Lawrence Berkeley National Laboratory
Recent Work

Title
RADIOACTIVE ISOTOPES OF THE RARE EARTH ELEMENTS PART III. HOLMIUM ISOTOPES

Permalink
https://escholarship.org/uc/item/7x32v2sk

Authors
Wilkinson, Geoffrey
Hicks, Harry G.

Publication Date
1950-04-27

eScholarship.org Powered by the California Digital Library
University of California

UCRL 677
Copy 2

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

TWO-WEEK LOAN COPY

This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 5545

BERKELEY, CALIFORNIA

DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

COPY 2

UNCLASSIFIED

UCRL-677
Unclassified Distribution

UNIVERSITY OF CALIFORNIA

Radiation Laboratory

Contract No. W-7405-eng-48

RADIOACTIVE ISOTOPES OF THE RARE EARTH ELEMENTS

PART III. HOLMIUM ISOTOPES

Geoffrey Wilkinson and Harry G. Hicks

April 27, 1950

Berkeley, California

INSTALLATION:	No. of Copies
Argonne National Laboratory	8
Armed Forces Special Weapons Project	1
Atomic Energy Commission, Washington	2
Battelle Memorial Institute	1
Brush Beryllium Company	1
Brookhaven National Laboratory	8
Bureau of Medicine and Surgery	1
Bureau of Ships	1
Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp. (K-25 Plant)	4
Carbide & Carbon Chemicals Div., Union Carbide & Carbon Corp. (Y-12 Plant)	4
Chicago Operations Office	1
Cleveland Area Office, AEC	1
Columbia University (J. R. Dunning)	1
Columbia University (G. Failla)	1
Dow Chemical Company	1
H. K. Ferguson Company	1
General Electric, Richland	6
Harshaw Chemical Corporation	1
Idaho Operations Office	1
Iowa State College	2
Kansas City Operations Branch	1
Kellex Corporation	2
Knolls Atomic Power Laboratory	4
Los Alamos Scientific Laboratory	3
Mallinckrodt Chemical Works	1
Massachusetts Institute of Technology (A. Gaudin)	1
Massachusetts Institute of Technology (A. R. Kaufmann)	1
Mound Laboratory	3
National Advisory Committee for Aeronautics	2
National Bureau of Standards	2
Naval Radiological Defense Laboratory	2
New Brunswick Laboratory	1
New York Operations Office	5
North American Aviation, Inc.	1
Oak Ridge National Laboratory	8
Patent Branch (Washington)	1
Rand Corporation	1
Sandia Laboratory	1
Santa Fe Operations Office	1
Sylvania Electric Products, Inc.	1
Technical Information Division (Oak Ridge)	15
USAF, Air Surgeon (R. H. Blount)	1
USAF, Director of Armament (C. I. Browne)	1
USAF, Director of Plans and Operations (R. L. Applegate)	1
USAF, Director of Research and Development (F. W. Bruner, and R. J. Mason)	2
USAF, Eglin Air Force Base (K. K. Compton)	1

INSTALLATION:	No. of Copies
USAF, Kirtland Air Force Base (H. G. Montgomery, Jr.)	1
USAF, Maxwell Air Force Base (F. N. Moyers)	1
USAF, NEPA Office	2
USAF, Office of Atomic Energy (A. A. Fickel, H. C. Donnelly)	2
USAF, Offutt Air Force Base (H. R. Sullivan, Jr.)	1
USAF, Wright-Patterson Air Force Base (Rodney Nudenberg)	1
U. S. Army, Atomic Energy Branch (A. W. Betts)	1
U. S. Army, Army Field Forces (James Kerr)	1
U. S. Army, Commanding General, Chemical Corps Technical Command (J. A. MacLaughlin thru Mrs. G. Benjamin)	1
U. S. Army, Chief of Ordnance (A. R. Del Campo)	1
U. S. Army, Commanding Officer Watertown Arsenal (Carroll H. Deitrick)	1
U. S. Army, Director of Operations Research (Ellis Johnson)	1
U. S. Army, Office of Engineers (B. D. Jones)	1
U. S. Army, Office of the Chief Signal Officer (Curtis T. Clayton thru George C. Hunt)	1
U. S. Army, Office of the Surgeon General (W. S. Stone)	1
U. S. Geological Survey (T. B. Nolan)	1
U. S. Public Health Service	1
University of California at Los Angeles	1
University of California Radiation Laboratory	5
University of Rochester	2
University of Washington	1
Western Reserve University	2
Westinghouse Electric Company	4
Univ. of Rochester, Physics Department (R. E. Marshak)	1
Total	145

Information Division
Radiation Laboratory
University of California
Berkeley, California

RADIOACTIVE ISOTOPES OF THE RARE EARTHS ELEMENTS

PART III. HOLMIUM ISOTOPES

Geoffrey Wilkinson and Harry G. Hicks*

Radiation Laboratory and Department of Chemistry
University of California, Berkeley, California

April 27, 1950

ABSTRACT

A study has been made of neutron deficient radioactive isotopes of holmium produced by α-particle bombardments of terbium, and by proton and deuteron bombardments of dysprosium.

* Present address: Chemical Research Section
General Electric Company
Hanford Engineer Works, Richland, Washington

RADIOACTIVE ISOTOPES OF THE RARE EARTH ELEMENTS

PART III. HOLMIUM ISOTOPES

Geoffrey Wilkinson and Harry G. Hicks

I. INTRODUCTION

In a previous paper[1] the techniques of study of radioactive isotopes of the rare earth elements have been described. Using the 60 inch Crocker Laboratory cyclotron, bombardments have been made of terbium with 38 Mev and lower energy α-particles, and of dysprosium with 10 Mev protons and 19 Mev deuterons. Separation of the rare earths was made by the ion exchange resin column procedure described previously.

(1) G. Wilkinson, H. G. Hicks, Phys. Rev. 75 1370 (1949).

With the exception of the 34 minute isotope, all the other activities studied decay with emission of electromagnetic radiations of half thicknesses 8.5 mg/cm^2 aluminum (6.8 Kev) and 70 mg/cm^2 lead (48 Kev), corresponding to dysprosium L and L x-radiation respectively, and indicating decay by orbital electron capture. Electron radiations of all the isotopes were checked for sign and energy on a simple beta ray spectrometer. In Table I, which summarizes the production and properties of the holmium activities, energies of electrons and γ rays are obtained from aluminum and lead absorption measurements; positron energies were obtained from the spectrometer.

Table I

Isotope	Type of Radiation	Half Life	Energy of Radiation in Mev Particles	γ Rays	Produced by
Ho^{160}	K, e^-, β^+(0.5%), γ	22.5 ± 0.5 mins.	0.17(e^-) ~1.3(β^+)	~1.2	Tb-α-3n
Ho^{161}	K, e^-, γ	4.6 ± 0.1 hours	~0.1(e^-)	1.1	Tb-α-2n Dy-p-n Dy-d-2n
Ho^{162}	K, β^-(~15%), e^-, γ	65 ± 0.5 days	~0.1(e^-) 0.8(β^-)	~1 (weak)	Tb-α-n Dy-p-n Dy-d-n, 2n
Ho^{163}	K, e^-, γ	5.2±0.05 days	0.4	0.4-0.5, 1.4	Dy-p-n Dy-d-n, 2n
Ho^{164}	β^-	34.0 ± 0.5 mins.	0.95		Dy-p-n

HOLMIUM ISOTOPES

In the bombardment of terbium with α-particles of various energies, radioactive isotopes of half lives 22.5 minutes, 4.6 hours and 65 days were observed. Short bombardments of dysprosium with 10 Mev protons allowed characterization of a 34 minute beta emitting isotope, together with the 4.6 hour and longer lived activities; in long bombardments of dysprosium with 10 Mev protons and 19 Mev deuterons, activities of 4.6 hours and 65 days half life, identical with those from Tb + α bombardments, were found together with an activity of 5.2 days half life.

The allocation of the 22.5 minute, 4.6 hour and 65 day holmium activities to masses 160, 161 and 162 respectively was made on the basis of yields in bombardments of terbium with 38, 30 and 19 Mev α-particles; the yields follow a pattern similar to that found for the production of thulium activities in α-particle bombardments of holmium.(1) The measured K x-radiation was taken as representing decay by orbital electron capture for the comparison of yields. The yields of the active isotopes formed in 10 Mev proton bombardments of dysprosium are approximately equal as would be expected from the similarity in abundance of the dysprosium isotopes of masses 161-4 inclusive. The 5.2 day activity is allocated to mass 163 since it was not observed in α particle bombardments of terbium, or in fast neutron bombardments of holmium, but was formed in yields approximately the same as the other isotopes in proton bombardments of dysprosium.

34.0 ± 0.5 minute Ho^{164}. An activity of 47 minutes half life produced by fast neutron bombardment of holmium has been reported in an early paper.(2)

---

(2) Pool, M. L., Quill, L. L., Phys. Rev. 53, 437 (1938).

The 34 minute isotope here described was produced by short bombardments of pure dysprosium oxide with 10 Mev protons. Identification of the activity with holmium has not been proved by chemical separation but no activities due to known dysprosium isotopes have been observed, and longer lived activities from the same bombardment have been shown to follow holmium chemistry.

A half life of 34.0 ± 0.5 minutes was obtained through eight periods, after subtraction of the longer lived holmium activities, principally the 4.6 hour activity, from the decay curves. The resolved aluminum absorption curve of the 34 minute activity shows this to have a simple beta particle. The Feather range, 370 mg/cm^2 aluminum, (0.95 Mev), agrees with the maximum energy obtained for the negative beta particle on a simple beta ray spectrometer. An upper limit of 0.05 γ ray quanta per beta particle can be set; no γ radiation or conversion electrons attributable to the 34 minute activity were observed even in very active samples.

5.20 ± 0.05 day Ho^{163}. This activity whose decay was followed through six periods was found only in long bombardments of dysprosium with deuterons or protons. The ratio of the various radiations obtained from absorption measurements and corrected for counting efficiency, absorption in counter window, etc. are approximately, 0.4 Mev electron; L x-rays; K x-rays: ~0.5 Mev γ ray: 1.4 Mev γ ray, 0.04: 0.6: 1: ~ 0.1: ~ 0.25. The isotope thus appears to decay predominantly by orbital electron capture; the 0.04 Mev electron probably results from conversion of the weak 0.5 Mev γ ray.

65 ± 0.5 day Ho^{162}. This activity, the decay of which has been followed for eight periods, is produced both in Tb + α and Dy + p bombardments and is identical in both cases. The Feather range of 300 mg/cm^2 (0.8 Mev)

for the hard electron corresponds well with the maximum energy of 0.8 Mev obtained from the spectrometer. The ratios of the radiations are 0.1 Mev e^-: 0.8 Mev β^-: L x-rays: K x-rays: 1.0 Mev γ ray = $\sim 0.1 : \sim 0.15 : \sim 1 : 1 : < 0.1$. The isotope thus appears to decay predominantly by orbital electron capture with ~15% branching decay by negative beta particle emission. The shape of the aluminum absorption curve (Fig. I) of the 0.8 Mev particle and also its distribution on the magnetic spectrometer is that of a negative beta particle.

4.6 ± 0.1 hour Ho^{161}. This activity was observed with identical radiation characteristics in both Tb + α and Dy + p bombardments. The decay of both electron and electromagnetic was followed through seven half lives. The approximate ratios of the various radiations obtained are ~ 0.1 Mev e^- L x-rays : K x-rays : 1.1 Mev γ ray $\approx \sim 0.1 : \sim 1 : 1 : \sim 1$.

22.5 ± 0.5 minute Ho^{160}. This activity was observed only in short 38 Mev α-particle bombardments of terbium together with the 4.6 hour and 65 day activities. The decay was followed through six periods. The approximate ratios of the radiation are: 0.17 e^- : β^+ : L x-rays : K x-rays : γ ray $\approx 0.1 : \sim 0.005 : \sim 0.4 : 1 : \sim 1$. Assuming that one K x-ray quantum represents one disintegration by orbital electron capture, branching decay by positron emission is about 0.5%.

ACKNOWLEDGMENTS

The authors wish to thank Profs. G. T. Seaborg and I. Perlman for their continued interest and advice and Dr. J. G. Hamilton and the crew of the 60-inch Crocker Laboratory cyclotron for assistance in bombardments.

The work described in this paper was performed under the auspices of the Atomic Energy Commission.

Figure 1

Aluminum Absorption of Radiations of 65 Day Ho^{162}; A is the measured curve with D, the electromagnetic radiation contribution obtained after removal of electrons in beryllium. B and C are respectively the negative beta particle of 0.8 Mev maximum energy and the 0.1 Mev electron.

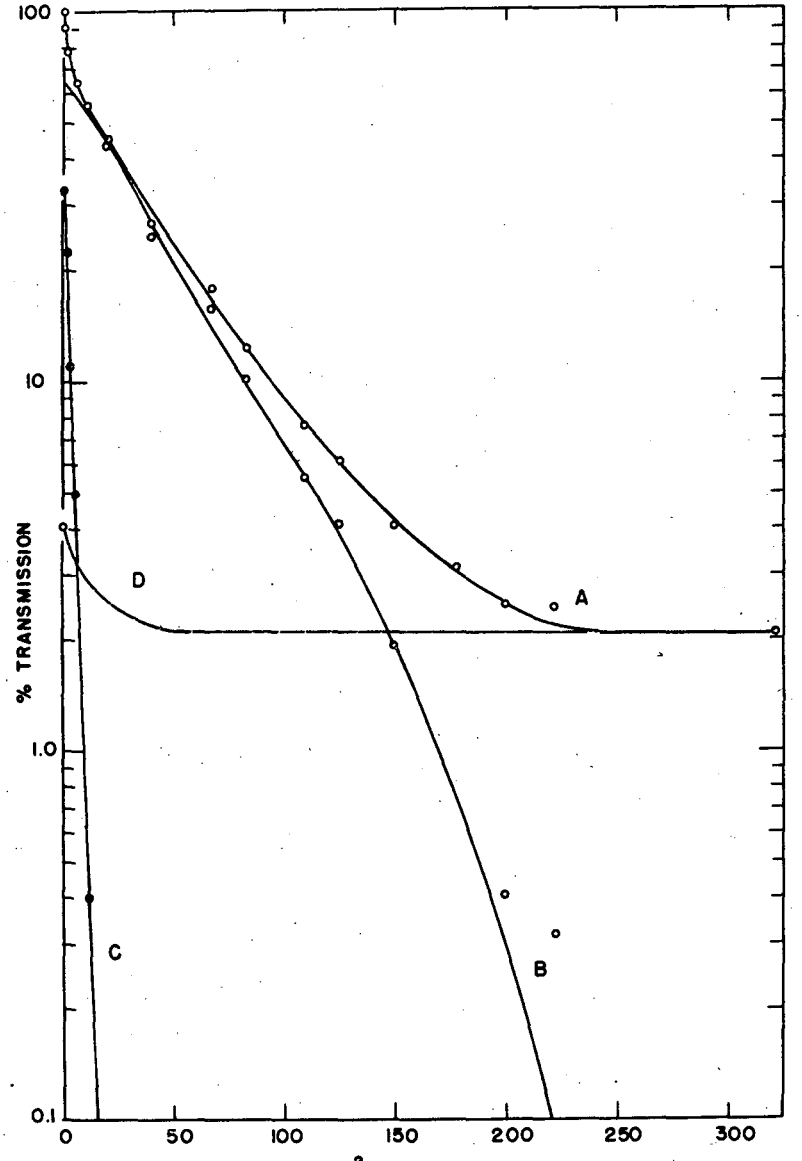
100
10
1.0
0.1
% TRANSMISSION
D
A
C
B
0
50
100
150
200
250
300
mg/cm² ALUMINUM ABSORBER
Mu 144
13197-1

FIG. 1