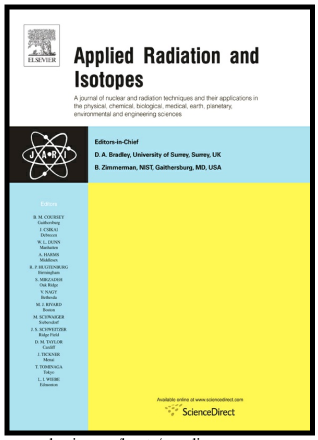
Author’s Accepted Manuscript



www.elsevier.com/locate/apradiso

Electron Linear Accelerator Production and Purification of Scandium-47 from Titanium Dioxide Targets

David A. Rotsch, M. Alex Brown, Jerry A. Nolen, Thomas Brossard, Walter F. Henning, Sergey D. Chemerisov, Roman G. Gromov, John Greene

PII: S0969-8043(17)30989-2
DOI: https://doi.org/10.1016/j.apradiso.2017.11.007
Reference: ARI8156

To appear in: *Applied Radiation and Isotopes*

Received date: 21 August 2017
Revised date: 20 October 2017
Accepted date: 5 November 2017

Cite this article as: David A. Rotsch, M. Alex Brown, Jerry A. Nolen, Thomas Brossard, Walter F. Henning, Sergey D. Chemerisov, Roman G. Gromov and John Greene, Electron Linear Accelerator Production and Purification of Scandium-47 from Titanium Dioxide Targets, *Applied Radiation and Isotopes,* https://doi.org/10.1016/j.apradiso.2017.11.007

Electron Linear Accelerator Production and Purification of Scandium-47 from Titanium Dioxide Targets

David A. Rotsch [a,*], M. Alex Brown [a], Jerry A. Nolen [b], Thomas Brossard [a], Walter F. Henning [b], Sergey D. Chemerisov [a], Roman G. Gromov [a], John Greene [b]

[a] Nuclear Engineering Division, Argonne National Laboratory, Argonne, IL, 60439
[b] Physics Division, Argonne National Laboratory, Argonne, IL, 60439

[*] Corresponding Author.
E-mail address: rotsch@anl.gov (D.A. Rotsch)

Abstract:

The photonuclear production of no-carrier-added (NCA) ^{47}Sc from solid $^{Nat}TiO_2$ and the subsequent chemical processing and purification have been developed. Scandium-47 was produced by the ^{48}Ti(γ,p)^{47}Sc reaction with Bremsstrahlung photons produced from the braking of electrons in a high-Z (W or Ta) convertor. Production yields were simulated with the PHITS code (Particle and Heavy Ion Transport-code System) and compared to experimental results. Irradiated TiO_2 targets were dissolved in fuming H_2SO_4 in the presence of Na_2SO_4 and ^{47}Sc was purified using the commercially available Eichrom DGA resin. Typical ^{47}Sc recovery yields were >90% with excellent specific activity for small batches (<185 MBq batches).

Introduction:

Scandium radioisotopes are of interest for both targeted radiotherapy and imaging. Scandium-47 ($t_{1/2}$ = 3.35 d) has nuclear decay properties that are useful for radiotherapy with low to moderate energy beta emissions of 0.600 (32%) and 0.441 (68%) MeV, and the gamma emission of 159 keV (68%) is very similar to that of ^{99m}Tc, thus ideal for currently used SPECT cameras. Further, the chemical characteristics (both trivalent hard acids) of scandium are very similar to the clinically established ^{177}Lu, suggesting that ^{47}Sc may be able to seamlessly integrate into clinical applications. Although the chemistry of Lu and Sc are very similar, they are not exact. Scandium-47 is chemically identical to ^{44}Sc ($t_{1/2}$ = 3.97 h, $E_{\beta+}$mean 0.632 MeV, positron branching 94.27%). This pairing represents one of the few true theranostic pairs available for medical applications. The shorter half-life of ^{47}Sc may result in a lower dose burden to the patient compared to the longer half-life of ^{177}Lu ($t_{1/2}$ = 6.65 d). Scandium-47 has also been suggested to be more appropriate for small-molecular-weight and peptide-based targeting applications than ^{177}Lu (Połosak, Piotrowska et al. 2013, Müller, Bunka et al. 2014). Recent studies have demonstrated the suitability of ^{47}Sc for therapeutic purposes with the diagnostic analogue ^{44}Sc (Müller, Bunka et al. 2013, Müller, Bunka et al. 2014). The above characteristics make ^{47}Sc a highly promising radionuclide for applications in theranostic nuclear medicine.

The production of ^{47}Sc has been explored with fast neutron reactions on titanium (^{47}Ti and natural) targets (Mausner, Kolsky et al. 1998, Deilami-nezhad, Moghaddam-Banaem et al. 2016), thermal neutrons on calcium-46 targets (Chakravarty, Chakraborty et al. 2017), high energy proton reaction on ^{48}Ti (Srivastava and Dadachova 2001, Srivastava 2013) and ^{48}Ca (Misiak, Walczak et al. 2017), and a ^{47}Ca/^{47}Sc generator (Mausner, Kolsky et al. 1993). Photonuclear approaches from ^{48}Ti targets