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THE NEW ISOTOPE Pu^{242} AND ADDITIONAL INFORMATION ON OTHER PLUTONIUM ISOTOPES

S. G. Thompson, K. Street, Jr., A Ghiorso, and F. L. Reynolds

June 23, 1950

Berkeley, California

Standard Distribution: Series A	Copy Numbers
Argonne National Laboratory	1-10
Atomic Energy Commission, Washington	11-12
Brookhaven National Laboratory	13-16
Carbide & Carbon Chemicals Division (K-25 Plant)	17-18
Carbide & Carbon Chemicals Division (Y-12 Plant)	19
General Electric Company, Richland	20-25
Hanford Operations Office	26
Iowa State College	27
Kellex Corporation	28
Knolls Atomic Power Laboratory	29-32
Los Alamos	33-35
Mound Laboratory	36-38
Naval Radiological Defense Laboratory	39
NEPA Project	40
New York Operations Office	41-42
Oak Ridge National Laboratory	43-48
Patent Branch, Washington	49
Technical Information Division, ORE	50-64
UCLA Medical Research Laboratory (Warren)	65
University of California Radiation Laboratory	66-68
University of Rochester	69-70
Total	70

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THE NEW ISOTOPE Pu^{242} AND ADDITIONAL INFORMATION ON OTHER PLUTONIUM ISOTOPES

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June 23, 1950

Investigation of the higher isotopes of plutonium produced by neutron irradiation has revealed the existence and properties of a new plutonium isotope, namely Pu^{242}, and has also yielded some additional information about the previously reported isotopes Pu^{240} and Pu^{241}. This letter will give only a brief report of these new results and a detailed description of the experiments will be deferred until a later date. The investigation of these isotopes was made possible by the intensive irradiation with neutrons of plutonium and americium samples originally consisting essentially completely of the isotopes Pu^{239} and Am^{241}, respectively. The production of Pu^{240} and Pu^{241} by the neutron irradiation of Pu^{239} has been previously reported.[1] Following the irradiation of the samples, which occurred over periods up to a few years, the plutonium, americium, and curium were chemically separated from each other and from fission products and impurities. The isotopic composition of each plutonium sample was then determined using a mass spectrograph which employed a thermal ionization source. Lines corresponding to plutonium isotopes of masses 241 and 242 produced by (n,γ) reactions were observed in addition to lines due to the other well-known plutonium isotopes (Pu^{238}, Pu^{239}, and Pu^{240}).

Pu^{240}.-- Using very thin samples formed by volatilization from a hot filament, the width of the observed alpha-pulse analysis peak corresponding to the alpha-particles in a sample containing the two isotopes Pu^{239} and Pu^{240} was such that there is not more than about 20 Kev difference in the alpha-particle energies of these two isotopes. Therefore, the alpha-particle energy[2] of Pu^{240} is 5.16 ± 0.02 Mev.

Pu^{241}.-- A low abundance group of alpha-particles at the energy 4.91 ± 0.03 Mev was observed in neutron bombarded plutonium using the 48 channel differential alpha-energy pulse analyzer. This group is present in the amount expected if it is due to the isotope Pu^{241}, i.e., best agreement with the alpha-decay systematics[3] is obtained if it is due to Pu^{241}, and it cannot be due to Pu^{242} in view of the results discussed below. To be a low energy alpha-group of the isotope, Pu^{240}, its abundance would apparently be greater by a factor[4] of 5-10. If this alpha-particle group is ascribed to Pu^{241}, its alpha intensity and isotopic abundance lead to a partial half-life of Pu^{241} for alpha-particle decay of roughly 4×10^5 years in agreement with previous results.[5]

The half-life of Pu^{241} for beta-particle decay was estimated from the growth of the daughter Am^{241} using tracer Cm^{242} to determine chemical yield in the separations of the Am^{241} from the plutonium. The separations were made with measured amounts of plutonium in which the daughter had been allowed to grow over successively measured intervals of time. Using the mass spectrographically determined value for the isotopic abundance of Pu^{241} in the plutonium, and a value of 475 years for the half-life[6] of Am^{241}, the half-life of the Pu^{241} for beta-decay was calculated as 14 years which is in rough agreement with the previous value (~10 years).[5]

A rough estimate of the cross section for the reaction $Pu^{241}(n,\gamma)Pu^{242}$ with pile neutrons was obtained using an estimated value for the neutron flux and the isotopic compositions determined in the mass spectrograph. The cross section so obtained was very roughly 250 barns but it is subject to large error due to uncertainty in the estimation of the neutron flux.

Pu^{242}.-- The isotope Pu^{242} was observed in a mass spectrographic analysis of neutron bombarded plutonium, but its abundance was too small to make it possible to identify the radioactive decay properties in such samples. However, O'Kelley, Crane, Barton, and Perlman[7] have observed that the 16-hour Am^{242m} undergoes

appreciable branching decay through the electron capture process. Advantage was taken of this by separating a plutonium fraction from a sample of americium (Am^{241}) which had been bombarded with neutrons for several months. Mass spectrographic analysis of the total plutonium produced during the irradiation showed that it consisted of about 50 percent Pu^{242} and 50 percent Pu^{238}, the former produced by the electron capture decay of Am^{242m} and the latter through the decay chain $Am^{242m} \xrightarrow[16\ hr.]{\beta^-} Cm^{242} \xrightarrow[162\ days]{\alpha} Pu^{238}$. Alpha-pulse analysis of this plutonium showed the presence of alpha-particles of 4.88 Mev in abundance corresponding to a half-life of roughly 5×10^5 years for Pu^{242}. This energy and half-life agrees well with those expected for Pu^{242} from the alpha-decay systematics which also indicate that this isotope should be beta-stable. A smaller sample of daughter plutonium containing a higher proportion of Pu^{242} with respect to Pu^{238} was obtained by separating plutonium from a sample of 16-hour Am^{242m} which was initially free of plutonium and which was allowed to decay for about a day. The alpha-pulse analysis of this sample also showed the 4.88-Mev alpha-particle of Pu^{242}, in this case present in greater relative abundance as expected.

We wish to acknowledge the advice and assistance of Professor Glenn T. Seaborg whose help contributed greatly to the success of this work.

The successful handling in a safe manner of the radioactivity involved was made possible through the operation and use of remote control equipment and excellent protective devices provided by Nelson Garden and the members of his Health Chemistry group. In this connection we especially wish to thank C. M. Gordon, W. G. Ruehle, and J. M. Davis for assistance during the experiments.

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