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Molecular Extraction of Terbium and Other Lanthanides: Challenges and Opportunities

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Tantalum targets can be used to produce lanthanide beams but in order to extract species with slow release times, such as terbium, the targets have to be pushed to extreme temperatures. This is especially true when it comes to medical isotope production that requires collections in the order of GBq/day of radionuclides with a minimum half-life of several hours. One way to volatilise the more refractory species is to extract them in the form of their fluoride molecules [1]. Previous studies have explored injecting reactive tetrafluoromethane (CF4) gas to different target and ion source combinations via calibrated leaks, observing the formation of fluoride molecules and molecular ions of different species [1-4]. Extracting fluoride molecules can also help to purify the beam by collecting on a sideband with fewer contaminants. This makes fluoride beams a promising potential avenue to extract more refractory lanthanides and to increase the experimental yields of more exotic isotopes that have not been accessible to study at ISOLDE so far. For nuclear medicine, this could facilitate more pre-clinical trials with terbium-based radiopharmaceuticals. Additionally, this approach could be advantageous for some other species that cannot be extracted from carbide targets due to their chemistry.

In this work, we report on systematic studies of terbium fluoride beams performed at CERN ISOLDE using a tantalum foil target coupled to a hot plasma ion source with injection of CF4 gas. The ion beam composition was investigated as a function of target, ion source, and gas injection conditions to optimise the terbium fluoride beam delivery for 144-168Tb. The ISOLTRAP MR-ToF MS [5] was the main tool used for the identification of beam composition and yield measurements. Additionally, collections were performed for offline yield measurements with gamma and alpha spectrometry.

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Author: WOJTACZKA, Wiktoria (KU Leuven (BE))

Co-authors: SCHWEIGER, Christoph (Max Planck Society (DE)); LANGE, Daniel (Max Planck Society (DE)); SOBRAL DOS REIS, Edgar Miguel; JOHNSON, Jake David (KU Leuven Association); NIES, Lukas (CERN); DESEYN, Marie (KU Leuven (BE)); BENHATCHI, Maroua; AU, Mia (CERN); HEINES, Michael (KU Leuven (BE)); Dr FISCHER, Paul (University of Greifswald); GIESEL, Paul Florian (University of Greifswald (DE)); ROTHE, Sebastian (CERN); Dr STEGEMANN, Simon Thomas (CERN); Prof. COCOLIOS, Thomas Elias (KU Leuven - IKS); BERLIN, Valentina (SY group)

Presenter: WOJTACZKA, Wiktoria (KU Leuven (BE))

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