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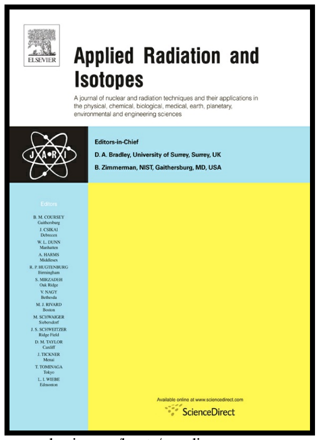

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Spot-welding solid targets for high current cyclotron irradiation.

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Abstract

Zirconium-89 finds broad application for use in positron emission tomography. Its cyclotron production has been limited by the heat transfer from yttrium targets at high beam currents. A spot welding technique allows a three-fold increase in beam current, without affecting ^{89}Zr quality. An yttrium foil, welded to a jet-cooled tantalum support base accommodates a 50 µA proton beam degraded to 14 MeV. The resulting activity yield of 48 ± 4 MBq/(µA·hr) now extends the outreach of ^{89}Zr for a broader distribution.

Keywords

Zirconium-89; ^{89}Zr; Zr-89; Ti-44; spot welding; cyclotron solid targetry

I. Introduction

There has been an increasing acceptance of the radiometals of the 3-d and 4-d subshells to label positron emission tomography (PET) tracers with protracted clearance rates. Peptides, monoclonal antibodies, nanostructures and a host of large molecules can target specific cellular receptors to signal disease, but require a radiolabel with both chemical versatility and a half-life of the order of hours to days to match the slow uptake kinetics often found in various tumors [Anderson and Welch, 2010]. The cyclotron production of scores-of-GBq-levels of the conventional positron emitters (^{11}C and ^{18}F) involve the proton irradiation of gaseous N_2 or liquid $H_2{}^{18}O$. This target science is well developed, while the seemingly simpler prospect of high current bombardment of solid target substrates remains challenging.

Zirconium-89 ($t_{1/2}$=78.4 h) is the most thoroughly clinically developed positron emitting radiometal nuclide with its incorporation into 11 United States clinical trials as of 2016 (clinicaltrials.gov). Its production in moderate (100s of MBq) quantities through the ^{89}Y(p,n)^{89}Zr nuclear reaction (Saha et al., 1966) is currently feasible using small medical cyclotrons capable of irradiating yttrium targets with 5 – 20 µA of 10 – 20 MeV protons. A variety of cyclotron targetry methods have been investigated including the irradiation of Y foils (Link et al., 1986 and DeJesus and Nickles, 1990), Y-sputtered copper (Meijs et al., 1994), powdered Y (Nagatsu et al., 2012), sedimented Y_2O_3 (Sadeghi et al., 2010), and aqueous solutions of $Y(NO_3)_3$ (Pandey et al., 2016).

[1] PAE and HFV contributed equally to this work.