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Thermal Release studies from Activated nat-Ti, nat-V and nat-Ta Target Materials - Investigation of Parameters Relevant for Isotope Mass Separation

Scandium (Sc) and Terbium (Tb) have gained significant interest in nuclear medicine due to their radioactive isotopes being suitable for cancer diagnostics and therapy, offering a promising avenue for theranostics. However, challenges persist in achieving high molar activity and radiochemical purity for medical applications. The physical isotope mass separation technique presents an interest to increase the purity of such samples for medical applications. Despite recent advancements in mass separation at CERN-MEDICIS and other different facilities, the efficiency and yield for some radionuclides known as "difficult to extract"such as Sc and Tb, remain sub-optimal to produce medically relevant activities.

This study aims to systematically investigate the thermal release kinetics of Sc radionuclides from activated natural titanium and vanadium foils, and of Tb radionuclides in tantalum, all studied in tantalum (Ta) environments of typical ISOL (Isotope Separation On-Line) target units. By elucidating the combination of target material structure and temperature conditions, enhanced release parameters were identified. Maximum Sc release from a non-embossed nat-Ti foil samples was achieved at 1200 ℃, for embossed nat-Ti foil samples at 1450 ℃ and for nat-V foil samples at 1600 ℃, within an hour of reaching the set temperature. However, maximum Tb release from a non-embossed nat-Ta foil samples was achieved at 2300 ℃, for embossed nat-Ta foil samples at 2300 ℃ Tb release reached only 80% and for natTa double folded samples maximum release was achieved at 1900 ℃, within an hour of reaching the set temperature.

Theoretical estimations were done to estimate radionuclide production in target materials and to identify the possible limiting factors during thermal release. A proof of concept for the methodology to study MEDICIS and ISOLDE-produced radionuclide release kinetics and behaviour from various target materials and structures is presented. This work also aims to complement radionuclide release studies in case of fire accidents for radiation protection purposes and provide a way to benchmark theoretical codes.

Additionally, due to the large number of radionuclides that are produced from high-energy proton irradiation of nat-Ta foils, several release curves were obtained for radionuclides, including some of interest in nuclear medicine. These findings offer insights into optimizing the mass separation process to improve the efficiency of radionuclide production by mass-separation both for fundamental physics and for medical applications.

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