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MASS ASSIGNMENTS OF ALPHA-ACTIVE ISOTOPES IN THE RARE EARTH REGION

J. O. Rasmussen, F. L. Reynolds, S. G. Thompson, and A. Ghiorso

August 9, 1950

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In a previous communication from this laboratory, the production of alpha-radioactivity in the rare earth elements was reported.[1] The suggestion was made that this might be due to the influence of the stable configuration of 82 neutrons on the daughter nuclides and some likely isotopic assignments were proposed on this basis. We have succeeded in testing this suggestion through the use of the mass spectrograph to make an isotopic assignment for one of the major artificial rare earth alpha-activities with the result that this explanation seems to be confirmed.

The mass assignment of the alpha-emitting terbium isotope of 4.0-hr. half-life and 4.0-Mev alpha-particle energy was made by performing a mass spectrographic separation of terbium activity onto a photographic plate and detecting alpha-activity by a transfer plate technique. The terbium activity (6×10^7 alpha-disintegrations per minute at end of a 5-hr. bombardment) was produced by bombardment of 30 mg of gadolinium oxide with 150-Mev protons in the 184-inch cyclotron, and rapid chemical separation was made by elution from cation exchange columns with 1/4 μg terbium carrier added before elution. The equipment and method used in the separations were essentially as described previously in the work by Thompson et al. on the new element berkelium.[2] Two column separations were made in order to remove all of the gadolinium, the first column of 1.0 cm diameter, the second of 2 mm diameter. One-fourth μg of samarium nitrate in solution was added to the active terbium fraction before mass spectrographic separation to serve as an internal mass standard. The products of the mass

spectrographic separation in the 60° slit-type mass spectrograph, using a thermal ionization source from a tungsten filament, were collected on an Eastman III-O photographic plate. Before development this plate was left face to face with an Eastman NTA transfer plate for a day. After development the collection plate showed solid lines at the mass numbers corresponding to all the stable samarium isotopes (as both Sm^{+} and SmO^{+}) and to stable terbium (as Tb^{+}). The transfer plate was searched with a microscope for alpha tracks. A concentration of alpha tracks was observed on the transfer plate only in a region corresponding to mass 149. The 4-hr. terbium alpha-activity was the only alpha-activity here present in large enough amount to be detected by this technique. Terbium 149 has 84 neutrons and would thus be expected to have the maximum alpha-decay energy of the terbium isotopes in this mass region.

The suggestion was also made in the previous communication[1] that the long-known natural radioactivity of samarium might be assigned to Sm^{147} or Sm^{148}, rather than to Sm^{152}, since this assignment would be more consistent with decay toward the stable configuration of 82 neutrons (on this basis the most alpha-unstable samarium isotope would be Sm^{146}, and its anomalous absence from nature would thus be explained). This hypothesis has also been tested and it has been found that a major part of this natural radioactivity should indeed be assigned to Sm^{147}. The possibility that there may be also some alpha-radioactivity of nearly the same energy associated with Sm^{148} has not been ruled out.

A sample of isotopically pure Sm^{147} was obtained by ion exchange chemical separation from an 0.8 mg amount of Pm^{147} (a beta-emitter variously reported as 2.26-yr.[3] or 3.7-yr.[4] half-life) which had been allowed to decay for about a year. This samarium sample was analyzed in an optical spark spectrograph to establish its chemical purity, in the mass spectrograph to prove the material was isotopically pure mass 147, and was examined for alpha-activity in an

ionization chamber with differential pulse height analyzer, which affords an alpha-energy determination in addition to detection. Alpha-activity of the same energy as that of the natural samarium alpha-activity was observed. The specific alpha-activity of this small sample of samarium 147 has not yet been accurately determined, but it is roughly of the order of magnitude to account for the total alpha-activity observed in natural samarium.

Dempster[5] had previously come to the conclusion that the natural samarium alpha-activity should be assigned to Sm^{147} on the basis of a continuance of his work using isotopic separation with the mass spectrograph together with the photographic technique for detection.

We are grateful for the advice and suggestions of Glenn T. Seaborg. We wish to thank Dr. John Swartout of Oak Ridge National Laboratory for making available to us the Pm^{147}. The help of J. C. Conway and M. F. Moore in the spectrographic analysis is also gratefully acknowledged. We wish also to thank J. T. Vale and the crew of the 184-inch cyclotron for their assistance in this work. This work was performed under the auspices of the U. S. Atomic Energy Commission.

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

[2] Thompson, Cunningham, and Seaborg, J. Am. Chem. Soc. 72, 2798 (1950).

[3] Inghram, Hayden, and Hess, Phys. Rev. 79, 271 (1950).

[4] J. A. Seiler and L. Winsberg, National Nuclear Energy Series, Plutonium Project Record, Vol. 9B, "Radiochemical Studies: The Fission Products," (McGraw-Hill Book Co., Inc., New York), to be published.

[5] A. J. Dempster, tentative result given in Argonne National Laboratory Report ANL-4355 (October, 1949).