Isotope Production R&D at Jefferson Lab’s High-Power Electron Accelerators

A. Hutton, Jefferson Lab (Principal Investigator)

J. Zweit, Virginia Commonwealth University (Co- Principal Investigator)

D. Wells, South Dakota School of Mines and Technology (Co- Principal Investigator)

Abstract:

High power (~100 kW) electron accelerators are well suited for the production of some important isotopes for medical and industrial use because the high power can compensate for lower cross-sections. The Low-energy Electron Recirculator Facility (LERF) at Jefferson Lab is ideal for this purpose, with beam power in excess of 100 kW over the relevant energy regime. High beam power requires targets and cooling systems that can handle the power dissipation. Irradiated target handling, multiple isotope separation, and adequate radiation shielding must also be considered.

We propose to evaluate photo-nuclear production of 67Cu using the 69Ga (𝛾,) 67Cu reaction. 67Cu is an attractive isotope with beta and gamma emissions that are near ideal for image-guided radiopharmaceutical therapy of cancer and inflammatory diseases. While radiopharmaceutical therapy of cancer has advanced with drugs specifically designed for target selectivity, research with 67Cu has been severely hampered due to the limited availability of 67Cu. The goal of this proposal is to demonstrate the viability of photonuclear production of 67Cu from a novel liquid Gallium target assembly.

We plan to achieve this goal through four major objectives: i) design a target system that can handle beam power up to 50kW and optimize the beam parameters; ii) quantify isotope/s yields and separation efficiency of 67Cu from the irradiated target; iii) measure other impurities (radioactive and stable), and characterize the radiochemical properties and quality of 67Cu, iv) evaluate the suitability of 67Cu for radio-immuno-targeting. Additionally, a graduate student will be trained in this field, with an excellent environment at both SDSMT and VCU for a successful studentship. This proposal is novel because it exploits the (𝛾,) production reaction and uses a liquid target approach for the production of 67Cu. We will also produce 67Cu via the 68Zn (𝛾,p) 67Cu route for a direct head-to-head comparison of the two approaches.

We will refine our preliminary simulations of target design and photo-nuclear simulations and verify them against experiments. To minimize radiological concerns, we will test our 50 kW target design with a high-current low-energy electron beam (≤ 10 MeV and ≥ 5 mA) at LERF. We will use higher beam energies at lower current parasitically in the CEBAF injector to produce isotopes in the targets. SDSMT will be guiding these experiments as the PI has considerable experience with this type of target irradiation. By decoupling high power tests from isotope production tests, we can meet our objectives at reasonable cost.

The targets will be transferred to VCU for separation and evaluation. The Molecular Imaging center at VCU is well equipped for this and has extensive experience in isotope separation, purification and nanoparticle delivery techniques. Jefferson Lab, VCU and SDSMT bring together all the expertise required for this R&D, extending a long-standing collaboration.

We expect this work to demonstrate the proof of concept, providing a path for efficient production of 67Cu, and hence provide the impetus of more 67Cu research in therapeutic and imaging applications of cancer and other diseases. We also expect that the high-power target irradiation technology can be applied for production of other clinically important isotopes in the future.