

Discovery of the Cadmium Isotopes

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Thirty-seven cadmium isotopes have so far been observed; the discovery of these isotopes is discussed. For each isotope a brief summary of the first refereed publication, including the production and identification method, is presented.

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1. INTRODUCTION

The discovery of the cadmium isotopes is discussed as part of the series of the discovery of isotopes which began with the cerium isotopes in 2009 [1]. The purpose of this series is to document and summarize the discovery of the isotopes. Guidelines for assigning credit for discovery are (1) clear identification, either through decay-curves and relationships to other known isotopes, particle or γ -ray spectra, or unique mass and Z-identification, and (2) publication of the discovery in a refereed journal. The authors and year of the first publication, the laboratory where the isotopes were produced as well as the production and identification methods are discussed. When appropriate, references to conference proceedings, internal reports, and theses are included. When a discovery includes a half-life measurement the measured value is compared to the currently adapted value taken from the NUBASE evaluation [2] which is based on the ENSDF database [3].

2. DISCOVERY OF $^{96-132}\text{CD}$

Thirty-seven cadmium isotopes from $A = 96 - 132$ have been discovered so far; these include 8 stable, 12 proton-rich and 17 neutron-rich isotopes. According to the HFB-14 model [4], ^{163}Cd should be the last particle stable neutron-rich nucleus (^{159}Cd is calculated to be unbound). Along the proton dripline five more isotopes are predicted to be stable and it is estimated that three additional nuclei beyond the proton dripline could live long enough to be observed [5]. Thus, there remain 38 isotopes to be discovered. About 50% of all possible cadmium isotopes have been produced and identified so far.

Figure A summarizes the year of first discovery for all cadmium isotopes identified by the method of discovery. The range of isotopes predicted to exist is indicated on the right side of the figure. The radioactive cadmium isotopes were produced using fusion evaporation (FE), projectile fragmentation or projectile fission (PF), light-particle reactions (LP), neutron capture (NC), neutron-induced fission

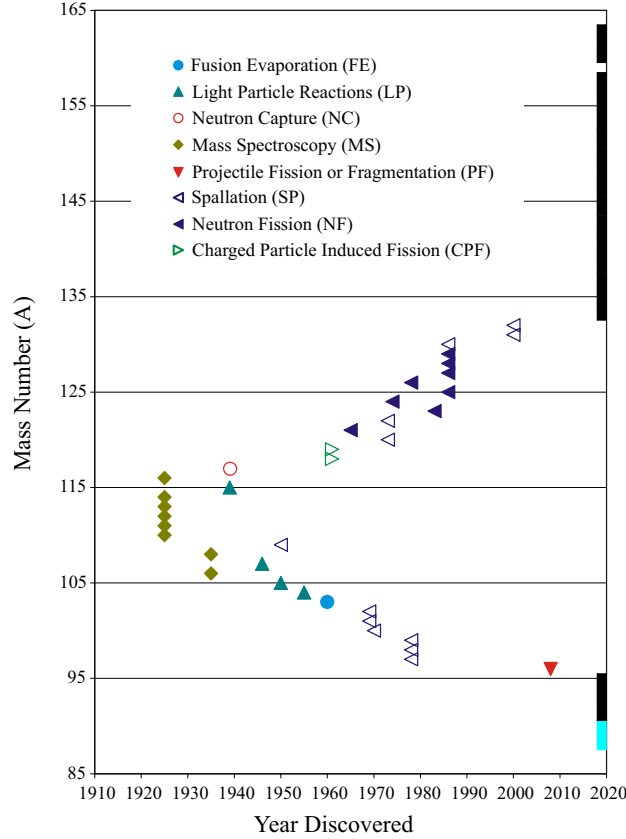


FIG. A. Cadmium isotopes as a function of time they were discovered. The different production methods are indicated. The solid black squares on the right hand side of the plot are isotopes predicted to be bound by the HFB-14 model. On the proton-rich side the light blue squares correspond to unbound isotopes predicted to have lifetimes larger than $\sim 10^{-9}$ s.

(NF), charged-particle induced fission (CPF) and spallation reactions (SP). The stable isotopes were identified using mass spectroscopy (MS). Heavy ions are all nuclei with an atomic mass larger than $A=4$ [6]. Light particles also include neutrons produced by accelerators. In the following, the discovery of each cadmium isotope is discussed in detail.

^{96}Cd

In 2008 Bazin *et al.* reported the discovery of ^{96}Cd in *Production and β Decay of rp -Process Nuclei ^{96}Cd , ^{98}In , and ^{100}Sn* [7]. At the National Superconducting Cyclotron Laboratory at Michigan State University a 120 MeV/nucleon ^{112}Sn primary beam reacted with a 195 mg/cm 2 ^9Be target and produced ^{96}Cd , ^{98}In , and ^{100}Sn . The A1900 fragment separator and the Radio Frequency Fragment Separator were then used to purify the products which were identified by energy loss, time-of-flight

measurements, and *gamma*-ray tagging. The half-lives of the isotopes were measured after implementation in the NSCL beta counting system. “The half-life of ^{96}Cd , which was the last experimentally unknown waiting point half-life of the astrophysical *rp* process, is $1.03^{+0.24}_{-0.21}$ s.” This half-life measurement is the only value for ^{96}Cd at this time.

$^{97-99}\text{Cd}$

Three new isotopes, ^{97}Cd , ^{98}Cd , and ^{99}Cd , were discussed in the 1978 publication of *Beta-Delayed Proton Emission from ^{97}Cd and ^{99}Cd* by Elmroth *et al.* [8]. A 115 g/cm^2 natural tin target was bombarded by 600 MeV protons from CERN’s synchro-cyclotron forming ^{97}Cd , ^{98}Cd , and ^{99}Cd in spallation reactions. The isotopes were separated and identified with the ISOLDE electromagnetic isotope separator. “Two new beta-delayed proton precursors, ^{97}Cd and ^{99}Cd , have been identified at the ISOLDE on-line isotope separator... A search for ^{98}Cd was also performed and it was found to be a pure β -emitter with a probable half-life of ~ 8 sec.” The half-life of ^{99}Cd was measured to be 16(3) s. The ^{99}Cd half-life corresponds to the currently accepted value, and the ^{98}Cd half-life is close to the accepted value of 9.2(3) s.

^{100}Cd

Hnatowich *et al.* identified ^{100}Cd for the first time in 1970 as reported in *The decay of Cadmium isotopes of mass 100, 101, and 102 to isomers in silver* [9]. A high purity molten tin target was irradiated with 600 MeV protons from the CERN 600 MeV synchro-cyclotron and ^{100}Cd was produced in the $\text{Sn}(p,3pxn)$ spallation reaction. The isotopes were separated and identified with the ISOLDE electromagnetic isotope separator. “We have measured the half-life of the new nuclide ^{100}Cd by beta counting of on-line sources in a proportional counter. From these observations, our value for the ^{100}Cd half-life, with an estimated error, is 1.1 ± 0.3 min.” This half-life value is close to the currently accepted value of 49.1(5) s.

$^{101,102}\text{Cd}$

Hansen *et al.* reported the first observation of ^{101}Cd and ^{102}Cd in the paper *Decay Characteristics of Short-Lived Radio-Nuclides Studied by On-Line Isotope Separator Techniques* in 1969 [10]. Protons of 600 MeV from the CERN synchrocyclotron bombarded a molten tin target and cadmium was separated using the ISOLDE facility. The paper summarized the ISOLDE program and did not contain details about the individual nuclei other than in tabular form. The measured half-lives of ^{101}Cd and ^{102}Cd were 1.2(2) m, and 5.5(5) m respectively. The measurement for ^{101}Cd is included in the weighted average of the currently accepted half-life of 1.36(5) m, while the measurement for ^{102}Cd is the currently accepted value. A previous report of half-life measurements of 15 m and 30 m for ^{101}Cd and ^{102}Cd , respectively [11], could not be confirmed.

^{103}Cd

Preiss *et al.* published the discovery of ^{103}Cd in 1960 in *A New Isotope: Cadmium-103* [12]. A 160 MeV ^{16}O beam from the heavy-ion accelerator of the Sterling Chemistry Laboratory at Yale University bombarded molybdenum oxide targets and formed ^{103}Cd in the fusion-evaporation reactions

$^{92-100}\text{Mo}(^{16}\text{O},2p3-11n)$. ^{103}Cd was identified by its decay curve and γ -ray measurements following chemical separation. "A new activity, produced by 160 MeV O^{16} bombardments of thick molybdenum oxide targets, is assigned to Cd^{103} on the basis of chemistry and its decay to Ag^{103} ." The measured half-life of 10.0(15) m is close to the currently accepted value of 7.3(1) m.

^{104}Cd

In *The New Isotopes Cd¹⁰⁴ and Ag¹⁰⁴*, Johnson reported the observation of ^{104}Cd in 1955 [13]. Protons, accelerated to 50 MeV by the McGill University 100 MeV synchrocyclotron, bombarded metallic silver. ^{104}Cd was studied with a 180-degree spectrograph, a lens spectrometer, and a scintillation spectrometer. "Two new neutron deficient isotopes Cd^{104} (59 min.) and Ag^{104} (27 min) have been produced by the reaction $\text{Ag}^{107}(p,4n)\text{Cd}^{104}$ at 50 Mev. in the McGill University synchrocyclotron and by the subsequent growth of silver from the cadmium." The measured half-life of 59 m is in agreement with the 57.7(10) m accepted value.

^{105}Cd

The new isotope ^{105}Cd was discussed in *Radioactive Isotopes of Ag and Cd* by Gum and Pool in 1950 [14]. Palladium was bombarded with 20 MeV alpha particles at Ohio State University producing ^{105}Cd in the reaction (α,n). "A Cd activity with a 57 ± 2 -min. half-life was produced when Pd was activated with 20-Mev alpha-particles... Cd bombarded with fast neutrons also yielded this activity. However, the activity is not observed when Ag is bombarded with deuterons or when Cd is bombarded with slow neutrons. These observations lead to the mass assignment of 105 for the 57-min half-life activity." This half-life agrees with the currently accepted value of 55.5(4) m.

^{106}Cd

Aston described the discovery of ^{106}Cd in the 1935 article *The Isotopic Constitution and Atomic Weights of Hafnium, Thorium, Rhodium, Titanium, Zirconium, Calcium, Gallium, Silver, Carbon, Nickel, Cadmium, Iron and Indium* [15]. Cadmium methyl was analyzed by anode rays using ordinary gas discharge. "As was hoped, the new spectra revealed three more isotopes 106, 108, 115, and enabled photometric estimates of the constitution of this very complex element..."

^{107}Cd

In 1946 ^{107}Cd was correctly identified in the article, *Isotopic Assignment of Cd and Ag Activities*, by Helmholtz [16]. A cadmium target enriched in ^{106}Cd was bombarded by slow neutrons produced in the Berkeley 60 inch cyclotron. The isotope was identified by absorption curves of the emitted electrons. "The 6.7 hour period was the predominant activity in the 106 sample after a few hours bombardment... The results then assign the 6.7 hr. Cd to Cd^{107} ,..." This half-life agrees with the accepted value of 6.50(2) h. A 6.7 h half-life had been observed earlier, but no mass assignment could be made [17,18]. Kirshnan and Gant assigned a 6.8 h half-life to either an isomeric state of ^{108}Cd or ^{110}Cd or to radioactive ^{107}Cd or ^{109}Cd [19]. Several other measurements were performed which could not make a unique mass assignment and referred to the 6.7 h activity as either ^{107}Cd or ^{109}Cd [20,21,22].

¹⁰⁸Cd

Aston described the discovery of ¹⁰⁸Cd in the 1935 article *The Isotopic Constitution and Atomic Weights of Hafnium, Thorium, Rhodium, Titanium, Zirconium, Calcium, Gallium, Silver, Carbon, Nickel, Cadmium, Iron and Indium* [15]. Cadmium methyl was analyzed by anode rays using ordinary gas discharge. “As was hoped, the new spectra revealed three more isotopes 106, 108, 115, and enabled photometric estimates of the constitution of this very complex element...”

¹⁰⁹Cd

In *The Spallation Products of Antimony Irradiated with High Energy Particles* Lindner and Perlman discuss their accurate identification of ¹⁰⁹Cd in 1950 [23]. ¹⁰⁹Cd was produced by bombarding a thick antimony target with deuterons and α -particles from the Berkeley 134-inch cyclotron with energies of 190 MeV and 380 MeV, respectively. Decay curves were recorded and absorption measurements were performed following chemical separation. “This [The 330-day Cd¹⁰⁹] activity was apparent in the decay curve taken through beryllium soon after the 6.7-hr. Cd¹⁰⁷ had disappeared. Ultimately it could be seen in the curve taken without absorber after the 42-day Cd¹¹⁵ had decayed. Identification was made certain by removal of its daughter, 40-sec. Ag^{109m}.” The half-life of 330 days is near the currently accepted half-life of 461.4(12) d. In 1940 Krishnan had reported a half-life of approximately one year but could not determine whether it was ¹⁰⁹Cd or ¹⁰⁷Cd [24]. In 1945 Bradt *et al.* measured a half-life of 158(7) d and assigned it to either ¹⁰⁹Cd or ¹⁰⁷Cd [21]. A year later they corrected the half-life to 330 days [22]. At the same time Helmholtz had assigned the 158 d activity to ¹⁰⁹Cd, however, we do not credit him with the discovery because the half-life differs significantly from the correct value. The work by Lindner and Perlman was submitted in February 1950 and it should be mentioned that in May of 1950 Cork *et al.* reported a half-life of 250 d for ¹⁰⁹Cd [25] and in June of 1950 Gum and Pool measured a half-life of 470 days [14].

^{110–114}Cd

In 1925 Aston reported the first observation of ^{110–114}Cd in *The Mass Spectra of Chemical Elements, Part VI. Accelerated Anode Rays Continued* [26]. The mass spectra were measured at the Cavendish Laboratory in Cambridge, UK using an anode ray discharge tube containing cadmium fluoride and lithium fluoride. “This element, unsuccessfully attacked before, has now yielded to improved experimental conditions... Cadmium has six isotopes 110, 111, 112, 113, 114, 116.” These isotopes were all assumed to be stable, however, ¹¹³Cd decays with a half-life of $7.7(3) \cdot 10^{15}$ y.

¹¹⁵Cd

The isotope ¹¹⁵Cd was first correctly identified by Goldhaber *et al.* in 1939 in *Radioactivity Induced by Nuclear Excitation* [27]. Cadmium was irradiated with neutrons produced by bombarding lithium with deuterons of 950 KeV at the Cavendish Laboratory. ¹¹⁵Cd was produced in the reaction ¹¹⁶Cd(n,2n). Decay curves were measured with a Geiger-Müller counter following chemical separation. “Our experiments show that In^{115*} grows from the parent Cd¹¹⁵ which decays with a half-life time of 2.5 days.” This measurement agrees with the accepted half-life of 53.46(10) h. In 1937, Cork and Thornton had reported half-lives of 58 h and 4.3 h and incorrectly assigned them to ¹¹⁷Cd and ¹¹⁵Cd, respectively [28]. A few months later Mitchell [29] measured half-lives of 52 h and 5 h, agreeing with

the assignment by Cork and Thornton. Seven months after the submission of the Goldhaber paper, Cork and Lawson independently reversed their assignment of newly measured half-lives of 56 h and 3.75 h to ^{115}Cd and ^{117}Cd , respectively [30]. It should be noted that Aston had incorrectly reported the observation of stable ^{115}Cd in 1935 [15].

^{116}Cd

In 1925 Aston reported the first observation of ^{116}Cd in *The Mass Spectra of Chemical Elements, Part VI. Accelerated Anode Rays Continued* [26]. The mass spectra were measured at the Cavendish Laboratory in Cambridge, UK using an anode ray discharge tube containing cadmium fluoride and lithium fluoride. “This element, unsuccessfully attacked before, has now yielded to improved experimental conditions... Cadmium has six isotopes 110, 111, 112, 113, 114, 116.”

^{117}Cd

The isotope ^{117}Cd was first correctly identified by Goldhaber *et al.* in 1939 in *Radioactivity Induced by Nuclear Excitation* [27]. Cadmium was irradiated with neutrons produced by bombarding lithium with deuterons of 950 KeV at the Cavendish Laboratory. Decay curves were measured with a Geiger-Müller counter following chemical separation. The observation of ^{117}Cd was only mentioned in a footnote: “They [Cork and Thornton [28]] also reported a radioactive isotope of In of 2.3-hr. half-life time which they ascribed to In^{117} and which appeared to grow from a 58-hr. Cd parent. We find this indium isotope only when we precipitate indium from the cadmium solution in a time less than two days after irradiation. By successive separations we find that it grows from a 4-hr. Cd parent, a radioactive isotope which has been previously reported by Cork and Thornton and at the time assumed to be Cd^{115} .” This half-life was assigned to ^{115}Cd in a table and must have been produced by neutron capture on ^{116}Cd . The 4 h half-life is in reasonable agreement with the presently accepted value of 2.49(4) h. As mentioned by Goldhaber *et al.*, Cork and Thornton in 1937 had reported half-lives of 58 h and 4.3 h and incorrectly assigned them to ^{117}Cd and ^{115}Cd , respectively [28]. A few months later Mitchell [29] measured half-lives of 52 h and 5 h, agreeing with the assignment by Cork and Thornton. Seven months after the submission of the Goldhaber paper, Cork and Lawson independently reversed their assignment of newly measured half-lives of 56 h and 3.75 h to ^{115}Cd and ^{117}Cd , respectively [30].

^{118}Cd

The 1961 article *Decay of 49-min Cd^{118} and 5.1-sec In^{118}* by Gleit and Coryell reported the discovery of ^{118}Cd [31]. Deuterons accelerated to 14 MeV by the M.I.T. cyclotron bombarded natural uranium foils. ^{118}Cd was produced by fission and identified by its β -decay following chemical separation. “An average of nine samples, each followed for more than seven half-lives, yields a half-life of 49.0 ± 1.5 min for Cd^{118} .” This half-life agrees with the currently accepted value of 50.3(2) m. A half-life of 30 m had been reported in 1953 in a conference proceedings [32].

^{119}Cd

The discovery of ^{119}Cd was reported in *Decay of Cd^{119} and In^{119} Isomers* by Gleit and Coryell in 1961 [33]. Deuterons accelerated to 14 MeV by the M.I.T. cyclotron bombarded natural uranium.

^{119}Cd was produced by fission and identified by its β -decay following chemical separation. “The true Cd half-life was calculated from a series of 14 experiments to be 2.7 ± 0.3 min... The 2.7-min Cd appears a parent of both 18-min In and 2.0-min In and is tentatively identified as Cd^{119m} .” The observed half-life could correspond to the isomeric state of ^{119}Cd with a half-life of 2.20(2) m; however it also could be the ground state which has a half-life of 2.69(2) m. In the same paper, Gleit and Coryell incorrectly identified a half-life of 9.5 m for the ground state of ^{119}Cd . A similar half-life of 10 m had previously also been incorrectly assigned to ^{119}Cd [34].

^{120}Cd

The identification of ^{120}Cd was reported in ^{120}Cd and ^{122}Cd by Scheidemann and Hagebo in 1973 [35]. The CERN 600 MeV synco-cyclotron was used to bombard a molten tin target with a 600 MeV proton beam. ^{120}Cd , produced in spallation reactions, was separated and identified with the isotope separator on line (ISOLDE). “The half-lives of ^{120}Cd and ^{120}In were measured on line by multianalysis of the spectrum or with the plastic detector and a scaler, and off line using a proportional-counter.” The measured half-life of 50.80(21) s is still the only half-life measurement of ^{120}Cd . It should be mentioned that a half-life of < 1 m was assigned to ^{120}Cd already in 1961, however, no quantitative analysis was performed [33].

^{121}Cd

Weiss reported the first observation of ^{121}Cd in the 1965 article *Near-Symmetric Fission-Identification and Yield of Cd-121* [36]. ^{121}Cd was produced via thermal neutron fission of enriched ^{235}U in the Vallecitos nuclear test reactor and the β -ray activity was measured on a gas-flow proportional β -ray counter. “The curve which resulted from a plot of ^{121}Sn activity as a function of separation time constituted a decay curve for ^{121}Cd ... The half-life of Cd^{121} derived from these data by the method of least squares is $12.8^{+0.4}_{-0.3}$ sec.” This half-life is included in the weighted average of the currently accepted value of 13.5(3) s.

^{122}Cd

The identification of ^{122}Cd was reported in ^{120}Cd and ^{122}Cd by Scheidemann and Hagebo in 1973 [35]. The CERN 600 MeV synco-cyclotron was used to bombard a molten tin target with a 600 MeV proton beam. ^{120}Cd produced in spallation reactions was separated and identified with the isotope separator on line (ISOLDE). “The half-life of ^{122}Cd was measured on line with the plastic detector using the analyser as a multiscaler.” The measured half-life of 5.78(9) s is consistent with the presently accepted value of 5.24(3) s. Scheidemann and Hagebo quote a previously measured half-life of 5.5(1) s from an unpublished report by the OSIRIS collaboration [37].

^{123}Cd

In the 1983 paper *Half-lives and emission probabilities of delayed neutron precursors $^{121-124}\text{Ag}$* Reeder *et al.* described the discovery of ^{123}Cd [38]. ^{123}Cd was produced by thermal neutron-induced fission at Brookhaven National Laboratory and separated by the TRISTAN on-line isotope separator. “From beta decay measurements a half-life of 2.07 ± 0.03 s was found at mass 123 and assigned to the

previously unknown ^{123}Cd .” This half-life is included in the weighted average of the currently accepted value of 2.10(2) s. A previously reported half-life of 6 s [39] could not be confirmed.

^{124}Cd

The discovery of ^{124}Cd was reported in the 1974 article *Levels and Transition Probabilities in ^{124}In as Observed in the Decay of ^{124}Cd* by Fogelberg *et al.* [40]. ^{124}Cd was produced by neutron induced fission at Studsvik, Sweden, and separated with the OSIRIS on-line facility. “At mass 124, transitions showing half-lives of 0.9 ± 0.2 , 2.4 ± 0.3 and 3.2 ± 0.3 s were found, and were identified as being due to the decay of ^{124}Cd and a high and a low spin isomer of ^{124}In , respectively.” The half-life of 0.9(2) s is consistent with the currently accepted value of 1.25(2) s.

^{125}Cd

The article *Measurements of Absolute γ -ray Intensities in the Decays of Very Neutron Rich Isotopes of Cd and In* by Gokturk *et al.* reported the discovery of ^{125}Cd in 1986 [41]. ^{125}Cd was formed by neutron induced fission of a ^{235}U target at the OSIRIS ISOL-facility at Studsvik, Sweden. “Four previously unknown or little known isotopes of Cd are reliably characterized for the first time.” The half-life ^{125}Cd was measured to be 0.75(4) s which is consistent with the currently accepted value of 0.65(2) s. A previously reported half-life of 12.2 s [39] could not be confirmed.

^{126}Cd

Gartner and Hill reported the first observation of ^{126}Cd in the 1978 article *Decay of Mass separated ^{126}Cd* [42]. ^{126}Cd was produced in neutron induced fission at the Ames Laboratory Research Reactor and separated with the Tristan on-line isotope-separator. “ γ rays from the decay of ^{126}Cd were observed using Ge(Li) and LEPS detectors located near the point of beam deposition... We propose therefore that the half-life of ^{126}Cd is 0.506 ± 0.015 sec.” This half-life is included in the weighted average of the currently accepted value of 0.515(17) s. Gartner and Hill quote a previously measured half-life of 0.53 s from an unpublished report by the OSIRIS collaboration [43].

$^{127-129}\text{Cd}$

The article *Measurements of Absolute γ -ray Intensities in the Decays of Very Neutron Rich Isotopes of Cd and In* by Gokturk *et al.* reported the discovery of ^{127}Cd , ^{128}Cd , and ^{129}Cd in 1986 [41]. These cadmium isotopes were formed by neutron induced fission of ^{235}U target at the OSIRIS ISOL-facility at Studsvik, Sweden. “Four previously unknown or little known isotopes of Cd are reliably characterized for the first time.” The half-lives reported for ^{127}Cd (0.43(3) s) and ^{128}Cd (0.34(3) s) are both included in the weighted average of the currently accepted values of 0.37(7) s and 0.28(4) s, respectively. The half-life of 0.27(4) s is currently the only measured value for ^{129}Cd . A previously reported half-life of 0.9 s for ^{128}Cd [39] could not be confirmed.

¹³⁰Cd

The discovery of ¹³⁰Cd was reported in 1986 by Kratz *et al.* in *The Beta-Decay Half-Life of ¹³⁰Cd and its Importance for Astrophysical r-Process Scenarios* [44]. A target of Uranium carbide was bombarded with 600 MeV protons from the CERN synchrocyclotron. ¹³⁰Cd was produced in spallation reactions and subsequently separated and identified with the ISOLDE on-line mass separator. “From the β dn-growth curve [β -delayed-neutron] the $T_{1/2}$ of ¹³⁰Cd was determined to (195 ± 35) ms.” This half-life is consistent with the currently accepted value of 162(7) ms.

^{131,132}Cd

¹³¹Cd and ¹³²Cd were first discovered in 2000 by Hannawald as reported in the article *Selective Laser Ionization of very neutron-rich cadmium isotopes: Decay properties of ¹³¹Cd and ¹³²Cd* [45]. A uranium-carbide/graphite target was bombarded by 1 GeV protons at CERN. ¹³¹Cd and ¹³²Cd were separated and identified using a resonance-ionization laser ion-source at ISOLDE. “For the new $N = 83$ isotope ¹³¹Cd a half-life of $T_{1/2} = (68 \pm 3)$ ms has been obtained, which is unanticipatedly short when compared to current model predictions... A somewhat similar picture arises for the new $N = 84$ isotope ¹³²Cd, where the experimental half-life of $T_{1/2} = (97 \pm 10)$ ms is again considerably shorter than the predicted $T_{1/2}(\text{GT})=633$ ms...” These half-lives of 68(3) ms and 97(10) ms determined for ¹³¹Cd and ¹³²Cd, respectively, are the currently accepted values.

3. SUMMARY

The discoveries of the known cadmium isotopes have been compiled and the methods of their production discussed. The first measured half-lives of several isotopes (¹⁰¹Cd, ¹⁰²Cd, ¹¹⁹Cd, ¹²³Cd, ¹²⁵Cd, and ¹²⁸Cd) were incorrect. The half-lives of ¹⁰⁷Cd and ¹⁰⁹Cd were first reported without a definite mass assignment. In addition, the initial assignments of ¹⁰⁷Cd and ¹⁰⁹Cd, as well as ¹¹⁵Cd, and ¹¹⁷Cd, were reversed. The half-lives of ¹¹⁸Cd, ¹²²Cd, and ¹²⁶Cd were first mentioned in a conference proceeding or unpublished reports several years prior to publication in refereed journals. Finally, ¹¹⁵Cd was initially incorrectly reported as being a stable isotope.

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EXPLANATION OF TABLE

TABLE I. Discovery of Cadmium Isotopes

Isotope	Cadmium isotope
Author	First author of refereed publication
Journal	Journal of publication
Ref.	Reference
Method	Production method used in the discovery: FE: fusion evaporation LP: light-particle reactions (including neutrons) NC: neutron capture MS: mass spectroscopy SP: spallation PF: projectile fragmentation or fission NF: neutron induced fission CPF: charged particle induced fission
Laboratory	Laboratory where the experiment was performed
Country	Country of laboratory
Year	Year of discovery

TABLE I. Discovery of Cadmium isotopes

See page 13 for Explanation of Tables

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Isotope	First Author	Journal	Ref.	Method	Laboratory	Country	Year
⁹⁶ Cd	D. Bazin	Phys. Rev. Lett.	Baz08	PF	Michigan State	USA	2008
⁹⁷ Cd	T. Elmroth	Nucl. Phys. A	Elm78	SP	CERN	Switzerland	1978
⁹⁸ Cd	T. Elmroth	Nucl. Phys. A	Elm78	SP	CERN	Switzerland	1978
⁹⁹ Cd	T. Elmroth	Nucl. Phys. A	Elm78	SP	CERN	Switzerland	1978
¹⁰⁰ Cd	D.J. Hnatowich	J. Inorg. Nucl. Chem.	Hna70	SP	CERN	Switzerland	1970
¹⁰¹ Cd	P.G. Hansen	Phys. Lett. B	Han69	SP	CERN	Switzerland	1969
¹⁰² Cd	P.G. Hansen	Phys. Lett. B	Han69	SP	CERN	Switzerland	1969
¹⁰³ Cd	I.L. Preiss	Nucl. Phys.	Pre60	FE	Yale	USA	1960
¹⁰⁴ Cd	F.A. Johnson	Can. J. Phys.	Joh55	LP	McGill	Canada	1955
¹⁰⁵ Cd	J.R. Gum	Phys. Rev.	Gum50	LP	Ohio State	USA	1950
¹⁰⁶ Cd	F.W. Aston	Proc. Roy. Soc.	Ast35	MS	Cambridge	UK	1935
¹⁰⁷ Cd	A.C. Helmholz	Phys. Rev.	Hel46	LP	Berkeley	USA	1946
¹⁰⁸ Cd	F.W. Aston	Proc. Roy. Soc.	Ast35	MS	Cambridge	UK	1935
¹⁰⁹ Cd	M. Lindner	Phys. Rev.	Lin50	SP	Berkeley	USA	1950
¹¹⁰ Cd	F.W. Aston	Phil. Mag.	Ast25	MS	Cambridge	UK	1925
¹¹¹ Cd	F.W. Aston	Phil. Mag.	Ast25	MS	Cambridge	UK	1925
¹¹² Cd	F.W. Aston	Phil. Mag.	Ast25	MS	Cambridge	UK	1925
¹¹³ Cd	F.W. Aston	Phil. Mag.	Ast25	MS	Cambridge	UK	1925
¹¹⁴ Cd	F.W. Aston	Phil. Mag.	Ast25	MS	Cambridge	UK	1925
¹¹⁵ Cd	M. Goldhaber	Phys. Rev.	Gol39	LP	Cambridge	UK	1939
¹¹⁶ Cd	F.W. Aston	Phil. Mag.	Ast25	MS	Cambridge	UK	1925
¹¹⁷ Cd	M. Goldhaber	Phys. Rev.	Gol39	NC	Cambridge	UK	1939
¹¹⁸ Cd	C.E. Gleit	Phys. Rev.	Gle61a	CPF	MIT	USA	1961
¹¹⁹ Cd	C.E. Gleit	Phys. Rev.	Gle61b	CPF	MIT	USA	1961
¹²⁰ Cd	O. Scheidemann	J. Inorg. Nucl. Chem.	Sch73	SP	CERN	Switzerland	1973
¹²¹ Cd	H.V. Weiss	Phys. Rev.	Wei65	NF	U.S. Naval Rad. Def. Lab.	USA	1965
¹²² Cd	O. Scheidemann	J. Inorg. Nucl. Chem.	Sch73	SP	CERN	Switzerland	1973
¹²³ Cd	P.L. Reeder	Phys. Rev. C	Ree83	NF	Brookhaven	USA	1983
¹²⁴ Cd	B. Fogelberg	Nucl. Phys. A	Fog74	NF	Studsvik	Sweden	1974
¹²⁵ Cd	H. Gokturk	Z. Phys. A	Gok86	NF	Studsvik	Sweden	1986
¹²⁶ Cd	M.L. Gartner	Phys. Rev. C	Gar78	NF	Ames	USA	1978
¹²⁷ Cd	H. Gokturk	Z. Phys. A	Gok86	NF	Studsvik	Sweden	1986
¹²⁸ Cd	H. Gokturk	Z. Phys. A	Gok86	NF	Studsvik	Sweden	1986
¹²⁹ Cd	H. Gokturk	Z. Phys. A	Gok86	NF	Studsvik	Sweden	1986
¹³⁰ Cd	K.L. Kratz	Z. Phys. A	Kra86	SP	CERN	Switzerland	1986
¹³¹ Cd	M. Hannawald	Phys. Rev. C	Han00	SP	CERN	Switzerland	2000
¹³² Cd	M. Hannawald	Phys. Rev. C	Han00	SP	CERN	Switzerland	2000

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