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November 8, 1947

UCRL-9

(Excerpts from talk to be presented as Sigma XI National Lecture at meeting of A.A.A.S. in Chicago, Illinois, on Tuesday, December 30, 1947)

THE EIGHT NEW SYNTHETIC ELEMENTS

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In an early continuation of the investigation of the radioactive isotopes of element number 43 (technetium) Segre and Seaborg produced by the deuteron and neutron bombardment of molybdenum the isotope Tc^{99} , which they observed to decay by means of an isomeric transition with a half-life of 6.6 hours to a lower isomeric state with a half-life greater than 40 years. The upper isomeric state of this isotope was observed by Segre and C. S. Wu to be produced in the fission of uranium and more recently R. P. Schumann and also D. C. Lincoln and W. H. Sullivan working on the Plutonium Project of the Manhattan District have independently observed the beta-particles of half-life about 10^6 years due to the lower isomeric state. Later work by E. E. Motta and G. E. Boyd sets a more accurate value of 9.4×10^5 years for this half-life. Since this isotope is formed in rather large amounts, namely, a fission yield of 6.2%, in the slow neutron induced fission of uranium it is now possible to isolate technetium in weighable amounts and in rather substantial quantities. For example, a uranium pile operating at a power level of 10^5 kw would produce about four grams of technetium, as the isotope Tc^{99} , per day. With such a long half-life the radioactivity associated with convenient amounts (some mg.) would be so small in intensity as to not create a problem provided reasonable care in handling were exercised. In fact W. F. Peed, B. G. Saunders and L. E. Burkhart have used a sample of the long-lived Tc^{99} , isolated from uranium fission products by G. W. Parker of Clinton Laboratories, to observe the K α

and $K\beta$ x-rays lines of technetium by the use of an x-ray spectrograph in conjunction with an x-ray tube for excitation of the x-rays of technetium in the standard manner. Parker and coworkers, using the long-lived Tc^{99} isolated from uranium fission products, and G. E. Boyd and coworkers, using the same nuclear species isolated from the pile neutron irradiation of molybdenum ($Mo^{98} + n \longrightarrow Mo^{99} + \gamma$; $Mo^{99} \xrightarrow{\beta^-} Tc^{99}$), have investigated the chemical properties of technetium using essentially pure material. -----

The production of the isotope 61^{147} in the fission reaction with a fission yield of 2.6% places this element among those which are now available in rather substantial weighable amounts. For example, the operation of a uranium pile at a power of 10^5 kw would produce element 61, as the isotope 61^{147} , at the rate of about 1-1/2 gram per day. In this case the half-life is sufficiently short so as to make it necessary to take precautions in handling, but the radiation consists solely of soft beta-rays (0.2 Mev) and therefore the problem of shielding is not difficult. In fact element 61, as 61^{147} , has been isolated in substantial weighable quantities, with a purity not yet well determined, by Parker and coworkers, using uranium fission products as the source, and also by Boyd and coworkers, using as a source neodymium which had been strongly irradiated with pile neutrons ($Nd^{146} + n \longrightarrow Nd^{147} + \dots$; $Nd^{147} \xrightarrow{\beta^-} 61^{147}$). -----

It may be noted that the title of the present discussion includes francium as a synthetic element which may be a questionable procedure in view of its first discovery among the natural radioactivities. There are, however, two facts which may make this nomenclature not inappropriate. The synthetic neptunium radioactive series, which has already been mentioned, contains as one of its members an alpha-

particle-emitting isotope of francium, Fr^{221} , which decays with a half-life of about 5 minutes. And it is interesting to note that also the isotope Fr^{223} may have its most important origin in the future from synthetic sources. In the research program already referred to, Peterson has shown that the neutron irradiation of ordinary radium (the 1600-year Ra^{226}) produces beta-particle-emitting Ra^{227} which leads to Ac^{227} . Thus, since Ac^{227} is rather difficult to extract directly from natural ores, the neutron irradiation of readily available radium in uranium piles offers a better, and synthetic, source of Ac^{227} and hence of Fr^{223} .

Any future elements which might be discovered must have atomic numbers greater than 96, that is, must lie in the "transcurium" region. It seems quite likely that it will be possible to produce and identify new elements in this region, but the major difficulty here is the one of starting materials. It seems likely that the most stable, that is, the longest-lived isotopes of the elements with atomic numbers 97 and 98 will be those with mass numbers perhaps as high as 247 and 248 and higher. Thus, it can be seen that the problem here is one of starting materials since the heaviest isotope now known is the Cm^{242} . The rather detailed understanding of the transition series which exists in this region makes it possible to make some good guesses about the chemical properties of such new elements, a fact which will be of considerable help in such a program.