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INTRODUCTION

Sm^{146} was discovered in 1953 by Seaborg and Dunlavey who produced the nuclide by an intense bombardment of neodymium with alpha particles.[1] They reported that it emitted alpha particles of 2.55 Mev energy and decayed with an alpha half life of approximately 5×10^7 years.

Macfarlane and Kohman, in 1959, made a search for Sm^{146} alpha activity in natural samarium employing a large internal-sample cylindrical ionization chamber.[2,3] They obtained a negative result and set an upper limit of 0.01 dis/g/sec for the specific activity in natural samarium.

A report has recently been made by Vorob'ev, Komar, Korolev, and Solgakin of an indication for the existence of Sm^{146} alpha particles in the natural samarium alpha spectrum although the level observed was not considered by them to be statistically significant.[4] They established an upper limit of 0.03 dis /g/ sec for the specific activity.

The purpose of this study was to increase the sensitivity over previous measurements for the detection of a natural Sm^{146} alpha activity by counting a sample "enriched in Sm^{146}". This sample was obtained from the mass 146 position of a calutron collection plate which had been used in the separation of macro amounts of samarium isotopes from natural samarium.

EXPERIMENTAL DETAILS

The samarium oxide was deposited on a stainless steel sheet and placed in an internal-sample cylindrical ionization chamber similar in design to that used previously by the author.[2] It measured 50 cm in length and 14 cm in inside diameter, providing an active sample area of 2000 cm^2. The collecting electrode was a 0.13-mm stainless steel wire strung axially along the full length of the counter and operated near ground potential. A negative potential of 1400 volts was applied to the sample backing. The counter was operated as a flow counter at 1 atm pressure with a gas mixture of 93% argon and 7% methane.

Electronic amplification was provided by a "ball and chain" preamplifier and a "Miemar" main amplifier.[5] The spectrum was recorded on a 100-channel pulse-height analyzer.[6]

RESULTS

An 89-mg sample (approximately 45$\mu g/cm^2$) of the samarium oxide "enriched in Sm^{146}" was counted for a period of 64 hours. The alpha-particle spectrum obtained is shown in Fig. 1. Only the Sm^{147} peak was prominent; there was no significant indication of the presence of second peak in the vicinity of 2.5 Mev.

It was estimated that a peak in the region between 2.4 and 2.7 Mev would have been recognized, had one channel been 20 counts higher than the neighboring channels for the 64-hour period. From the spectra of natural samarium samples of similar thickness, it was found that the channel in which the main portion of the alpha peak was contained, accounted for 3% of the total disintegration rate. From these data, a limit of 0.03 dis/g/sec was established for the specific activity of Sm^{146} in this sample.

On comparison of the Sm^{147} specific activity in the "enriched Sm^{146}" sample with that for naturally occurring samarium, it appeared that an enrichment of 1.7 was realized for Sm^{147}. Based on the mass analyses of other samples which had been mass-separated under the same conditions, an enrichment of 1.7 in an adjacent mass (Sm^{147}) would correspond to at least a factor-of-10 enrichment in the isotope of interest (Sm^{146}), provided it had been present initially in low isotopic abundance.

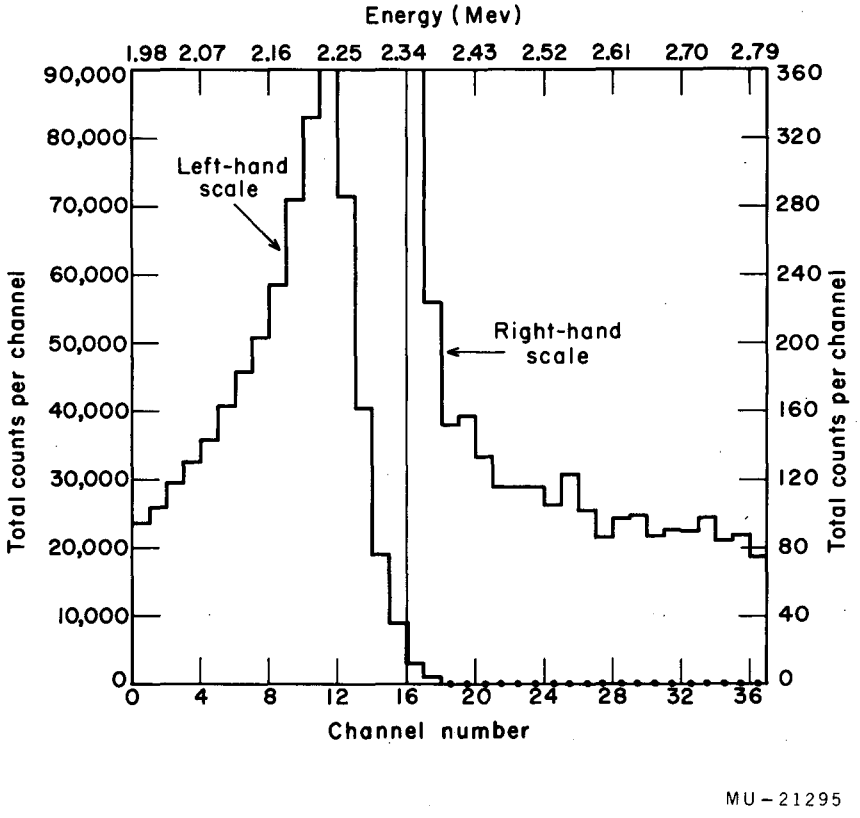

Fig. 1. Alpha particle spectrum of "enriched Sm^{146}" sample.

In terms of the specific activity for an equivalent natural Sm sample, then, the limit would be smaller by a factor of 10 than for the "enriched Sm^{146}" sample, or 0.003 dis/g/sec.

TABLE I

Summary of results on the specific activity of Sm^{146} in nature.

Investigator	Specific Activity (dis/g/sec)
Vorob'ev et al.[4]	≤ 0.03
Macfarlane and Kohman[2,3]	≤ 0.01
This work	≤ 0.003

DISCUSSION

Using the value of the half life of 5×10^7 years obtained by Seaborg and Dunlavey,[1] an upper limit for the isotopic abundance of Sm^{146} can be calculated from the results obtained above. An upper limit of 2×10^{-7}% for the isotopic abundance of Sm^{146} in natural samarium was calculated. The best mass spectrometric limit, obtained by Collins, Rourke, and White, is 8×10^{-5}%.[7]

Recently, the alpha-particle energy of Sm^{146} (produced by bombardment of neodymium with alpha particles) was rechecked and found to agree exactly with the value Seaborg and Dunlavey originally reported (2.55 Mev).[8] From theoretical considerations based on this energy, an alpha half life in the neighborhood of 6×10^7 years is favored. If this is the correct half life, all primordial Sm^{146} should now be Nd^{142}!

ACKNOWLEDGMENTS

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