TRITIUM PRODUCTION IN FUSION REACTORS

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The production of lithium-6 isotopes is essential for the generation of tritium in nuclear fusion reactors. Tritium, one of the fuels used in fusion, is produced in breeding blankets containing lithium. For this production to be self-sufficient, lithium-6 must be enriched to levels above 10%, depending on the reactor design. Currently, there are no facilities dedicated to the large-scale production of this isotope, making the development of an efficient process urgent. Among the available isotopic separation methods, the chemical route by ion exchange chromatography is considered the most promising. It offers advantages such as low cost, reuse of resins, and lower environmental impact. In Brazil, the development of this technology is being conducted at IPEN Lithium Laboratory. An automated system with four ion exchange columns in series, operating continuously, was implemented. With this configuration, it was possible to achieve 10.12% enrichment in lithium-6 and 95.86% in lithium-7, starting from a natural abundance of 92.5% for isotope 7. The purity of the starting material is critical: the LiOH used must have a purity greater than 99.95%, which requires advanced purification steps. The use of crown ether resins, such as benzo-15-crown-5, has shown promise in increasing separation efficiency. The goal is to master lithium isotope enrichment technology, ensuring national autonomy for nuclear fusion programs and opening up possibilities for exporting enriched isotopes. Lithium titanate (Li_2TiO_3) is a promising breeder material due to its chemical stability and favorable tritium release behavior. However, tritium retention in the crystalline lattice reduces recovery efficiency. Synthesizing Li_2TiO_3 nanoparticles can mitigate this issue by increasing surface area and shortening diffusion paths. Li_2TiO_3 nanoparticles were prepared using the sonochemical method. The nanoparticles analysis by XRD analysis showed partial amorphization in the as-prepared powder and improved crystallinity after annealing at 900 °C. BET measurements revealed a high specific surface area (51 $m^2\ g^{-1}$) and mesoporosity favorable for tritium diffusion. TGA identified mass losses related to water removal, organic decomposition, and phase crystallization. The results indicate that sonochemistry is an effective route to obtain nanostructured Li_2TiO_3. Ongoing neutron irradiation tests will assess its performance under fusion-relevant conditions. For the irradiation experiments, data on neutron flux in the IEA-R1 reactor, neutron spectrum, and reaction rates will be obtained. Activation will be monitored with dosimetry sheets. The project will also include engineering designs for the irradiation bulb and support, process and instrumentation diagrams, safety analysis, and development of the vacuum system and microwave oven for controlled tritium release.