Radioactive Tellurium: Further Production and Separation of Isomers

We have found seven chemically identified radioactive periods of tellurium as the result of deuteron and neutron bombardment of tellurium, fast neutron bombardment of iodine, and deuteron and proton bombardment of antimony. This work has made it possible to make the isotopic assignments for all of the activities and to show that there are three pairs of isomers. The "isomer separation" method of Segrè, Halford and Seaborg,[1] as already applied to tellurium,[2] was tried for each of these pairs. It is remarkable that all three isomeric pairs were chemically separable, the short period growing from the long-lived activity in each case.

Te^{127}: *90 days and 10 hours.*—Prolonged bombardment of iodine with the fast neutrons from Li+D produces in the tellurium precipitate not only the electron-emitting ten-hour activity previously reported[3] but also a new activity with a 90-day half-life. Since there is only one stable iodine the reaction must be I^{127} (n, p) Te^{127} and both periods must be due to isomers of Te^{127}. These activities are produced with much greater intensity by deuteron bombardment of tellurium; it is possible to separate the ten-hour period from tellurium activated in this manner long after the directly formed ten-hour period has completely decayed (in one case, 45 days after the bombardment). The 90-day activity is due to the higher of the two isomeric levels and decays, probably by a converted gamma-ray transition, to the lower level, which then decays with a ten-hour half-life by beta-emission to stable iodine.

Te^{131}: *1.2 days and 25 minutes.*—We have already shown[4] that an electron-emitting eight-day iodine grows from a tellurium isotope, necessarily either Te^{129} or Te^{131}, with both a 1.2-day and a "short" half-life; further work[2] has demonstrated that the period of the shorter-lived parent of the iodine is about 25 minutes. The 1.2-day and 25-minute activities, which are both directly produced by deuteron bombardment of tellurium, are isomeric and isomer separation experiments show that the 25-minute period grows from the 1.2-day activity; it is in fact possible to observe, by successive extractions of iodine, the growth of the eight-day iodine from the 25-minute tellurium activity obtained by extraction from its parent isomer. Bothe and Gentner[5] did not find a 25-minute activity (but did observe a 60-minute period, which aids in assigning another pair of isomers to Te^{129}) when exposing tellurium to gamma-rays; this activation could produce Te^{129} but not Te^{131}, so it appears that the 1.2-day and 25-minute isomers must belong to Te^{131}.

Te^{129}: *30 days and 70 minutes.*—Deuteron bombardment of tellurium also produces a tellurium period of approximately 30-days half-life. Isomer separations show that a 70-minute tellurium activity grows from this 30-day period. The 70-minute activity is also undoubtedly produced directly by deuteron bombardment, but the presence of so many other activities makes it difficult to observe; however, an electron emitting activity with half-life about one hour seems to be present in the deuteron activated samples. If our electron-emitting 70-minute activity is to be identified with the 60-minute period that is produced by gamma-rays,[5] the only remaining possibility for the isotopic assignment is Te^{129}. This Te^{129} decays into I^{129} which should be unstable; the period of this iodine must be either very short or very long, since iodine extractions from the active tellurium have not revealed any daughter activity.

Te^{121}: *120 days.*—The activation of antimony with eight-Mev deuterons or with four-Mev protons gives in both cases a new chemically identified tellurium with the half-life about 120 days. The only reasonable reactions which would lead to unstable tellurium isotopes are Sb^{121} $(d, 2n)Te^{121}$ and Sb^{121} $(p, n)Te^{121}$. Low energy electrons are emitted. It is probable that the electrons result from an internally converted gamma-ray following the decay by K-electron capture to stable Sb^{121}. (Of course the possibility exists that the electrons come from a converted gamma-ray arising from a transition between two isomeric states in Te^{121} or in a stable tellurium isotope.)

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[1] E. Segrè, R. S. Halford and G. T. Seaborg, Phys. Rev. **55**, 321 (1939).
[2] G. T. Seaborg and J. W. Kennedy, Phys. Rev. **55**, 410 (1939).
[3] J. J. Livingood and G. T. Seaborg, Phys. Rev. **53**, 1015 (1938).
[4] J. J. Livingood and G. T. Seaborg, Phys. Rev. **54**, 775 (1938).
[5] W. Bothe and W. Gentner, Naturwiss. **25**, 191 (1937).

Isotopic Constitution of Hafnium, Yttrium, Lutetium and Tantalum

Hafnium ions were obtained from a high frequency spark between nickel tubes packed with a mixture of lanthanum metal and hafnium oxide. Doubly charged ions were photographed as they gave greater photographic intensity due to the greater accelerating voltage possible. In addition to the five isotopes reported by Aston, at 180, 179, 178, 177, and 176, a new isotope was found at 174 on six photographs. Its intensity was estimated at 0.3 percent of the total. That the line was not due to strontium (87) or rubidium (87) was shown by the absence of the stronger isotopes of these elements at 86 and 85, respectively. The mass could also be compared with the neighboring isotopes with sufficient accuracy to rule out the possibility of it belonging to these lighter elements which have a much smaller packing fraction.

On three of the photographs a much fainter mass near 86 was observed. This is possibly another isotope of hafnium at 172, but further experiments will be necessary to rule out the possibility of its being strontium (86).

With yttrium ions from a mixture of yttrium oxide and lanthanum metal it could be shown that no isotope existed at mass 91 as intense as 0.05 percent of the strong mass at 89.

A sample of lutetium oxide was kindly supplied by