



Measurement of the ^{64}Zn , $^{47}\text{Ti}(\text{n,p})$ cross sections using a DD neutron generator for medical isotope studies



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ABSTRACT

Cross sections for the $^{47}\text{Ti}(\text{n,p})^{47}\text{Sc}$ and $^{64}\text{Zn}(\text{n,p})^{64}\text{Cu}$ reactions have been measured for quasi-monoenergetic DD neutrons produced by the UC Berkeley High Flux Neutron Generator (HFNG). The HFNG is a compact neutron generator designed as a “flux-trap” that maximizes the probability that a neutron will interact with a sample loaded into a specific, central location. The study was motivated by interest in the production of ^{47}Sc and ^{64}Cu as emerging medical isotopes. The cross sections were measured in ratio to the $^{113}\text{In}(\text{n,n}')^{113\text{m}}\text{In}$ and $^{115}\text{In}(\text{n,n}')^{115\text{m}}\text{In}$ inelastic scattering reactions on co-irradiated indium samples. Post-irradiation counting using an HPGe and LEPS detectors allowed for cross section determination to within 5% uncertainty. The $^{64}\text{Zn}(\text{n,p})^{64}\text{Cu}$ cross section for $2.76_{-0.02}^{+0.01}$ MeV neutrons is reported as 49.3 ± 2.6 mb (relative to ^{113}In) or 46.4 ± 1.7 mb (relative to ^{115}In), and the $^{47}\text{Ti}(\text{n,p})^{47}\text{Sc}$ cross section is reported as 26.26 ± 0.82 mb. The measured cross sections are found to be in good agreement with existing measured values but with lower uncertainty (<5%), and also in agreement with theoretical values. This work highlights the utility of compact, flux-trap DD-based neutron sources for nuclear data measurements and potentially the production of radionuclides for medical applications.

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1. Introduction

There has been significant interest in the past several years in exploring the use of neutron-induced reactions to create radionuclides for a wide range of applications. This interest is due to the volumetric absorption of neutrons as compared to charged particle beams (ranges of g/cm^2 as compared to 10 's of mg/cm^2), together with the fact that isotope production facilities often produce large secondary neutron fields. Particular interest has been paid to (n,p) and (n, α) charge-exchange reactions since these reactions produce high-specific activity radionuclide samples without the use of chemical carriers in the separation process.

Two other potential neutron sources for (n,x) reactions exist in addition to the secondary neutron fields generated at existing isotope production facilities: reactors and neutron generators that utilize the $\text{D}(\text{T},\text{n})\alpha$ (“DT”) and $\text{D}(\text{D},\text{n})^3\text{He}$ (“DD”) reactions. While reactors produce copious quantities of neutrons, their energy spec-

tra are often not well-suited to the preparation of high-purity samples due to the co-production of unwanted activities via neutron capture, in addition to the significant start-up costs and proliferation concerns involved in their commissioning [1]. Similarly, while the higher energy 14–15 MeV neutrons produced at DT generators are capable of initiating (n,p) and (n, α) reactions, their higher energy opens the possibility of creating unwanted activities via (n,pxn) and (n, α xn) reactions that cannot easily be separated from the desired radionuclides. DT generators may also often be limited by the restricted use of tritium at many institutions.

In contrast, the neutron spectrum from a DD reaction, which ranges from approximately 2–3 MeV, is ideally suited to (n,p) radionuclide production. However, the lower achievable flux from these generators limits their production capabilities. An additional complication is the relative paucity of high-quality, consistent cross section data for neutrons in the 2–3 MeV DD energy range.

The purpose of the present work is to explore the potential to use high-flux neutron generators to produce high-specific activity samples of radionuclides at the mCi level for local use in the application community. The research group at UC Berkeley has

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