UCRL-9287

UNIVERSITY OF CALIFORNIA

Lawrence Radiation Laboratory
Berkeley, California

Contract No. W-7405-eng-48

PREPARATION OF LONG-LIVED TERBIUM-157 AND TERBIUM-158

Robert A. Naumann, Maynard C. Michel and John L. Power

July 1960

DISCLAIMER

PREPARATION OF LONG-LIVED TERBIUM-157 AND TERBIUM-158*

Robert A. Naumann† and Maynard C. Michel

Lawrence Radiation Laboratory
University of California
Berkeley, California

and

John L. Power

Frick Chemistry Laboratory and Palmer Physics Laboratory
Princeton University
Princeton, New Jersey

July 1960

Previous investigations of the unstable terbium isotopes having mass 157 and 158 have revealed that the mass-157 nuclide has a half life of less than 10 minutes or greater than 25 years[1] while a 111-kev magnetic octupole transition has been attributed to the de-excitation of an isomeric state of the odd-odd 158 nuclide.[2,3] Nuclear spectroscopic investigations indicate that the nuclear ground state of terbium-157 has spin 3/2[4] in accordance with the unified nuclear model,[5] which, in addition, predicts even (positive) parity for this ground state. Investigations using paramagnetic resonance and optical spectroscopy have revealed that stable gadolinium-157 also has nuclear spin 3/2,[6,7] while odd (negative) parity is indicated by the unified nuclear model. The ground state of terbium-158 may be described by assigning the odd proton to the 3/2+ orbital indicated for terbium-157 and the odd neutron to the 3/2⁻ orbital for gadolinium-157. The two states with spins and parities 0- and 3- that arise from these orbitals satisfactorily account for the isomerism observed. On this basis the beta decays of both the terbium-157 and terbium-158 ground states to low-lying states of the respective product nuclei are expected to be at least first-forbidden. Additionally, low energies are expected for these beta-decay processes, since both terbium nuclides lie close to stability; thus it appears reasonable that these isotopes have long lifetimes and have previously remained unobserved.

---

*Work done under the auspices of the U.S. Atomic Energy Commission.

†Procter and Gamble Faculty Fellow, Princeton University, Princeton, N.J.

In the continuation of a program to identify and study long-lived isotopes in the rare earth region,[8] a 5-mg sample of dysprosium oxide enriched to 13.8% in the mass-156 isotope has been irradiated with neutrons in the Materials Testing Reactor. The sample, contained in a quartz ampoule, received an exposure of 2×10^{21} neutrons/cm^2 over a 3-month interval. Four months after irradiation, mass analysis of the unseparated sample was made by using a 30-cm-radius solid-sample mass spectrometer. The presence of mass peaks at 157, 159, 165, and 166, unobservable in the sample before irradiation, indicated neutron capture in dysprosium-156, -158 and -164. The sample was next chemically fractionated by cation-exchange chromatography to yield pure fractions of the various rare earth elements. The holmium, dysprosium, and terbium fractions were identified by scintillation spectroscopy, which revealed the presence of holmium-166, dysprosium-159, and terbium-160. Mass-spectrometric investigation of the terbium fraction revealed the existence of mass peaks at 157, 158, 159, and 160, indicating the preparation of new long-lived isotopes terbium-157 and -158 in addition to the stable terbium-159 and 76-day terbium-160. The relatively high abundance of terbium-158 produced by the neutron capture of terbium-157 points to a high cross section for this process.

A lower limit for the K-capture half life of both terbium-157 and terbium-158 may be set by observing that the isotopic ratios of terbium-157 and -158 to terbium-160 are approximately 160 and 70, respectively, and also that the K x-ray and gamma-ray spectrum of the terbium fraction is predominantly that of 76-day terbium-160. Assuming that the K radiation due to K-capture of terbium-157 and terbium-158 is less than the K radiation accompanying the decay of terbium-160 (primarily due to the high K conversion of the 84-kv transition in gadolimium-160), we conclude the K-capture half lives of these isotopes are greater than 30 years and 15 years respectively. These isotopes will be further examined to search for evidence of electron-capture processes and to determine pertinent neutron cross sections.

It is a pleasure to acknowledge the cooperation of the staff of the Materials Testing Reactor in carrying out the irradiation.

REFERENCES

1. T. H. Handley and W. S. Lyon, Phys. Rev. 99, 1415 (1955).

2. C. L. Hammer and M. G. Stewart, Phys. Rev. 106, 1001 (1957).

3. N. B. Gove, L. T. Dillman, R. W. Henry, and R. A. Becker, Bull. Am. Phys. Soc. Ser. II, 2, 341 (1957).

4. J. W. Mihelich, B. Harmatz, and T. H. Handley, Phys. Rev. 108, 989 (1957).

5. S. G. Nilsson, Mat.-fys. Medd. Kgl. Danske Videnskab. Selskab 29, No. 16, (1959).

6. W. Low, Phys. Rev. 103, 1309 (1956).

7. D. R. Speck, Phys. Rev. 101, 1725 (1956).

8. R. A. Naumann, M. C. Michel, and J. L. Power, Preparation of Long-Lived Holmium-163, J. Inorg. Nuclear Chem. (to be published).

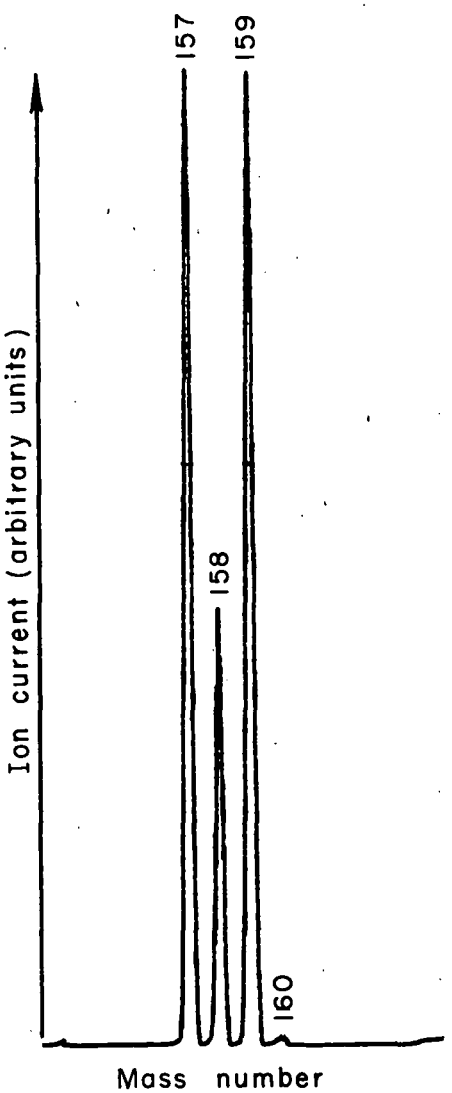
157
159
158
160
Ion current (arbitrary units)
Mass number
MU-20043

Fig. 1.