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I. PREPARATION AND ISOLATION OF Sn^{113} AND In^{114} FROM CADMIUM

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August 11, 1949

Berkeley, California

CARRIER-FREE RADIOISOTOPES FROM CYCLOTRON TARGETS I. PREPARATION AND ISOLATION OF Sn^{113} AND In^{114} FROM CADMIUM[1]

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The cyclotron is the only practical source of many carrier-free[3] radioisotopes. The preparation and radiochemical isolation of a number of these activities, produced in the 60-inch cyclotron of Crocker Laboratory, will be presented in this paper and in subsequent papers of this series. In most cases the carrier-free radioisotopes were prepared for use in biological systems and the final preparations were in the form of isotonic saline solutions at a range of pH from 5 to 8.

The present paper reports the radiochemical isolation of carrier-free Sn^{113} and In^{114} produced by bombarding cadmium with 38 Mev alpha-particles. At this energy, Sn^{113} and In^{114} are produced in a thick target by the nuclear reactions[4]; $Cd^{110}(\alpha,n)Sn^{113}$, $Cd^{111}(\alpha,2n)Sn^{113}$, $Cd^{112}(\alpha,3n)Sn^{113}$, $Cd^{111}(\alpha,p)In^{114}$, $Cd^{112}(\alpha,pn)In^{114}$. The shorter-lived tin and indium activities together with the possible radioisotopes of silver produced by (n,p) reactions, were allowed to decay out prior to the chemical separations.

(1) This document is based on work performed under the auspices of the Atomic Energy Commission.

(2) Lieutenant Colonel, U. S. Army, now stationed at Walter Reed Hospital, Washington, D. C.

(3) This term is used to indicate that no stable isotopic carriers have been intentionally added. In a "carrier-free" separation the specific activity is determined by the chemical purity of the reagents.

(4) G. T. Seaborg and I. Perlman, Rev. Mod. Phys., 20, 585 (1948)

The target, a block of C.P. cadmium metal, soft soldered to a water-cooled copper plate, was bombarded with 38 Mev alpha-particles for a total of 450 μa-hrs. at an average beam intensity of 3.4 μa. After aging for one week, the bombarded surface was milled off and dissolved in a minimum volume of 16 N HNO_3.

0.2 gm of target cadmium nitrate was dissolved in 25 ml. of water, and the tin and indium activities were carried quantitatively on 10 mg of $Fe(OH)_3$ precipitated with NH_4OH. The $Fe(OH)_3$ was dissolved in 15 ml of 36 N H_2SO_4 and transferred to an all-glass distilling flask.[5,6] 9 N HBr was added dropwise while a stream of CO_2 was bubbled through the solution at 220° C. The distillate, containing the carrier-free Sn^{113}, HBr, Br_2 and traces of H_2SO_4 was caught in a series of traps filled with 12 N HCl; the indium activity remained in the residue. Carrier-free radio-tin collected in HNO_3 or H_2SO_4, forms a radiocolloid[7,8] and is adsorbed onto the walls of the containing vessel. 12 N HCl keeps the radio-tin in solution presumably as the chlorostannate complex. The trap contents were treated with 5 ml. of 16 N HNO_3 to destroy HBr, 15 mg of citric acid were added and the solution was evaporated on a steam bath to the 1-2 ml volume of H_2SO_4 carried over in the distillation. Citric acid prevents the formation of radiocolloid after removal of HCl.

The H_2SO_4 solution was diluted with 25 ml of water and the radio-tin was carried down on $Fe(OH)_3$ precipitated with NH_4OH. The $Fe(OH)_3$ was dissolved in 8 N HCl and iron was extracted with isopropyl ether. The aqueous phase, containing

(5) J.A.Scherrer, J.Research Natl.Bur.Standards 21, 95 (1938)

(6) J.Schwaibold, W.Borchers and G.Nagel,Biochem. Z.,306,113 (1940)

(7) O.Hahn, Applied Radiochemistry,Cornell University Press,Ithaca,N.Y. 1936

(8) The colloidal properties of carrier-free radio-tin are being investigated. These results will be published elsewhere.

HCl, Sn^{113} and equilibrium amounts of the In^{113} daughter, was evaporated to dryness on 10 mg of sodium citrate. The activity dissolved quantitatively in distilled water.

The carrier-free Sn^{113} was identified by its 105-day half-life and by the 0.39 Mev conversion electron of the In^{113} daughter[9]. The indium fraction from a chemical separation of an equilibrium mixture using tin and indium carriers, showed the 105 min. period of In^{113}.

The residue from the tin distillation, containing Fe^{+++} and In^{114}, was neutralized with NH_4OH. The $Fe(OH)_3$ plus indium activity was dissolved in 8 N HCl, and extracted with isopropyl ether. The HCl solution of In^{114} was evaporated to dryness on 10 mg of NaCl. The activity dissolved quantitatively with the addition of distilled water. The In^{114} was identified by the assigned 48-day half-life and by the 0.19 Mev conversion electron 9,10.

The authors wish to express their appreciation to Professor G. T. Seaborg for his interest in this work, to Mr. T. Putnam and B. Rossi and the 60-inch cyclotron staff for bombardments, and to Mrs. Alberta Mozley and Mrs. Helen Haydon for technical assistance.

July 1949

(9) S. W. Barnes, Phys. Rev. 56, 414 (1939)

(10) J. L. Lawson and J. M. Cork, Phys. Rev. 57, 982 (1940)