A STUDY OF RADIOXENON PRODUCTION FROM PROTON BOMBARDMENT OF METALLIC CESIUM

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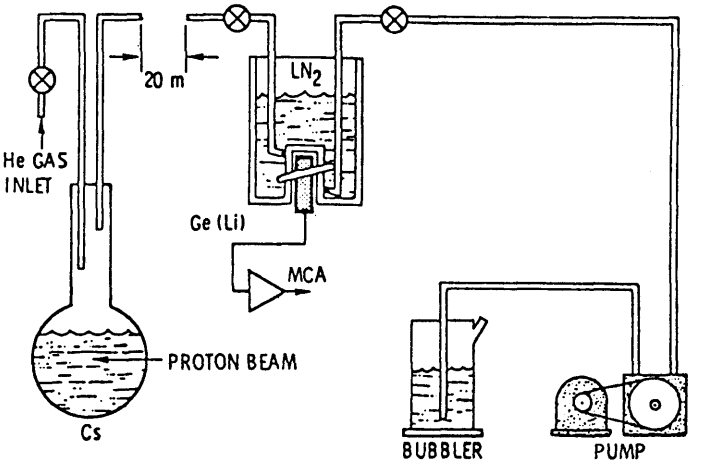
A liquid cesium target has been developed which allows the production and separate identification of the neutron deficient isotopes of Xenon. Nature has been benevolent in making cesium monoisotopic and in separating the radioxenon isotopes ^{123}Xe, ^{125}Xe, ^{127}Xe and ^{129m}Xe by the stable isotopes ^{124}Xe, ^{126}Xe, ^{128}Xi and ^{130}Xe. As a consequence, there exists an incident proton energy at which the yield of a particular radioxenon is a maximum. That is, optimization of the yield vs. contamination by neighboring radioxenons can be achieved for the production of each of the neutron deficient isotopes. The present report describes our preliminary results from the irradiation of this target utilizing 28 to 160 MeV protons, in which Xenon isotopes as light as 119 were observed.

The practical application of radioxenons in nuclear medicine provides the motivation for this study. Xenon-123 is medically the most important radioxenon because it is the parent of ^{123}I, which is used directly in thyroid studies and in labelling many pharmaceutical compounds.[1] Xenon-125 is similarily valuable as the parent of ^{125}I, while ^{127}Xe is used directly in lung profusion studies. If available, ^{129m}Xe may also prove useful for similar studies. Furthermore, ^{129m}Xe is of interest because it exhibits a Mössbauer transition. Previous Mössbauer studies were made using rather weak sources produced by reactor irradiation of natural Xenon followed by mass separation.[2]

The target used for the experiment was a 5 cm diameter by 1 cm thick, thin walled stainless steel container of liquid cesium to which there was attached a vertical reflux column. The cesium was electrically heated to about 80°C so that the radioxenons produced would rapidly reach the liquid surface and evolve from the target. A description of the development, operation and advantages of this "Self-Vapor Cooled Target" system is found in Ref. 3. The radioxenons produced in the target at each bombarding energy were carried away in 6mm diameter tubing by a low flow of helium gas (≤ 50 cc/min) as they evolved from the cesium. They were collected on charcoal in a cold trap operating at liquid nitrogen temperature. The gamma radiation spectra from the charcoal trap were taken during bombardment, and repeatedly for a 30 minute period following bombard-



Cesium target system.

Figure 1.

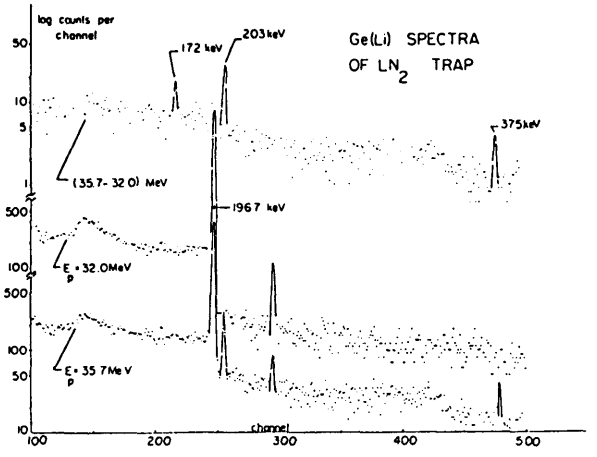


Figure 2.

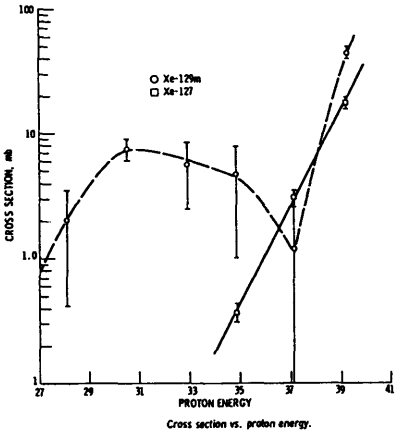


Figure 3.

ment. The trap was subsequently sealed off and then removed from the target system for later determination of the yield of longer lived radioxenons. The experimental configuration is shown schematically in Fig. 1.

The data from 28 to 41 MeV proton bombarding energy were taken using the NASA-LEWIS Research Center's variable energy cyclotron. Analyses of these data were carried out using the cyclotron computer system to fit Gaussian line shapes to the peaks after an appropriate background subtraction. For more complex spectra, consisting of ^{127}Xe and ^{129m}Xe, as observed at 35.7 MeV, a pure ^{129m}Xe spectrum (as observed at 32.0 MeV) was subtracted with proper normalization to permit more accurate analysis of the ^{127}Xe radiation. This technique was used throughout the energy range of the experiment and is illustrated in Fig. 2. The reaction cross section is due to the reactions taking place in a thickness of the target ΔX, where ΔX is the difference in the proton range at the two energies. This ΔX can be converted into an areal density of target nuclei, which together with the number of incident protons and the increase in the yield of the radioxenon permits the calculation of a cross section. These results are shown in Fig. 3 and reported in detail in Ref. 4.

The continuation of these measurements from 41 to 160 MeV was carried out at the IUCF cyclotron Facility in three separate runs using 96, 140 and 160 MeV proton beams. The excitation data for the various radioxenons were made in approximately 5 MeV steps through this energy range by the utilization of energy degrading foils at each proton beam energy. Both Be and C foils of various thicknesses, located in two rotatable target wheels of 9 positions each, were used in combination to provide the desired energy reduction. The analysis of these data is similar to that of the low energy data, except that at these energies, the proton beam does not stop in the target. Hence, while the background subtraction is still accomplished in a manner similar to above, more care must be taken

in determining the production cross sections of the various radioxenons from this yield. Here, the difference in the yield at two successive energies is now assumed to be caused by the reactions taking place in that thickness of the target ΔX in which the higher energy beam is degraded to the lower energy. However, an additional correction must be made to the yield difference because of the effective difference in the target thickness for the lower energy beam in both runs.

The analyses of these data are still in progress; however, preliminary indications are that the peak production cross sections for ^{123}Xe, ^{125}Xe and ^{127}Xe occur at energies of 140, 73 and 60 MeV respectively.

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3) J.W. Blue, K.L. Scholz and V.J. Sodd, "Self-Vapor Cooled Targets for Production of ^{123}I at High Current Accelerators," NASA Technical Memorandum, NASA TMX-71620, Oct. 1974.

4) J.W. Blue, R. Leonard, S. Jha, V.J. Sodd and J.S. Vincent, "A Target for Production of Radioxenons," NASA Technical Memorandum, NASA TMX-73409, April, 1976.