Contribution ID: **71** Type: **Poster contribution**

Development of porous non-actinide target materials for the facility ISOL@MYRRHA

Tuesday, 21 October 2025 19:05 (1 minute)

Isotope Separation Online (ISOL) facilities produce purified radioactive isotope beams (RIBs) for applications in fundamental research, solid-state physics, biology and medicine. As part of the first phase of the MYRRHA program at SCK CEN, an ISOL facility is being developed to operate with a high-power 100 MeV proton beam (with intensities up to 500 µA). This study focuses on optimizing non-actinide-based target materials for efficient isotope release at extreme temperatures (≥2000 C). High porosity (over 30%) targets with a micrometric or even nanometric grain size (<10 µm, down to 100 nm) are crucial to enhance the diffusion and release of refractory isotopes.
Mechanisms that hinder sintering are essential to maintain the stability of these materials at high temperature to ensure that the RIB yield doesn't decrease during operation. These mechanisms typically focus on reducing the coordination number of the target material grains, e.g. tuning the particle shapes and/or the addition of a non-soluble, chemically inert and high melting point secondary phases (e.g. carbon). In this work, various carbon sources were evaluated for their effectiveness in the carbothermal reduction of oxide materials to produce porous carbide ISOL targets. Carbon black, expanded graphite, graphite, multi-walled carbon nanotubes (MWCNTs), and carbon aerogels, were tested as reducing agents and pore formers to maintain high porosity volumes at high temperatures. These carbon materials were mixed with ZrO_2 (to form ZrC), TiO_2 (to form TiC), and NbC, followed by a carbothermal reduction or heat treatment up to 2000℃ demonstrating their potential in tailoring material properties and stability at extreme temperatures for optimized isotope release.
Additionally, pore formers were added to the starting powder mixtures to realize additional porosity during the thermal treatment. ZrO2 for example was mixed with ammonium bicarbonate (AB) and graphitic carbon nitride (g-CN). The effects of these pore formers on the porosity and density after thermal treatment were investigated. The results indicate that g-CN is most effective in reducing density, while AB generates large irregular pores. The findings from this study highlight the potential for fine-tuning porosity and density in ZrO2, TiC, NbC and ZrC target materials, contributing to the development of the next-generation ISOL targets for improved isotope production and release.

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Funding Agency

SCK CEN

Classification

Isotope production, target, and ion source techniques

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Session Classification: Poster Session

Track Classification: Isotope production, target, and ion source techniques