Letters to the Editor

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Neutron Deficient Isotopes of Rhodium and Palladium

M. LINDNER AND I. PERLMAN
Radiation Laboratory and Department of Chemistry, University of California, Berkeley, California
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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 was 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 hr. for the parent of Rh^{101}.

In order to better characterize these isotopes tentatively assigned to Pd^{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-inch 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 hr., 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:

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

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

9-hr. Pd^{101}.—From the ratio of x-rays to positrons it was estimated that this isotope decays ~90 percent by orbital electron capture and ~10 percent 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 1.8 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 was 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 percent conversion.

19.4-hr. Rh^{100}.—This rhodium isotope could be removed from the palladium fraction which had been purified fol-

lowing 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 percent by positron branching and ~95 percent 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	$\sigma(cm^2 \times 10^{24})$
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

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[1] W. H. Sullivan, N. R. Sleight, and E. M. Gladrow, *Rhodium Radioisotopes Induced in Deuteron-Bombarded Ruthenium*, Declassified Plutonium Project Report No. MDDC-918.

Telluric Bands of Methane in the Fraunhofer Spectrum

ROBERT R. McMATH, ORREN C. MOHLER, AND LEO GOLDBERG
McMath-Hulbert Observatory of the University of Michigan, Lake Angelus, Pontiac, Michigan

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IN an earlier communication,[1] the writers described preliminary results obtained from a high resolution recording of the solar spectrum between 1 and 2μ. This initial investigation was carried out with a spectrometer consisting of a Cashman PbS cell employed in conjunction with a 15,000-line plane grating and 25-foot focal length lens arranged in Littrow fashion. Sunlight was imaged on the spectrometer slit by a 12-inch by 50-foot achromat mounted in the 70-foot McGregor tower of the McMath-Hulbert Observator.

Beginning in October, 1947, the lens optics were eliminated by the installation of a four-mirror Pfund-type spectrometer, employing a 15,000-line plane reflection grating loaned by the Mt. Wilson Observatory. The grating was specially ruled to produce a high concentration of energy in the green fourth-order spectrum. The over-all focal length of the spectrometer is 23½ feet. Also, the objective lens in the solar tower was replaced by a Cassegrain reflecting telescope of 10½-inch aperture and approximately 45-foot focal length. With this arrangement, the solar spectrum has been mapped with greatly improved resolution from 1 to 2.5μ. The spectrum was registered in the form of direct-intensity tracings by a Speedomax recorder, giving a dispersion of about 1.25 wave numbers per centimeter on the tracings. The slit width employed varied from 0.04 cm^{-1} at 1.6μ to 0.07 cm^{-1} at 2.2μ.

The new solar map contains not only a wealth of solar atomic lines but also numerous well resolved band structures originating in the earth's atmosphere. Of particular interest is a band system centered at 6003 cm^{-1}, or 1.6660μ, which appears to be due to absorption by atmospheric CH_4 molecules. This feature is clearly shown on many tracings, the first of which was obtained in August, 1947. The band consists of a zero branch in which 10 components are clearly shown, a positive branch made up of 11 components, and a negative branch showing 8 members. A tracing of the central Q-branch, together with the first two members of the P- and R-branches, is shown at the bottom of Fig. 1.

The 1.66μ band of methane has been investigated in the laboratory by Moorhead[2] and by Norris and Unger,[3] with relatively low resolution. On the laboratory tracings the zero branch is unresolved and, according to Norris and Unger, appears sharp and intense, with a slight broadening on the low frequency side. The observed broadening suggests that the line spacings in the Q-branch increase toward the low frequency end of the band, which is confirmed by the Lake Angelus tracings. The line spacing in the P- and

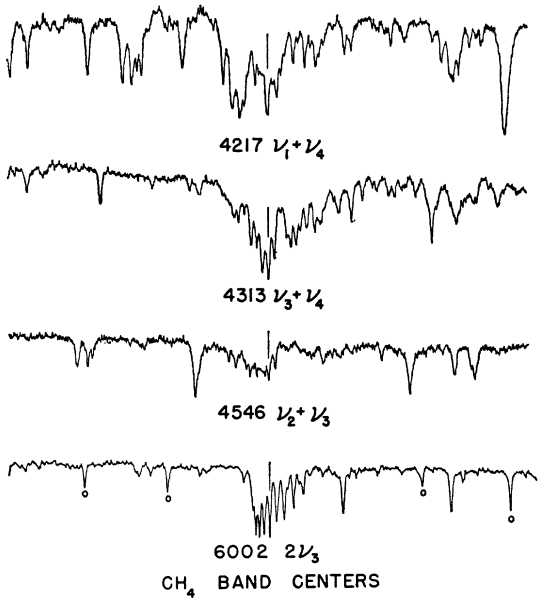

FIG. 1. Band centers of the CH_4 molecule in the absorption spectrum of the earth's atmosphere. The central vertical lines correspond to the listed wave numbers. The small circles in the lower tracing mark the 0–1, 1–2, 2–1, and 3–2 lines of the $2\nu_3$ band.