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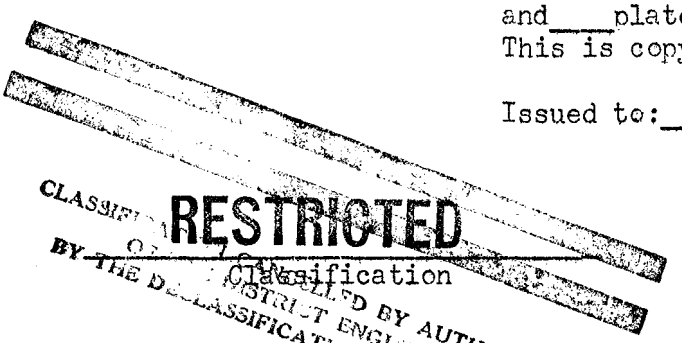

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NEUTRON DEFICIENT ISOTOPES OF RHODIUM AND PALLADIUM

by
Manfred Lindner and I. Perlman

February 2, 1948

Berkeley, California

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Neutron Deficient Isotopes of Rhodium and Palladium

Manfred Lindner and I. Perlman

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

ABSTRACT

A 9-hour palladium activity assigned to mass 101 and 4.0 day activity assigned to mass 100 have been identified.

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Neutron Deficient Isotopes of Rhodium and Palladium

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University of California, Berkeley, California

As a part of an investigation being carried out on the nuclear reactions resulting from the irradiation of antimony with high energy particles (200 Mev deuterons) it became of interest to examine the products some 20 mass units below the target nucleus, that is, around mass number 100. This region covers heavy isotopes of Mo and Tc, stable isotopes of Ru and light isotopes of Rh and Pd. It was not possible to isolate chemically the rhodium fraction from the complex mixture of reaction products but the palladium fraction could be purified in good yield. The decay curve was too complex to resolve accurately as it proved to consist of at least six different palladium activities and a similar number of daughter activities growing in with a considerable spread of half-lives. By periodically isolating from the palladium the silver and rhodium daughters a considerably better picture of the species present could be obtained. For example, silver fractions removed at intervals proved the presence of palladium β^- - emitters as part of the following isobar pairs: 13 hr Pd^{109} - 40 sec Ag^{109*}, 26 min Pd^{111} - 7.5 d Ag^{111}, 21 hr Pd^{112} - 3.2 hr Ag^{112}. In similar manner the presence of two new neutron deficient isotopes of palladium was deduced by removing rhodium daughters periodically. The rhodium so obtained could be resolved into half-life periods suggestive of two activities reported by Sullivan, Sleight and Gladrow[1] as 21-hr Rh^{100} and 5.9-day Rh^{101}. These activities were formed from palladium at rates corresponding to half-lives of ~4 days for the parent of Rh^{100} and ~10 hrs for the parent of Rh^{101}.

In order to better characterize these isotopes tentatively assigned to Rh^{101} and Pd^{100} they were prepared in another manner. It was estimated that 50-Mev deuterons on rhodium (Rh^{103}) should promote (d,4n) and (d,5n) reactions

in good yield and minimize the yield of Pd^{103} (d, 2n reaction). Furthermore Pd^{99} would probably have a half-life too short to interfere with the measurements and Pd^{98} could probably not be reached at this energy. The palladium β^- - emitters could, of course, not be made by irradiating rhodium.

A thin rhodium metal foil was bombarded with 50-Mev deuterons in the 184" cyclotron, the rhodium was dissolved by $KHSO_4$ fusion and the palladium fraction was removed by precipitating palladium dimethylglyoxime from slightly acid solution.

The palladium fraction proved to contain the activities that were sought and the resolution into the components was accomplished by methods described below. The palladium contained three activities, of half-lives 9 hrs, 4.0 days and 17 days. Rhodium which was removed from the palladium showed a 4.3 day period which is the daughter of 9-hr Pd and a 19.4 hr-Rh daughter of the 4.0-day Pd. The 57 min Rh^{103*} daughter of 17-day-Pd^{103} was not observed because of the low yield of Pd^{103} and the unfavorable conditions for detection. Since the rhodium isotopes are probably the same as those reported by Sullivan, Sleight, and Gladrow[1] from deuterons on ruthenium and since the present measurements are not in disagreement with the isotopic assignments made by them, the decay chains may be summarized:

$$Pd^{101} \xrightarrow{9\ hr} Rh^{101} \xrightarrow{4.3\ day} Ru^{101}$$

$$Pd^{100} \xrightarrow{4.0\ day} Rh^{100} \xrightarrow{19.4\ hr} Ru^{100}$$

9 hr-Pd^{101} From the ratio of x-rays to positrons it was estimated that this isotope decays ~90% by orbital electron capture and ~10% by positron emission. The positron energy was measured as 2.3±0.2 Mev with a low resolution beta ray spectrometer. No electrons or γ-rays were seen. The half-life as determined in three different ways gave values from 8 to 10 hours. The positron decay was measured directly using the spectrometer, the decay was determined indirectly by the rate of decrease in amount of 4.3 day-Rh^{101} which grew into the palladium fraction, and the x-ray decay curve showed this component when corrected for the

growth of 19.4 hr Rh^{100}.

4.0 day- Pd^{100} After the decay of 9 hr-Pd^{101}, the half-life for Pd^{100} was determined by removing the rhodium isotopes which had grown and following the decay after the 19.4-hr Rh^{100} again came to equilibrium. Absorption data taken soon after rhodium removal showed no appreciable amount of electrons. In the electromagnetic radiation were found x-rays characteristic of the region, a hard gamma-ray of about 1.6 Mev (lead absorbers) and a soft gamma-ray of 90 Kev (lead, aluminum and silver absorbers). This isotope apparently decays entirely by orbital electron capture.

4.3 day-Rh^{101} Rhodium removed from palladium contained only the 4.3-day-Rh^{101} after the 19.4 hr Rh^{100} had decayed. Using lead absorbers a 0.35 Mev gamma-ray was detected as were K x-rays characteristic of the rhodium region. Measurement with the spectrometer showed no positrons but a line of electrons were observed which could have arisen from K-shell conversion of the 0.35 Mev gamma-ray. If so, the measured abundance of electrons indicated ~10% conversion.

19.4 hr-Rh^{100} This rhodium isotope could be removed from the palladium fraction which had been purified following the decay of 9 hr-Pd^{101}. Positrons of 3.0 Mev and conversion electrons of 0.6 Mev were determined with the spectrometer. Lead absorption curves taken on samples in which the electrons and positrons were taken out with beryllium showed characteristic x-rays and a 1.2 Mev γ-ray. In comparing the yield of positrons and x-rays, it was estimated that the decay proceeds ~5% by positron branching and ~95% by orbital electron capture. Gamma-rays corresponding to the 0.6 Mev electron as well as annihilation radiation were apparently in too low abundance to be seen readily.

Cross-sections for the formation of the palladium isotopes from rhodium with 50-Mev deuterons could only be approximated principally because of uncertainties in the deuteron beam strength and in the target geometry with undeflected beam. Values are based on yields of x-rays and relative to each other are probably considerably more reliable than the absolute values.

Product	Reaction	σ ($cm^2 \times 10^{-24}$)
Pd^{103} (17-day)	d,2n	0.0024
Pd^{101} (9-hr)	d,4n	0.24
Pd^{100} (4.0-day)	d,5n	0.28

The cooperation of Dr. Duane Sewell, Mr. J. T. Vale and the 184-inch cyclotron group is gratefully acknowledged.

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Reference

1. Sullivan, W. H., N. R. Sleight and E. M. Gladrow (reference to be added)