Production of Nb^{93m} by the Pile Irradiation of Niobium

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Low-energy electrons and Nb K x-rays, believed to be due to the decay of the isomer Nb^{93m}, have been found in neutron-irradiated niobium. The electrons have energies of about 8.5 kev and 23 kev and are believed to be K and L conversion electrons from a 27-kev gamma ray. The half-life of the activity is about four years.

ADDITIONAL measurements have been made on the samples of niobium which had been irradiated for a long time in the Chalk River reactor and subsequently carefully purified. These measurements have shown the presence of low-energy electrons and x-rays, in addition to the 0.50-Mev beta and 0.70-, 0.87-, and 1.57-Mev gammas previously described.[1]

When some of the niobium was counted with a 4π counter, it showed a much higher specific activity then could be attributed to the 0.50-Mev Nb^{94} beta. An absorption curve taken with a low absorption counter showed that the additional activity is a very weak electron activity with a half-thickness of about 0.36 mg/cm^2 in aluminum. By using the top half of a 4π counter as a proportional counter spectrometer, the energy spectrum of the weak electrons was determined; two peaks were found, the larger one at about 23 kev and the smaller one at about 8.5 kev. The energies were determined by comparison with the energy of the MnK x-ray from Fe^{55}.

An aluminum absorption curve of the niobium radiations taken through sufficient beryllium to absorb all the beta rays showed the presence of a photon of about 15-kev energy in addition to the gamma rays. A proportional counter spectrometer showed an x-ray peak at 16 kev as determined by comparison with MnK x-rays. By the use of Rb, Sr, Y, Zr, Nb, and Mo critical absorbers, it was shown that the photons are niobium K x-rays.

The niobium samples have been followed for decay on an internal sample counter for a period of eight months, and a half-life of about four years has been obtained for the weak electron activity.

Since the x-rays are niobium x-rays, the electrons must be conversion electrons emitted during the isomeric transition of a niobium isotope. The isomer decays by the emission of an almost completely converted ($\sim$27 kev) gamma with L conversion ($\sim$23-kev e^-) more probable than K conversion ($\sim$8.5 kev e^-).

The isomer is most likely the 3.65-year isomer of Nb^{93} that has been reported by Glendenin and Steinberg.[2] They found that the isomer is produced by the decay of Zr^{93} and decays by the emission of conversion electrons with $K/L=0.14$ from a 29.2-kev gamma.

We feel that the weak electron activity in the niobium samples is due to Nb^{93m} which is produced from Nb^{93} by the inelastic scattering of fast neutrons. If so, the Chalk River pile neutron cross section for its formation is about 0.8 millibarn. The author wishes to give special thanks to the Chalk River Laboratories for making possible the long-term irradiation of the niobium, and also to thank Mrs. A. C. Mewherter for her help with the preparation of the counting samples.

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[1] Douglas, Newherter, and Schuman, Phys. Rev. **92**, 369 (1953).

[2] Hollander, Perlman, and Seaborg, Revs. Modern Phys. **25**, 520 (1953).