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SNETP Forum

TERBIUM-161, IRRADIATION, SEPARATION AND RECOVERY OF TARGET MATERIAL

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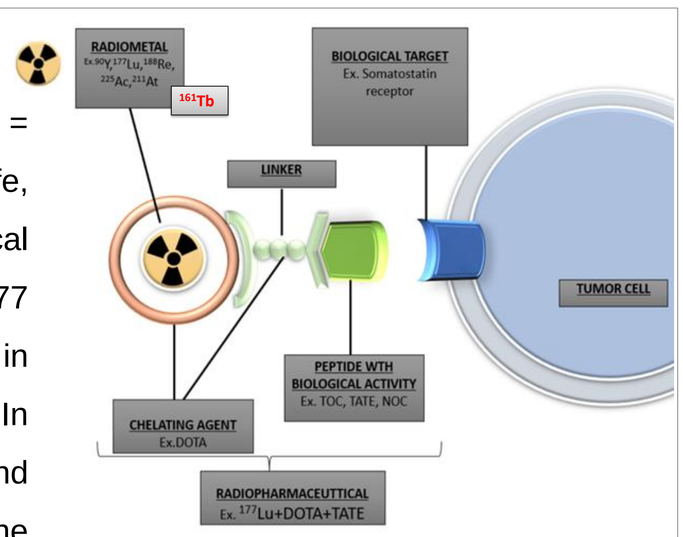
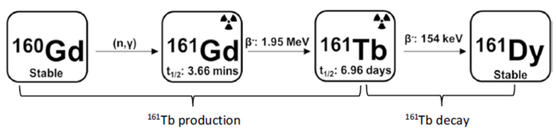
1. Introdaction

Terbium-161 (^{161}Tb, $t_{1/2}$ = 6.9 d; $E^{\beta-}_{av}$ = 0.15 MeV) is an β- emitter. Its half-life, beta energy emission, and chemical properties are similar to lutetium-177 (^{177}Lu), which makes it useful in targeted radionuclide therapy. In addition, the emitted conversion and Auger electrons suggest that the therapeutic effect of ^{161}Tb is better than that of ^{177}Lu. Tb-161 can be produced in nuclear reactors in following nuclear reaction.



Cancers 2022, 14, 584. https://doi.org/10.3390/cancers14030584



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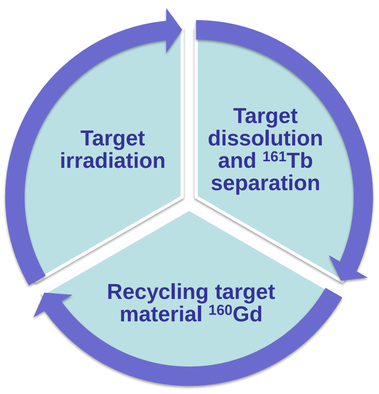
We present the results of Tb-161 separation after irradiation of enriched gadolinium-160 (97.5%; 97.8%) in the Maria Research Reactor (NCBJ, Poland).

2. Description of the research problem



- Target irradiation in Maria Research Reactor
- Development of an efficient Tb-161 separation method after irradiation of the Gd-160 target material
- Recycling of the target material for reuse

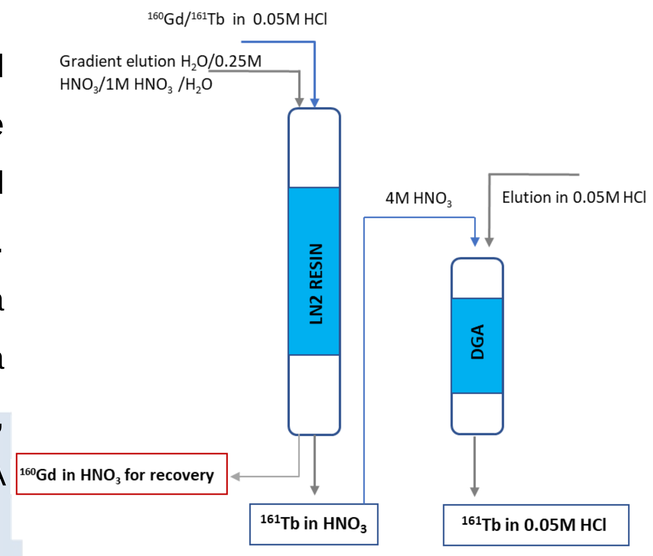
3. Methodology

The separation of Tb-161 from a gadolinium target was optimized in a two-step extraction chromatography, first on LN2 resin and then on DGA resin.

the gadolinium oxalate precipitation method was used and experiments were carried out with natural Gd and Gd solution after the separation process.

3.1. Separation method

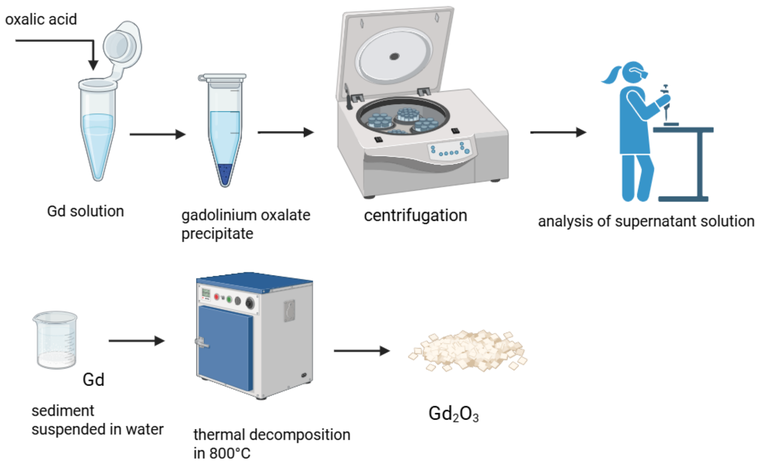
Gadolinium oxide enriched in ^{160}Gd (97.5 %; 97.8 %) was activated in the Maria research reactor in a declarated thermal neutron flux of 2×10^{14} $ns^{-1}cm^{-2}$. The separation of Tb-161 from a gadolinium target was optimized in a two-step extraction chromatography, first on LN2 resin and then on DGA resin.



After dissolving the target in 3 M HCl, the solution was loaded on the LN2 column, and Tb-161 was eluted with a nitric acid gradient from 0.25 M to 1 M system. Then, the Tb-161 nitrate solution was loaded on the DGA column and eluted with diluted hydrochloric acids. Quality control tests included radionuclidic, chemical and radiochemical purity. The suitability of ^{161}Tb solution was assessed by radiolabeling of the peptide DOTA-TATE (Radioisotope Centre POLATOM, NCBJ). The efficiency of radiolabeling was over 99 %.

3.2. Recovery method

Recovery of the target material was carried out by precipitation of gadolinium oxalate and subsequent thermal decomposition of the precipitate to gadolinium oxide.

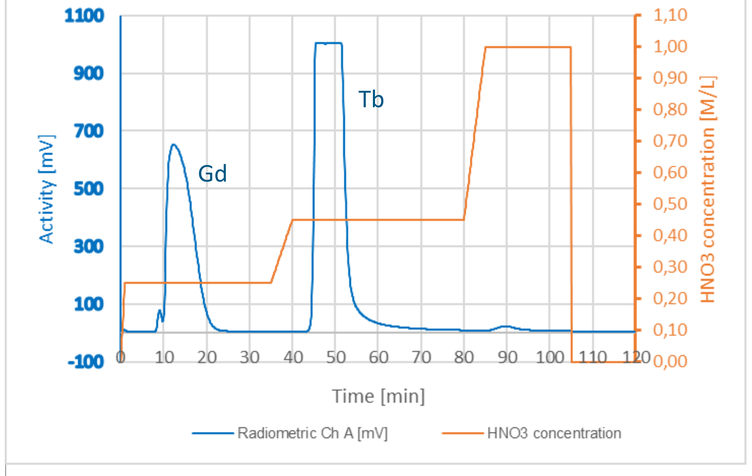


4. Results

Results of the three irradiations of [^{160}Gd]Gd_2O_3 in the Maria reactor depending on the time of irradiation, the mass of the target, and target enrichment in ^{160}Gd are shown in Table 1.

Table 1. The radionuclide composition of the two target materials after irradiation and dissolution.

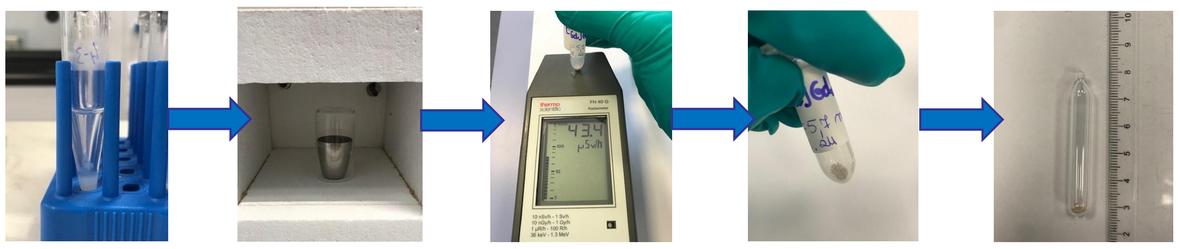
				Radioactivity at EOB [MBq]					^{160}Tb content [%]	SA ^{161}Tb [MBq/mg Gd]
Batch No.	Irradiation time [h]	Target enrichement in ^{160}Gd [%]	Target mass [mg Gd]	^{161}Tb	^{160}Tb	^{154}Eu	^{156}Eu	^{153}Gd		
03 P	215	97.5	7.3	**6880**	18.17	nd	nd	1.71	0.26	942.5
04 P	216	97.8	10.1	**8602**	nd	0.12	0.56	nd	nd	851.7
05 P	335	97.8	10.1	**10435**	nd	nd	4.43	0.54	nd	1033.2



The Fig.1. presents the elution profile from LN2 column. Narrow, well-separated peaks were obtained from individual gadolinium and terbium fractions.

Fig.1. Elution profile from LN2 column (50-100 µm) 100x10 mm. Radiometric detector blue line. Peaks: Rf= 8 min - Eu, Rf=12 min - Gd, Rf=46 min - Tb. The orange line shows changes in HNO_3 concentration in the UV detector.

The method of precipitation of natural gadolinium oxalate was optimized by investigating the influence of pH and volume of oxalic acid on the precipitation efficiency. The method was verified by preparing recycled material and preparing the target for re-irradiation. Gamma spectrometry measurements and ICP-OES analysis of the solution after irradiation and dissolution of the target were performed. The photos below show the steps of obtaining the recycled [^{160}Gd]Gd_2O_3 target material and packing the weighed portion into a quartz ampoule.



5. Conclusions

The presented results confirm the effectiveness of the proposed Tb-161 separation method and the Gd-160 target material recovery method. Well separated gadolinium and terbium-161 fractions were obtained. The recovered target material can be used for re-irradiation to obtain Tb-161.

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