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Alpha radioactivity in the rare earth region was first observed in natural samarium by Hevesy and Pahl.[1] Further investigations of samarium proved the emitting isotope[2] to be Sm^{147} with an alpha particle energy of 2.18 Mev.[3] No other naturally occurring alpha radioactivity has yet been reported among the rare earths, but following the discovery[4] of artificially produced rare earth alpha emitters on the neutron deficient side of stability, a comprehensive experimental survey and correlation of such rare earth nuclides has been made by Rasmussen, Thompson, and Ghiorso.[5] This work showed that the alpha particle energies for isotopes of a given element increase with decreasing mass number, reaching a maximum in that isotope which decays to the stable configuration of 82 neutrons. The effect is analogous to that found in the heavy element region where the maximum alpha energy for a given element occurs in that isotope which decays to the stable configuration of 126 neutrons.[6]

For the element samarium, the maximum alpha particle energy would be expected to occur in Sm^{146}. This even-even isotope is presumed to be beta stable since it occurs between the even-even beta stable isotopes Sm^{144} and Sm^{148}. Therefore, the absence of Sm^{146} (abundance <0.002 percent[7]) from natural samarium has been believed due to its decay by alpha particle emission with a half-life of upper limit $\sim 10^8$ years.

A successful attempt to produce an amount of this isotope sufficient for investigation of its properties was made by intensely bombarding a target of purified neodymium metal of natural isotopic composition with 40 Mev helium ions in the internal beam of the 60-inch cyclotron. At a time several days after the bombardment, the samarium fraction was separated through the use of a column packed with Dowex-50 cation exchange resin and the use of ammonium lactate eluent. After the intensely radioactive 47-hour Sm^{153} had decayed, aliquots of the samarium fraction in dilute ammonium citrate solution of pH 8 were impregnated into Ilford C-2 and E-1 nuclear photographic emulsions for 72-hour exposure intervals.

Examination of the developed emulsions with a microscope revealed about ten alpha particle tracks of mean energy 2.55 ± 0.05 Mev. This alpha energy value, considered together with the properties of the known samarium isotopes, indicates that the emitting isotope is Sm^{146} formed by (α, n), (α, 2n), and (α, 3n) reactions. This energy for Sm^{146} agrees well with that predicted by Rasmussen, et al.[5]

The beta activity of Sm^{153} (47 hr), formed by the (α, n) reaction, and the electron capture activity of Sm^{145} (410 day), formed by (α, n), (α, 2n), and (α, 3n) reactions, were observed quantitatively using a windowless proportional counter. An approximation of the total Sm^{146} produced was then made through yield comparisons by calculating the amounts of both Sm^{153} and Sm^{145} initially formed and estimating the ratio of the amount of Sm^{146} formed to each of these. Correlation with the observed rate of the 2.55 Mev alpha particle emission gives a half-life approximation of 5×10^7 years for Sm^{146}.

This value agrees, within experimental error, with the theoretical half-life calculated using the formula of Preston[8] and Kaplan.[9] In this calculation, the value used for the nuclear radius of the rare earth region was that reported by Rasmussen, et al,[5] which was obtained through substitution of the experimental alpha decay energy and half-life of the even-even nuclide Gd^{148} in the Preston and Kaplan formula. Thus 2.55 Mev corresponds to a half-life of 1.3×10^7 years while 2.50 Mev gives a half-life about a factor of four longer and 2.60 Mev corresponds to a half-life about four times shorter.

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[1] G. Hevesy and M. Pahl, Nature 130, 846 (1932)

[2] Rasmussen, Reynolds, Thompson, and Ghiorso, Phys. Rev. 80, 475 (1950); B. Weaver, Phys. Rev. 80, 301 (1950); A. J. Dempster, Argonne National Laboratory Report ANL-4355 (1949)

[3] W. P. Jesse and J. Sadanskis, Phys. Rev. 78, 1 (1950)

[4] Thompson, Ghiorso, Rasmussen, and Seaborg, Phys. Rev. 76, 1406 (1949)

[5] Rasmussen, Thompson, and Ghiorso, Phys. Rev. 89, 33 (1953). For semi-empirical considerations see T. P. Kohman, Phys. Rev. 76, 448 (1949) and E. Feenberg, Revs. Modern Phys. 19, 239 (1947)

[6] Perlman, Ghiorso, and Seaborg, Phys. Rev. 77, 26 (1950)

[7] Inghram, Hess, Jr., and Hayden, Phys. Rev. 73, 180 (1948)

[8] M. A. Preston, Phys. Rev. 71, 865 (1947)

[9] I. Kaplan, Phys. Rev. 81, 962 (1951)