Production and Purification of ⁴⁷Sc from natV Targets

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Introduction

An example of a clinically used therapeutic pair is “Ga”-Lu. While “Ga”-Lu have shown to be clinically important as a therapeutic strategy, there is a drawback to using this pair of radionuclides. The two radionuclides have differing chemistries, so this can pose several challenges in attempting to develop imaging and therapeutic agents with identical properties. A solution to these challenges would be to develop an elementally matched therapeutic pair. This will result in identical complexation chemistry, identical in vivo binding, and identical in vivo pharmacokinetics. An elementally matched therapeutic pair would allow scientists and physicians to image for treatment assessment, determine dosimetry of radiopharmaceuticals, therapy, and follow-up assessment. Three isotopes of scandium (⁴⁷Sc, ⁴⁹Sc, and ⁵¹Sc) have the decay properties for potential use in medicine as a therapeutic pair compared to “Ga”-Lu (decay scheme below).

- Availability for high radionuclide purity scandium isotopes are limited due to lack of robust production techniques.
- Our goal is to develop a technique to produce high purity radio scandium isotopes from proton irradiation of natV foil targets.

Production

UAB’s TR24 Cyclotron

Production of ⁴⁷Sc from Vanadium Targets

Isotopes of natV
- ⁴⁷V: 99.75%
- ⁴⁹V: 0.25%
- ⁵¹V: 0.004%

Figure 2: Nuclear reactions that occur during this production method.

Cross-sections for ⁴⁷V(p,pp)⁴⁷Sc and ⁴⁷V(p,α)⁴⁷Sc

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Nuclear reaction</th>
<th>Cross section (mb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>⁴⁷Sc</td>
<td>⁴⁷V(p,pp)⁴⁷Sc</td>
<td>0.0226</td>
</tr>
<tr>
<td>⁴⁷Sc</td>
<td>⁴⁷V(p,α)⁴⁷Sc</td>
<td>0.004</td>
</tr>
</tbody>
</table>

Table 1: Products from natV

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Nuclear reaction</th>
<th>Half-life</th>
</tr>
</thead>
<tbody>
<tr>
<td>⁴⁷Sc</td>
<td>⁴⁷V(p,pp)⁴⁷Sc</td>
<td>3.3 days (15968.3s)</td>
</tr>
<tr>
<td>⁴⁷Sc</td>
<td>⁴⁷V(p,α)⁴⁷Sc</td>
<td>22.3 days (15970.3s)</td>
</tr>
<tr>
<td>⁴⁹V</td>
<td>⁴⁹V(2n,3n)⁴⁹Cr</td>
<td>42.3 min (9.950 s)</td>
</tr>
<tr>
<td>⁴⁹Cr</td>
<td>⁴⁹V(p,n)⁴⁹Cr</td>
<td>27.7 days (720.109s)</td>
</tr>
</tbody>
</table>

Figure 3: Cross-sections for ⁴⁷Sc and ⁴⁹Cr on natV provided by TENDL.

Purification

Dissolution Process

- 0.254 mm thick foil
- 10 mm diameter disc
- 24 MeV for ⁴⁷V(p,p+α)⁴⁷Sc
- 30A
- 1 h bombardment
- 2 mm tantalum target holder

Figure 1: PET imaging using ⁴⁷Sc

Column Equilibration

- Add 1.31 grams of AG MP-50 resin
- Add 20 mL of 10% 1 M ammonium acetate
- Add 20 mL of MilliQ water
- Add 20 mL of 8 M HCl

Figure 9: structure of DOTA

Separation

Figure 5: Step by step separation process

Separation Results

Figure 6: Separation profile of ⁴⁷Sc (left y-axis) and ⁴⁹Cr (right y-axis)

Figure 7: Inductively coupled plasma mass spectroscopy results for trace metal analysis

Figure 8: High Purity Germanium data from the dissolved foil

Figure 9: High Purity Germanium data from the pure ⁴⁷Sc

References


Conclusions

- Production of high purity ⁴⁷Sc from proton bombardment of natV foils have been shown to be feasible and provide high recovery when separated.
- Preliminary studies conducted to validate utility of recovered ⁴⁷Sc by radiolabeling to DOTA showed promise for further use of this radionuclide.

Acknowledgements

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Radiolabeling

Preliminary studies were conducted to prove the utility of the purified ⁴⁷Sc.
- Evaporate ⁴⁷Sc down to dryness and brought up to 100µl of 0.3 M HCl
- 1 mg/mL stock of DOTA (1,4,7,10-Tetraazacyclododecane-1,4,7,10-tetraacetic acid)
- 0.25 M ammonium acetate pH 4
- 5 µL of ⁴⁷Sc in each vial
- Heated and vortexed at 95°C at 800 rpm for 30 minutes
- 5G/ILTC developed in 1 M citrate buffer

Figure 12: iTLC data

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