Recent developments on Terbium mass separation from Tantalum target materials for medical applications at CERN-MEDICIS facility

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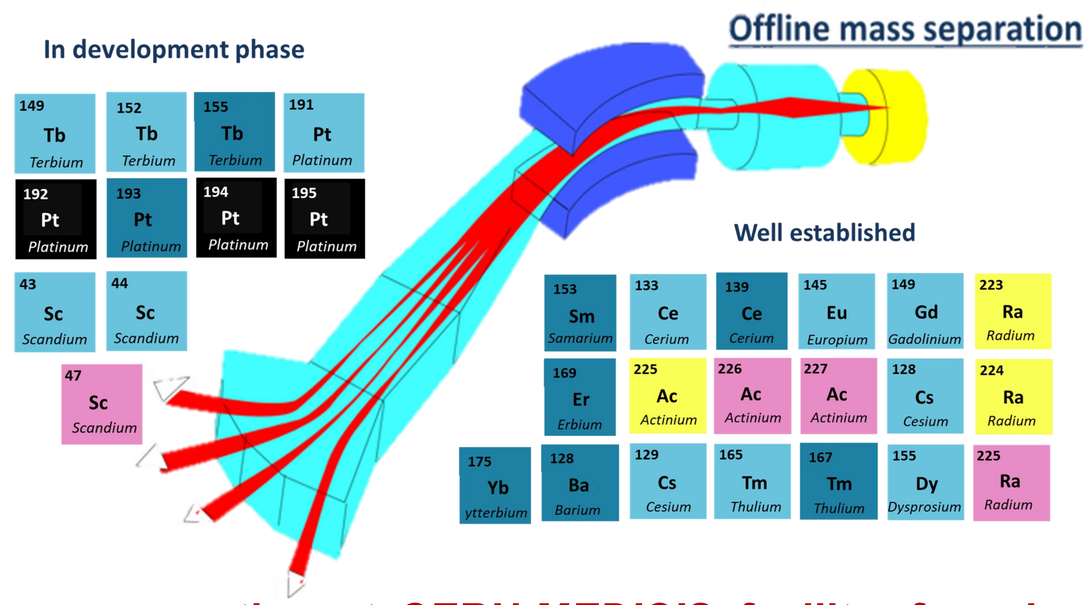
INTRODUCTION and PURPOSE

Terbium (Tb) has gained significant interest in **nuclear medicine** due to its 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 facilities, the efficiency for some radionuclides known as “difficult to extract” such as Tb, remain sub-optimal to produce medically relevant activities.

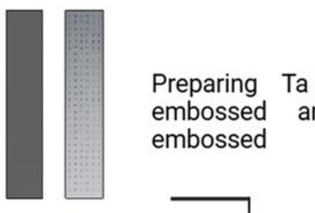
CERN-MEDICIS



This work investigates recent developments in terbium mass separation at CERN-MEDICIS facility, focusing on optimizing efficiency using different tantalum-based target materials. The study aims to improve terbium isotope production for future theranostic applications.

MATERIALS CHARACTERISATION

Tantalum foils



Preparing Ta foils - embossed and non embossed

Preparing sample cylinders from both foils

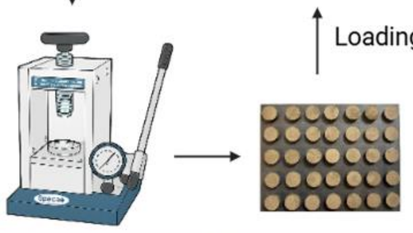
Loading in the target unit

Tantalum carbide

Loading in the target unit

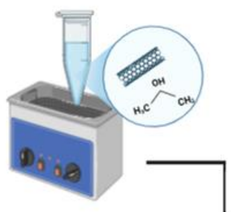
Pressing

Loading



Tantalum carbide mixed with MWCNT

MWCNT + IPA homogenisation



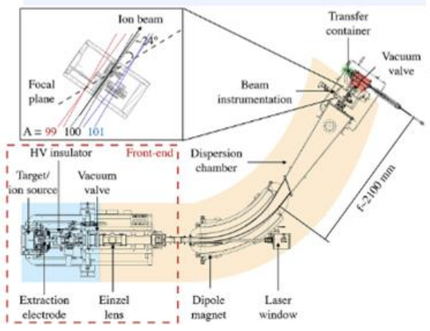
Adding TaC in the mixture

Liquid evaporation

TaC-MWCNT

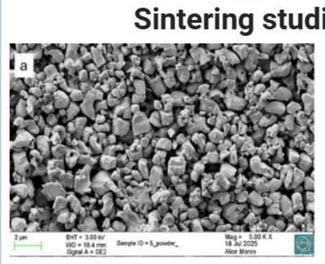
Pressing and loading in the target unit

Terbium mass separation

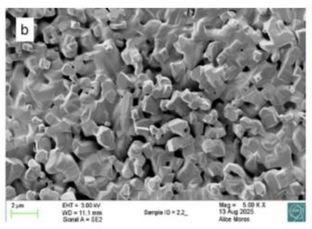


SINTERING STUDIES

1 Sintering studies



TaC pellet before heat-treatment



TaC pellet after heat-treatment in 2000ºC

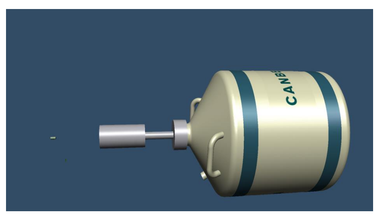
2 Sintering studies

Ta foils: a,b) Reference c,d) After Heating

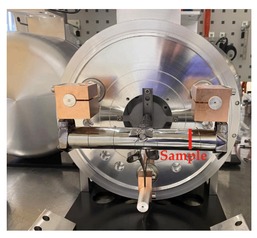
Ta foil after 2000ºC

RELEASE STUDIES

Sample irradiation at CERN-ISOLDE facility by indirect proton beam

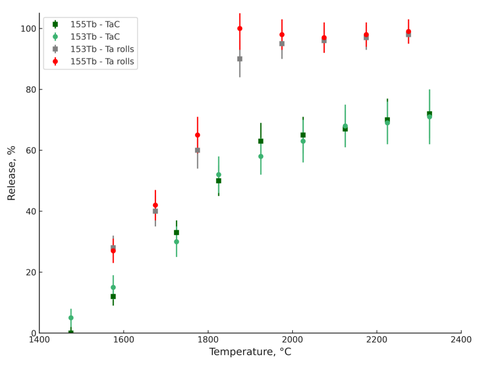


Gamma spectrometry to determine sample activity before and after release



View of a sample placed inside the target container of a typical ISOL target unit. The vacuum and heating is controlled. Temperature up to 2000ºC can be reached with a vacuum around 1E-6 mbar

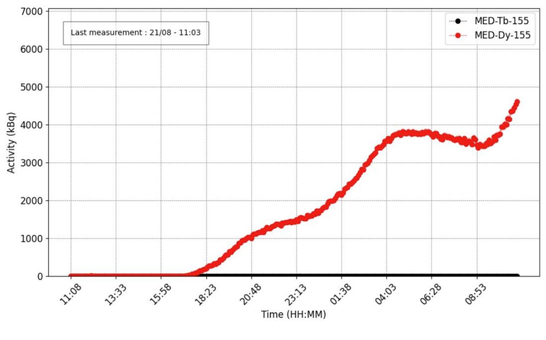
Experimental setup for thermal release studies



Tb-153/155 thermal release from Ta foils and TaC pellets

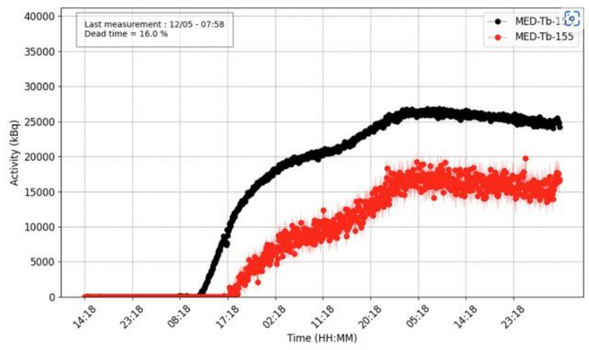
MASS SEPARATION at CERN-MEDICIS and SUMMARY

Ta foils



- Low mass separation efficiency <0.3% (~6Mbq of Tb-155)
- Sinters in high temperatures, reduces efficiency for next runs
- High ^{139}Ce contamination (usually 2x more than Tb-155) after mass separation
- Separation in elemental form
- Lasers are needed
- Separation trough the Dy-155 decay

TaC pellets



1. Improved mass separation efficiency comparing to Ta foils (~2%) -->19MBq of Tb-155 collected and shipped to CHUV
2. Faster isotope release
3. No Ce-139 contamination
4. Improved isotopic purity and enhanced separation efficiency for Tb-155 and Tb-149 isotopes never achieved so far
5. Lower temperature needed for Tb beam --> beam visible from 1900ºC
6. Reduced mass separation efficiency in the second time of target use -> material sintering