The Production of ^{13}N using Beam-Target D-^3He Fusion

B.B. Cipiti & G.L. Kulcinski

Fusion Technology Institute
University of Wisconsin
Madison, WI
kulcinski@engr.wisc.edu

The University of Wisconsin Inertial Electrostatic Confinement device has successfully been used to generate medical radioisotopes using the D-^3He fusion reaction. This project is unique in that it uses the by-products of fusion for a commercial application. Inertial Electrostatic Confinement (IEC) is a simple, relatively inexpensive method for sustaining steady-state fusion reactions. It may be developed into a small, semi-portable unit for producing isotopes, and perhaps a cheaper source of isotopes than what is currently available.

Electrostatic acceleration creates high-energy fusion ions to allow for the use of advanced reactions, such as D-^3He. The D-^3He reaction generates 14.7 MeV protons, and these protons have plenty of energy for the cross-sections needed in isotope production. Most of the D-^3He reactions in the IEC device have been found to occur as beam-target reactions in the cathode grid wires due to ion bombardment. This result led to the design of a beam-target method for generating isotopes.

The Wisconsin IEC project has focused initially on the production of isotopes used in Positron Emission Tomography (PET). The positron emitters used in PET scans all have relatively short half-lives. Their use would be greatly enhanced if a small or portable production unit were available. Short-lived species result in much lower residual radiation doses to patients. The isotope ^{13}N, with a ten-minute half-life, was created with the Wisconsin IEC device.

The cathode in the IEC device was replaced with a thin-walled, water-cooled, stainless steel tube. During operation, deuterium and helium-3 are driven into the tube wall, and further bombardment causes embedded fusion reactions to occur. Roughly half of the D-^3He protons travel deeper into the tube to reach the water flowing inside. The high-energy protons are able to generate ^{13}N through the $^{16}O(p,\alpha)^{13}N$ reaction using the oxygen in the water.

At a cathode voltage of 85 kV sustained for a few minutes, approximately 1.0 nCi of ^{13}N was created in a proof of principle experiment. The experimental setup and operation are described along with a discussion about ways to further increase the production yield. Although tens of mCi's are typically needed for PET medical scans, the experiments at the University of Wisconsin represent the first time D-^3He fusion has been used for this application.