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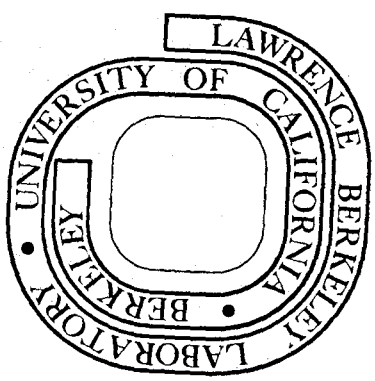

DISCLAIMER

THE HALF-LIFE AND THE α-DECAY BRANCHING RATIO OF ^{207}Po*

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ABSTRACT

^{207}Po was produced via ^{3}He activation of lead samples. Polonium was chemically separated from the irradiated targets. Measurements were performed with Ge(Li) and surface-barrier type α counters. The decay of the 992-keV γ-ray of ^{207}Po was followed and a half-life of 350.3 ± 4.1 min (or 5.84 ± 0.07 hrs) was obtained for ^{207}Po. The α-decay branching of ^{207}Po was measured to be 0.0210 ± 0.0018%.

INTRODUCTION

The α-decay branching ratio of ^{207}Po has not been experimentally determined yet. The only literature value available is the estimation made by Templeton et al. [1] in which an approximate value of 0.01% is predicted. Furthermore, the half-life of ^{207}Po is not accurately known either. Templeton et al. [1] observed its half-life to be 5.7±0.1 hrs by counting its gamma radiation with a Geiger counter. Later John [2] obtained a value of 6.2±0.1 hrs for $T_{1/2}$ of ^{207}Po by counting the gamma activities with a NaI scintillation counter. However, Bell and Skarsgard [3] observed a 5.7-hr activity by counting the K x-rays of ^{207}Po. By measuring the α activity of ^{207}Po, Tielsch-Cassel obtained a value of 5.7±0.3 hrs for the ^{207}Po half-life [4].

Our studies of the ^{3}He reaction with lead has shown that ^{207}Po is produced abundantly. Because of the need for an accurate value for the half-life of this nuclide in our activation analysis studies [5], and due to the abundance of data available from the determination of the excitation function for the production of ^{207}Po from irradiation of Pb by ^{3}He, the evaluation of ^{207}Po half-life and the α-decay branching ratio was undertaken.

Recently the decay scheme of ^{207}Po has been studied very accurately [6,7]. Using the results of the decay scheme work, we measured the half-life and the α-decay branching ratio of ^{207}Po with the techniques of γ- and α-spectroscopy.

EXPERIMENTAL PROCEDURE

The ^{207}Po activity was produced by bombarding foils of 2 mg/cm^2 thick metallic lead evaporated onto a thin Al backing with ^{3}He of energy 34-38 MeV for a period of one hour. This energy range had been found to be maximum for

^{207}Po production [5]. The procedures for target preparation, irradiation, and chemical separation were similar to the ones described by Parsa and Markowitz [5]. In each case, the chemically separated Po portion, which was deposited on a 1-inch diameter and 5-mil thick Ag foil, was finally mounted on an Al sample card for counting.

γ-Ray Spectroscopy

Two trapezoidal Ge(Li) detectors of 30 cm^3 active volumes were used in conjunction with standard charge-sensitive preamplifiers, linear amplifiers, and biased amplifiers. With a Northern 1024-channel or a Victoreen 400-channel pulse-height analyzer, a system resolution of approximately 3 keV (FWHM) as measured at the ^{60}Co 1.33 MeV line was obtained. In every experiment the γ-ray photopeak efficiencies of the Ge(Li) detectors were measured with a set of International Atomic Energy Agency (IAEA) calibrated standards. In the half-life determination, the γ-ray spectra of the chemically separated polonium samples were analyzed. In each case the decay of the 992-keV γ-ray of ^{207}Po (the most intense γ-ray of ^{207}Po) was followed continuously--at first in 20-min and later in 40- and 80-min intervals--for a period of about two days.

α-Particle Spectroscopy

A surface-barrier silicon detector of 12-mm sensitive diameter together with associated electronics and a RIDL 400-channel pulse-height analyzer was used. Routinely, the α spectra had peaks of approximately 20 keV FWHM. The energies of the peaks in the α spectra were determined with ^{210}Po, ^{241}Am, and ^{243}Am sources. The efficiency of the α detector was measured by computing the area of the 5.305-MeV α-particle emitted in 100% of the decays of a standard ^{210}Po

source; this source was plated onto a 1-inch diameter Ag foil in the same manner as were the ^{207}Po samples. Thus, both sample and standard would have the same counting geometry and backscattering effects. The alpha energy of the ^{207}Po was 5.120 MeV [4]. The α sources were essentially "weightless". For the α-branching ratio experiments, the α spectra were followed for a period of approximately one week. The counting commenced immediately after the chemical purification. In each experiment, the gamma-ray spectrum of the source was recorded prior to α counting.

RESULTS AND DISCUSSION

For each half-life determination experiment, the 992-keV photopeak areas from consecutive measurements of the ^{207}Po decay together with the time datum were calculated. Then, the full set of data for each sample was analyzed by use of the laboratory's CDC 7600 computer and the CLSQ code [8]. A corresponding half-life was obtained. Figure 1 illustrates a typical decay curve of the 992-keV γ-ray of ^{207}Po. The results of seven individual experiments for the determination of ^{207}Po half-life are compiled in Table 1. From these results a mean half-life and standard deviation of 350.3 ± 4.1 min (or 5.84 ± 0.07 hrs) is obtained for the ^{207}Po half-life.

For the α-decay branching experiments, the analysis of the α spectra of ^{207}Po was expected to be complicated due to the presence of 2.9-yr ^{208}Po also produced in the Pb + ^{3}He bombardments. Polonium-208 has an α branch (100%) at 5.118 MeV which is extremely close to the 5.120 MeV alpha energy of the ^{207}Po [4]. However, the interference was not serious due to the much longer half-life and lower production cross section of ^{208}Po. Here, the complex nature of the decay

curve of such double lines were used for identifications and manipulations. After the 5.12-MeV peak decayed for several days, the shorter-lived ^{207}Po completely diminished and ^{208}Po was the sole contributer of the α peak. Figure 2 presents a typical α-decay plot of the 5.12-MeV lines as observed in different times. By following the decay of this peak for a period of about one week the ^{208}Po component was resolved and the remaining portion was observed to decay with a half-life corresponding to 5.8 hrs. In each experiment, subsequent measurements of the ^{208}Po α line from the two faces of the polonium-plated Ag foil proved that the Po deposition was the same in both sides of the foil. Finally, the two-side contribution of ^{207}Po counting rate was corrected for the detection efficiency in order to obtain the total ^{207}Po α activity of the source. Alpha self-absorption of the plated polonium activity was negligible since the thickness of the carrier-free deposit was only in the order of 0.1 ng/cm^2. Subsequently, the total ^{207}Po disintegration rate of the source was calculated from the results of the γ-spectroscopy data. The absolute intensity of the 992-keV γ-ray of ^{207}Po was calculated to be 0.59 ± 0.04 γ/d based on Astner and Alpsten's proposed decay scheme and their table of transition intensities [6]. Then the data were corrected for different times of analyses of α- and γ-spectroscopy measurements and the subsequent ^{207}Po decay. Table 2 shows the results of the analyses of the α-decay branching experiments. The mean value and the standard deviation for the α-decay branching of ^{207}Po is found to be 0.0210 ± 0.0018%.

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FOOTNOTES AND REFERENCES

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Table 1. Results of the ^{207}Po half-life determinations.

Expt. No.	half-life (min)
1	346.5
2	357.0
3	344.7
4	352.8
5	349.9
6	349.0
7	352.2
Ave.	350.3 ± 4.1 min

Table 2. Results of the ^{207}Po α-branching experiments.

Expt. No.	α branching (%)
1	0.0229
2	0.0217
3	0.0215
4	0.0224
5	0.0192
6	0.0185
Ave.	0.0210 ± 0.0018%

FIGURE CAPTIONS

Fig. 1. Decay curve of the 992-keV γ-ray of ^{207}Po.

Fig. 2. Alpha spectrum of ^{207}Po at various times. The 5.12-MeV alpha line is composed of alpha particles from ^{207}Po and ^{208}Po.

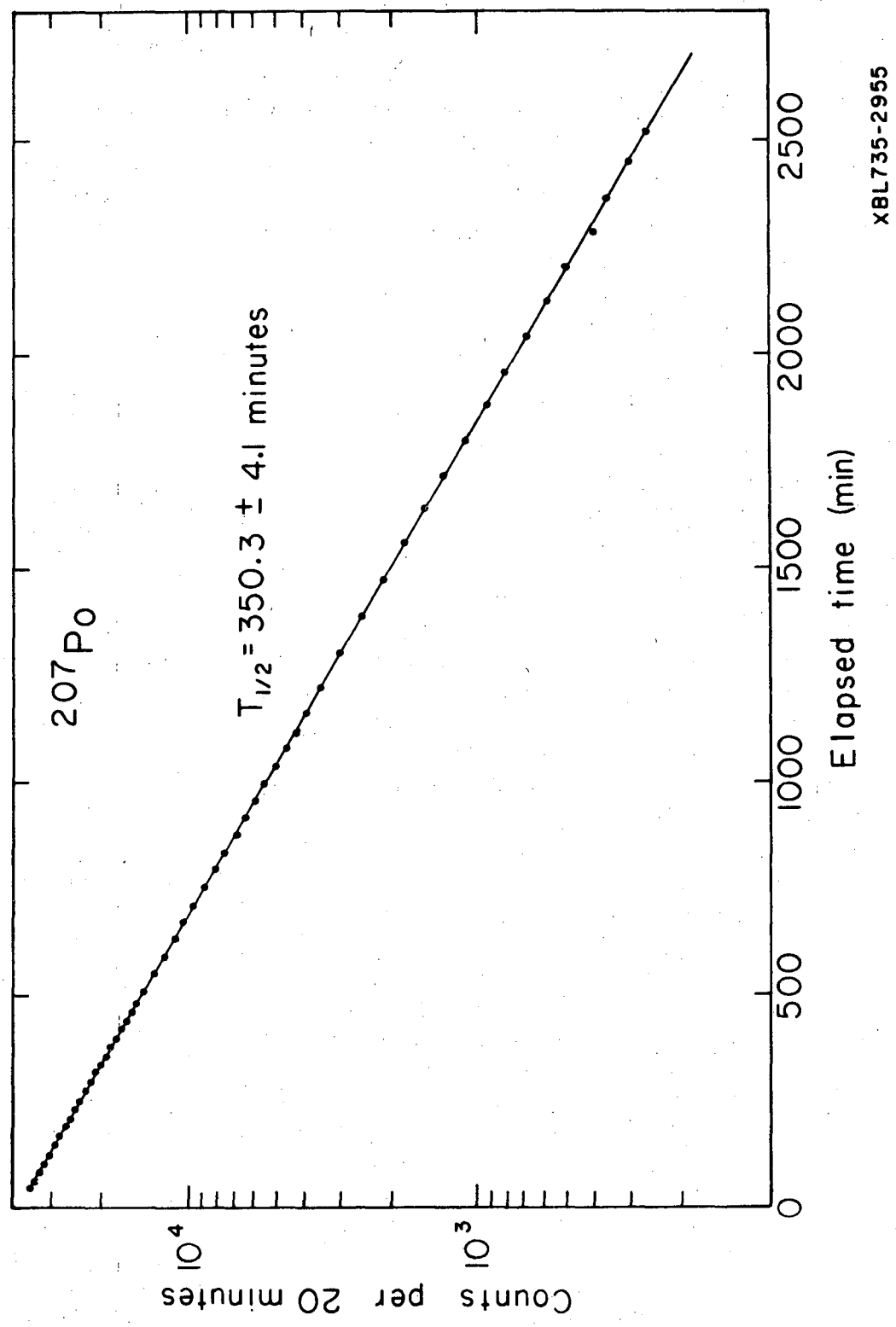
^{207}Po
$T_{1/2} = 350.3 \pm 4.1$ minutes
Counts per 20 minutes
10^4
10^3
0
500
1000
1500
2000
2500
Elapsed time (min)
XBL735-2955

Fig. 1

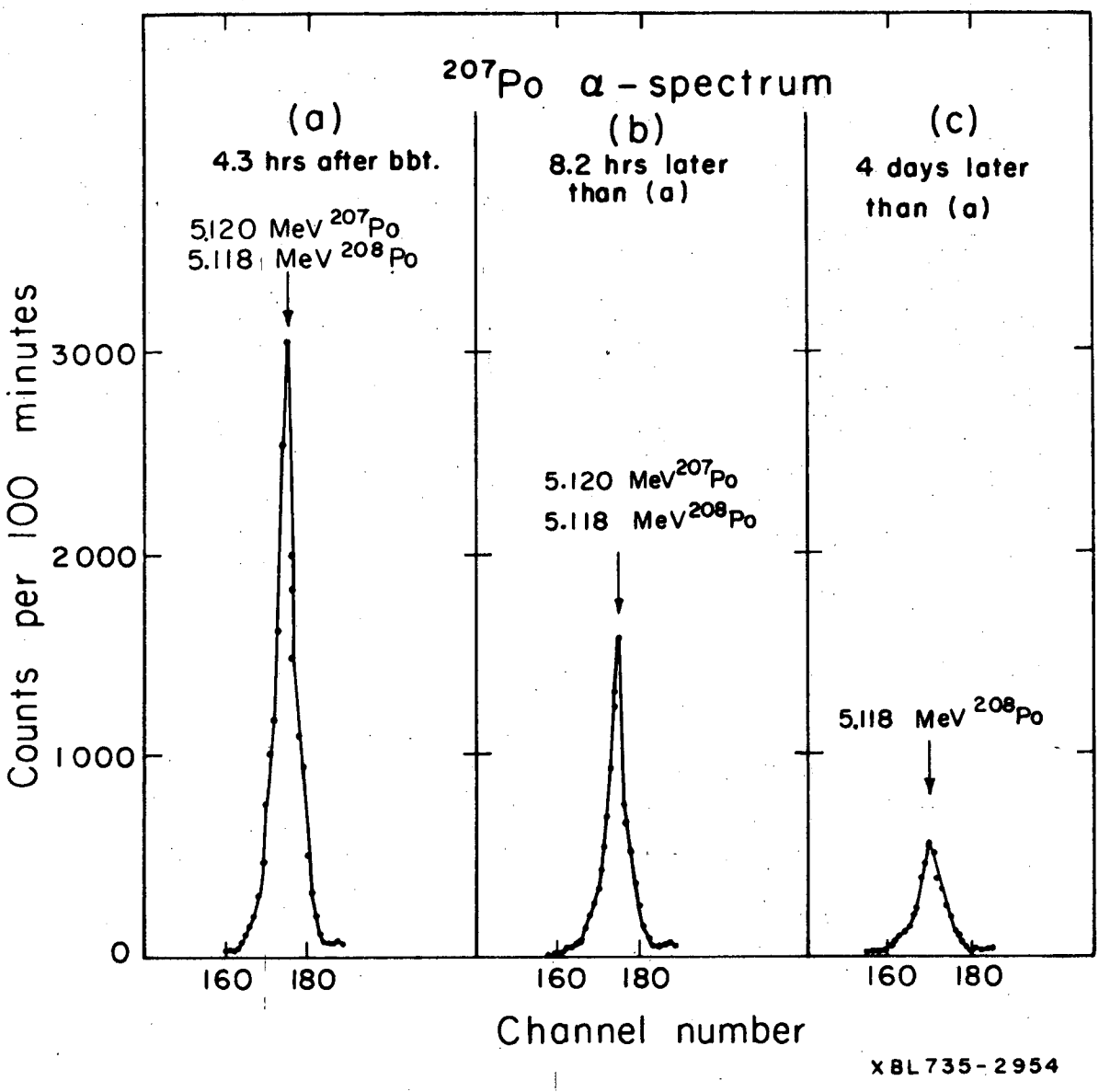
^{207}Po α - spectrum
(a)
4.3 hrs after bbt.
5.120 MeV ^{207}Po
5.118 MeV ^{208}Po
(b)
8.2 hrs later than (a)
5.120 MeV ^{207}Po
5.118 MeV ^{208}Po
(c)
4 days later than (a)
5.118 MeV ^{208}Po
Counts per 100 minutes
3000
2000
1000
0
160
180
Channel number
XBL735-2954

Fig. 2

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