OVERVIEW OF THE HRIBF RIB DEVELOPMENT PROGRAM

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Every radioactive beam species presents unique challenges and requires extensive research and development before beams of sufficient intensity for performing meaningful research can be produced. Ion sources are initially developed and tested off-line at the Ion Source Test Facility, followed by on-line tests at the UNISOR facility using low intensity proton and deuteron beams from the tandem accelerator to study release times, ionization efficiencies, and target/ion source operating parameters. Following low-intensity tests at UNISOR, promising target/ion source systems are installed on the RIB injector for testing with high intensity beams from the ORIC. Bombardment with high intensity beams subjects the target to high temperatures and radiation fields and establishes the operational limits for the target/ion source system.

Over the past two years, the RIB development program has concentrated on the development and testing of targets and ion sources for the production of arsenic and gallium beams from molten metal targets, and for the production of fluorine beams from fibrous metal-oxide targets. Good progress has been made on both target systems and radioactive arsenic and gallium beams were delivered to the experimenters.

Beams of radioactive arsenic and gallium isotopes were produced by (p,xn) and (p,αxn) reactions using 42 MeV protons from the ORIC to bombard a molten ^{70}Ge target coupled to an EBP positive-ion source and the first radioactive beam, ^{69}As, was delivered to the experimenters in February and May of 1997. With the present target design, it was determined that the ORIC beam intensity is limited to a maximum of approximately 5 μA. At higher beam intensities, the increase in target temperature due to beam heating increases the vapor pressure of the germanium to the point that the ion source efficiency decreases rapidly. Development of a vapor-transport tube that incorporates cooled condensing surfaces to collect and recirculate the vaporized target material is in progress. Also being studied is a germanium target that may be operated at lower temperatures while maintaining the same or better release properties.

Many different varieties of metal-oxide targets have been tested as potential candidates for making ^{17}F beams using the ^{16}O(d,n) reaction. Alumina, in the form of 3-5 μm diameter fibers, provided reasonable release efficiencies when irradiated with low intensity deuteron beams from the tandem. However, tests with high intensity ~40 MeV deuteron beams from the ORIC have established that the alumina deteriorates rapidly, due to thermal breakdown, at deuteron beam intensities above about 3 μA. Hafnia fiber targets, which can withstand higher temperatures without degradation, have been tested at beam intensities up to 10 μA and are presently being used for the production of ^{17}F beams. Other potential metal-oxide target materials, such as zirconia-yttria, are also being tested at the UNISOR facility.

Since elemental fluorine is chemically reactive, the fluorine atoms produced in the target must be transported as metal-fluoride molecules, AlF molecules being used

in the present case. Although the alumina target provides sufficient aluminum atoms to act as 'carriers', an aluminum-vapor feed system had to be developed for use with the other oxide targets. The AlF molecules are then positively ionized and transported to a charge exchange cell where collisions with Cs atoms break the molecular bond and produce negative fluorine ions. The molecular breakup process introduces a large energy spread, 300-400 eV, which prevents separation of the ^{17}O isobar that, fortunately, is weak. For the hafnia target and EBP ion source, the ratio $^{17}O/^{17}F$ is found to be less than 0.01. A negative-ion source that would eliminate the need for the breakup-charge exchange process has progressed to the point of on-line testing.

Recently our development efforts have begun examining possibilities for producing neutron-rich radioactive ion beams. The only means for producing such nuclei is through fission and low-intensity measurements of proton induced fission of uranium have been initiated.

Longer-lived radionuclides are also of interest to the research community. In particular, beams of doubly-magic ^{56}Ni, $T_{1/2}$ = 6.1 days, would be desirable. A 'batch-mode' ion source is being developed for the production of such isotopes.

Detailed results from the various RIB development programs are presented elsewhere in this report.

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