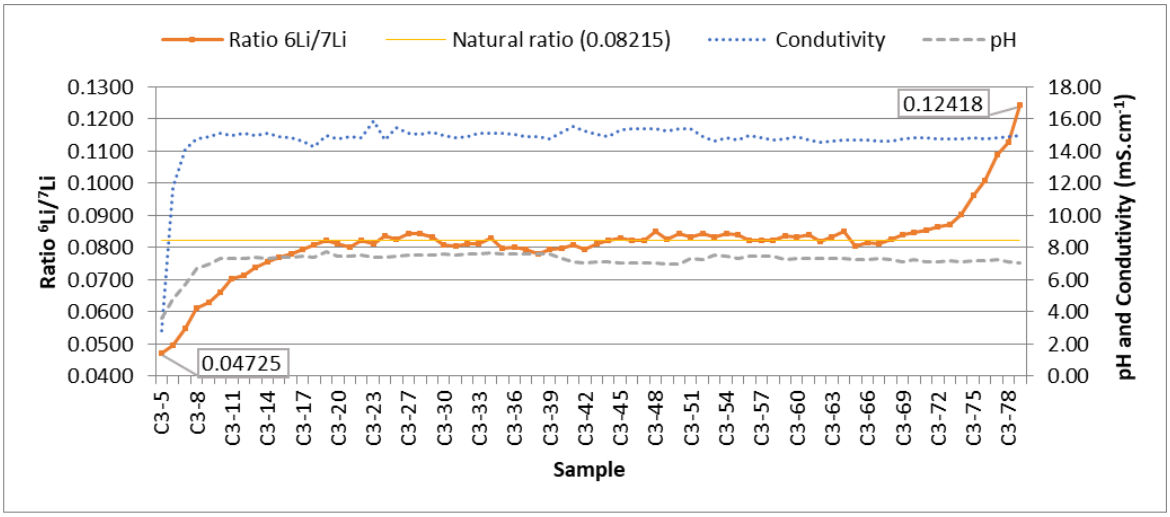

Figure 1: Relationship between the $^{6}Li/^{7}Li$ ratio (isotopic ratio), pH and conductivity in the samples.

4. Conclusions

The results obtained are the outcome of the initial research procedures, constituting a part of an ongoing preliminary study. Thus, with the advancement of this work, it is possible to achieve an even higher degree of enrichment. Therefore, it can be concluded that the procedure for separation and enrichment of Li isotopes via ion exchange is suitable for the proposed objective.

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