

The Production of ^7Be in a Nuclear Reactor

M. C. Fornaciari Iljadica^{1,2}, I. M. Cohen²

¹Comisión Nacional de Energía Atómica, Centro Atómico Ezeiza, Gerencia de Capacitación, Química Nuclear y Ciencias de la Salud, Presbítero González de Aragón N° 15, B1802AYA Ezeiza, Buenos Aires, Argentina

²Universidad Tecnológica Nacional, Facultad Regional Buenos Aires, Departamento de Ingeniería Química, Av. Medrano 951, C1179AAQ Buenos Aires, Argentina

Abstract – The production of ^7Be in a nuclear reactor, through the reactions induced on lithium by recoil protons produced after collisions with the fast neutrons of the spectrum, is described.

Keywords – Beryllium-7; Nuclear reactors; Recoil protons

I. INTRODUCTION

The interest in the production of ^7Be ($t_{1/2}$ 53.6 d) lies on the fact that this radionuclide is the only practicable beryllium radiotracer. In addition, ^7Be sources are often employed in high resolution gamma spectrometry for the determination of energy calibration curves, since the gamma ray peak associated with its decay by electron capture (477.6 keV) corresponds to a region where the availability of adequate standards is scarce.

Currently, the production of ^7Be is accomplished in charged particle accelerators. Some of reactions used are: $^6\text{Li}(d,n)^7\text{Be}$; $^7\text{Li}(p,n)^7\text{Be}$; and $^{10}\text{B}(p,\alpha)^7\text{Be}$.

The authors have explored the possibility of obtaining ^7Be in a nuclear reactor, through the reactions induced on lithium by the protons ejected from hydrogenous compounds after collisions with the fast neutrons of the spectrum.

As it is well known, the average energy lost by a neutron of kinetic energy E , which encounters a nucleus of atomic mass A , is $2EA/(A + 1)^2$. The recoil protons originated by collisions will have, on the average, nearly half of the primary energy of the neutrons. Thus, in principle, a considerable fraction of these protons can overcome the coulombic barrier of lithium and induce nuclear reactions.

II. EXPERIMENTAL

All the irradiations were carried out in one of the positions of the RA-3 reactor (Ezeiza Atomic Centre). The fast flux at this position, as measured by the reaction: $^{54}\text{Fe}(n,p)^{54}\text{Mn}$, is 1.04×10^{13} n.cm⁻².s⁻¹, and the thermal to fast flux ratio is 3.1. Although the fast flux was not fully characterized, some preliminary experiments tend to demonstrate that it is similar to an undisturbed ^{235}U fission flux.

The measurements by high resolution gamma spectrometry were performed with a (EG&G Ortec, 18% efficiency) HPGe detector, with 1.97 keV resolution for the 1332.5 ^{60}Co peak, and associated electronics.

Lithium hydroxide (about 40 mg) was initially irradiated for three hours. After 7 days decay, beryllium was separated

by solvent extraction as follows [1]:

The irradiated compound was dissolved in 5 ml distilled water and the pH was adjusted to 6.5; 1 ml acetyl acetone was added, in the presence of rubidium and cesium hold-back carriers. The complex of beryllium with acetyl acetone was extracted three times with 3 ml chloroform. Beryllium was back-extracted from the organic phase with two aliquots (4 ml) of HCl; this aqueous phase was finally washed three times with 2 ml chloroform and measured.

The production of ^7Be by recoil protons in aqueous medium was also investigated; 0.1 ml of a slightly acid solution of Li_2CO_3 and about 200 mg solid LiOH were sealed in quartz ampoules and simultaneously irradiated for 6 hours. After a decay of several days, ^7Be was non-destructively measured in both samples.

Since ^7Be could potentially be obtained by (p,n) reaction on ^7Li and also by (p, γ) on ^6Li , the preferential mode of production was investigated: 0.1 ml of Li_2CO_3 solution (natural isotopic composition) was irradiated together with an equal volume of $^6\text{Li}_2\text{CO}_3$ solution having similar concentration and the ^7Be activity induced were measured.

III. RESULTS AND DISCUSSION

The ratio of the activity obtained by irradiation of lithium in solution to that induced in solid LiOH is 4.3. However, a production based on long irradiations, of the order of several days, should contemplate the risks involved in the evolution of gaseous radiolysis products in aqueous media.

The experiments allow to conclude that ^7Be is almost exclusively formed by $^7\text{Li}(p,n)^7\text{Be}$ reaction: the activity ratio for the irradiated solutions of Li_2CO_3 and $^6\text{Li}_2\text{CO}_3$ is 40.9, thus proving that the production via the $^6\text{Li}(p,\gamma)^7\text{Be}$ is, from the practical point of view, negligible.

The extrapolation of the results obtained shows the feasibility of producing activities of 23.3 μCi per gram of lithium for a routine of two irradiation cycles of five days and 2 days elapsed between cycles (several tens of grams can be irradiated in an irradiation can). In conclusion, the possibilities of producing ^7Be as tracer in laboratory scale, and for the preparation of calibration sources, are promising.

REFERENCES

- [1] A. W. Fairhall, The Radiochemistry of Beryllium. National Academy of Sciences, National Research Council (1960).