ARGONNE NATIONAL LABORATORY
P. O. Box 299
Lemont, Illinois

CHEMICAL AND RADIOCHEMICAL STUDIES OF TELLURIUM
IN FLUORIDE VOLATILITY STUDIES

by

J. Fischer and R. K. Steunenberg

Chemical Engineering Division

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ABSTRACT

Chemical and radiochemical studies were made to clarify the behavior of fission product tellurium in fluoride volatility processes for the recovery of uranium from spent reactor fuels. The chemical nature of mixtures of tellurium hexafluoride and bromine trifluoride was investigated in the gas phase at 75°C and 100°C, and in the liquid phase at 25°C. The gas phase behaviour of tellurium hexafluoride in bromine pentafluoride was studied at 75°C, and liquid mixtures of tellurium hexafluoride and bromine were examined at 25°C. In none of these systems was there evidence for a chemical reaction which would produce tellurium compounds of low volatility.

Quantitative radiochemical observations were made on the partial reduction of tellurium hexafluoride and the separation of daughter isomers due to the internal conversion of gamma rays of $\text{Te}^{127\text{m}}$ and $\text{Te}^{129\text{m}}$. It was found that tellurium activity could be separated from bromine trifluoride by distillation. The activity remaining after the volatilization of a mixture of tellurium hexafluoride and uranium hexafluoride was a small fraction of the short-lived isomers Te^{127} and Te^{129} .

INTRODUCTION

Various processes have been proposed in which the uranium from spent reactor fuels is recovered and decontaminated by distillation of the hexafluoride. One such scheme involves dissolution of the fuel by liquid bromine trifluoride.¹ The resulting mixture is then distilled to separate

¹H. H. Hyman, R. C. Vogel and J. J. Katz, "Decontamination of Irradiated Reactor Fuels by Fractional Distillation Processing Using Uranium Hexafluoride" presented at the International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, (A/Conf. 8/P/546-USA-July 7, 1955).

the uranium hexafluoride product from the bromine trifluoride, its reduction products and the fission product fluorides. The separation of fission product tellurium is of considerable importance, since it represents the major portion of the volatile activity in a process of this type.

Tellurium hexafluoride, which is relatively volatile, should be readily separable from bromine trifluoride, bromine pentafluoride, bromine and uranium hexafluoride (see Table I). There has been evidence² that the removal of tellurium, as the hexafluoride, from bromine trifluoride may not be as simple as one would expect from a consideration of their relative volatilities.

Table I

BOILING POINTS OF PERTINENT COMPOUNDS

Compound	Boiling (or Sublimation) Point (C)
TeF ₆	-38.9 (s)
BrF ₅	42.2
Te ₂ F ₁₀ *	~54.
UF ₆	56.4 (s)
Br ₂	58.7
BrF ₃	125.7
TeF ₄	371.3

*W. D. English and J. W. Dale, J. Chem. Soc., 2498 (1953).

It has been reported² that a tellurium compound or complex of low volatility was produced when tellurium hexafluoride or tellurium metal reacted with bromine trifluoride or bromine pentafluoride. These experiments were performed with radioactive tracers of tellurium obtained from pile-irradiated tellurium metal. Some radioactive species less volatile than bromine trifluoride had been produced, but the chemical identity of the non-volatile activity had not been ascertained.

²W. R. Page "A Continuous Flow Pilot Plant for the Separation of Bromine-Fluorine Compounds and Light End Fission Product Fluorides from Uranium Hexafluoride," BNL-174, (March 1952).

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A tellurium compound less volatile than the hexafluoride may have been formed as a product of a chemical reaction between tellurium hexafluoride and the bromine fluorides or bromine. It is also possible that a compound of low volatility may have resulted from a radiochemical reaction. One explanation for past references to a non-volatile tellurium compound in halogen fluoride media may lie in the use of total gamma activity measurements in tracer experiments, which may be misleading if the tracer activity is not well defined. This is particularly true when the decay schemes are complex and the gamma activity is in the energy range where internal conversion is possible. Two of the major long-lived radioactive isotopes of tellurium found in fission products and irradiated tellurium are $\text{Te}^{127\text{m}}$ and $\text{Te}^{129\text{m}}$. These nuclides decay in the following manner:

It has been shown that the internal conversion of these gamma rays is practically complete.^{3, 4}

The formation of non-volatile reduced fractions in radioactive tellurium hexafluoride had been found by R. R. Williams, Jr.⁵ to be prevalent to the extent that about fifty per cent of the atoms of $\text{Te}^{129\text{m}}$ undergoing gamma transitions resulted in the separation of Te^{129} as a non-volatile component, probably a lower fluoride. Because their conversion ratios were high, only a small fraction of the gamma rays from the nuclei of $\text{Te}^{127\text{m}}$ and $\text{Te}^{129\text{m}}$ were observed. A mixed sample of $\text{Te}^{127\text{m}}$ and $\text{Te}^{129\text{m}}$ in secular equilibrium with the daughters Te^{127} and Te^{129} underwent beta decay with a half-life intermediate between 33.5 and 115 days, depending upon the proportions of the two nuclides. Therefore, beta counting can be used as a measure of the $\text{Te}^{127\text{m}}$ and $\text{Te}^{129\text{m}}$ present in the original mixture.

The internal conversion occurring in the gamma decay of $\text{Te}^{127\text{m}}$ and $\text{Te}^{129\text{m}}$ may result in a chemical reaction which permits a separation of the Te^{127} and Te^{129} from the original mixture. These latter species in separated fraction would then exhibit beta decay with a half-life between 9.3 hours and 72 minutes, depending upon the relative proportions of

³E. P. Cooper, Phys. Rev. 61, 1 (1942).

⁴A. C. Helmholz, Phys. Rev. 60, 415 (1941).

⁵C. D. Coryell and N. Sugarman, "Radiochemical Studies: The Fission Products," Book 1, National Nuclear Energy Series McGraw-Hill (1951), page 220.

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Te¹²⁷ and Te¹²⁹ present. Therefore, the half-life characteristics of the beta decay in a chemically separated fraction can be used as an indication of whether the metastable species have been separated from the non-metastable species through a chemical reaction induced by internal conversion.

Both chemical and radiochemical studies were made to determine whether any reactions would occur to prevent the effective distillation of tellurium hexafluoride from bromine trifluoride solutions. The chemical studies are described in Part I. These consisted of an examination of various gas and liquid phase mixtures of tellurium hexafluoride with bromine trifluoride, bromine pentafluoride and bromine for possible chemical reactions which would produce non-volatile tellurium compounds or complexes.

The radiochemical studies, reported in Part II, were made to establish whether non-volatile forms of tellurium are produced by internal conversion reactions, and, if so, whether the tellurium remains in a non-volatile state in the presence of bromine trifluoride.

PART I - CHEMICAL STUDIES

Materials

The bromine fluorides used in these studies were obtained from commercial sources and redistilled in a 40-inch nickel column, 1/2 inch in diameter and packed with 1/8-inch nickel helices.

Merck reagent grade bromine was used without further purification.

The tellurium, which was obtained from Anaconda, was shown by spectroscopic examination to contain only traces of metallic impurities. The tellurium hexafluoride was prepared by the direct combination of the tellurium metal with fluorine in a nickel vessel. It was separated from any tellurium tetrafluoride formed in the reaction by distillation at 25°C. The excess fluorine was removed by vacuum distillation from the tellurium hexafluoride at -195°C. The molecular weight of the tellurium hexafluoride was calculated from its vapor density at 25.5°C to be 239.7 g/G.M.V., which is in good agreement with the value of 240 reported by Junkins and Barber.⁶ The formula weight is 241.6 g/mole.

⁶J. H. Junkins and E. J. Barber, "Preparation and Properties of Tellurium Tetrafluoride," K-768, p. 6, Carbide and Carbon Chemicals Co. (1951).

Apparatus

The vapor-phase mixtures were investigated at 75°C and 100°C in a nickel and Monel apparatus which, with minor modifications, was that used previously in a study of the vapor-liquid equilibria between bromine and bromine trifluoride.⁷ The pressures within the system were measured with Booth-Cromer pressure transmitters used in conjunction with well-type mercury manometers. Two different vessels were used for the vapor-phase investigations. Vessel I had previously contained liquid bromine and bromine fluorides at 75°C and 100°C, with the result that considerable amounts of corrosion products in the form of metal fluorides may have been deposited on its surface. Vessel II, however, had contained only the gas-phase mixtures, so the accumulation of metal fluorides was probably smaller than that in Vessel I.

Experimental Procedure and Results

The behavior of tellurium hexafluoride-bromine trifluoride mixtures in the vapor phase was observed at 75°C and 100°C by following the rate of pressure changes in the system. A few examples of typical data are given in Table II. Most of the experiments were performed in Vessel I, in which it was observed, both at 75°C and 100°C, that the addition of tellurium hexafluoride to bromine trifluoride rapidly gave a total pressure less than the sum of the pressures of the added components. Higher initial pressures of either tellurium hexafluoride or bromine trifluoride increased the magnitude of this pressure drop. After the initial drop, the total pressure increased gradually until it finally reached the sum of the initial pressures. The rate of this rise was fast for low initial pressures of the two components and slower for high initial pressures. Various physical measurements made after the pressure had risen to its final value indicated that no addition compound was present. These measurements included vapor density, vapor pressures at 3°C and -195°C, and removal of the volatile components from the bromine trifluoride at 3°C by vacuum distillation. On the other hand, vapor density measurements made soon after mixing indicated that the vapor mixture was somewhat depleted in tellurium hexafluoride (Expt. 1019, Table II).

When the tellurium hexafluoride and bromine trifluoride were mixed in Vessel II, the initial decrease in total pressure was less than in Vessel I, as shown by Experiment 1024 in Table II. This behavior suggests the possibility of a reversible sorption phenomenon which is dependent upon the types of gaseous components in the system, their pressures, and the surface of the reaction vessel.

A similar gas-phase experiment on a tellurium hexafluoride-bromine pentafluoride mixture in Vessel I at 75°C showed no unusual effects. The total pressure remained equal to the sum of the pressures of the components added.

⁷J. Fischer, J. Bingle and R. C. Vogel, J. Am. Chem. Soc. 78, 902 (1956).

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Table II

THE BEHAVIOR OF TELLURIUM HEXAFLUORIDE-BROMINE
TRIFLUORIDE MIXTURES IN THE VAPOR PHASE

Vessel I probably contained more corrosion products than Vessel II, since it had been exposed to liquid BrF_3 in other, unrelated experiments.

Experiment 1001, Vessel I, at 75°C

Pressures added initially (mm)	BrF_3	100.3
	TeF_6	180.6
	Total	280.9
After mixing:	Time (sec)	Pressure (mm)
	50	252.7
	7,200	261.0
	58,600	275.0
	∞	281.8

Experiments 1018-1019, Vessel I, at 100°C

Pressures added initially (mm)	1018	1019
	BrF_3	199.2
	TeF_6	218.0
Mole fraction of TeF_6		
	Initial	0.53
	At 400 sec	-
	At 99,000 sec	0.55 ^b

Experiment 1024, Vessel II, at 100°C

Pressures added initially (mm)	BrF_3	207.9
	TeF_6	207.9
	Total	415.8
After mixing:	Time (sec)	Pressure (mm)
	100	411.2
	61,000	417.7

^aBased on a vapor density measurement made as soon as possible after mixing.

^bBased on vapor density after the pressure had risen to the total pressure added initially.

The possibility of a chemical reaction between tellurium hexafluoride and bromine pentafluoride in the liquid state was investigated by mixing about two ml of each in a weighed Fluorothene tube. The liquids, which were only partially miscible, were vacuum distilled from the tube, which was then reweighed to determine whether any non-volatile substance had formed. A similar experiment was performed on a mixture of tellurium hexafluoride and bromine, which also were only partially miscible liquids. In the former experiment the Fluorothene tube showed a weight gain of 6 mg, and in the latter, 2 mg. The residues were dissolved in warm nitric acid and assayed colorimetrically for tellurium, using sodium diethyl-dithiocarbamate.⁸ Less than 0.3 mg was found in both cases, indicating that no appreciable amount of non-volatile material was formed.

Since the Brookhaven work² had been performed in aluminum equipment, the possibility of a reaction between aluminum and tellurium hexafluoride was checked. Liquid tellurium hexafluoride was brought into contact with a thin aluminum plate in a Fluorothene tube, which had been weighed along with its aluminum contents. After one hour of contact the tellurium hexafluoride was distilled out of the tube, which was reweighed with the aluminum. No weight change had occurred.

Conclusion

No chemical reactions were observed in any of these systems which would account for the formation of a low-volatility tellurium compound in mixtures of tellurium hexafluoride and bromine trifluoride.

PART II - RADIOCHEMICAL STUDIES

Materials

Tellurium metal, irradiated for 28 days, was obtained from Oak Ridge National Laboratory. Fifty grams of the irradiated tellurium were cooled for 21 days in order to allow the Te^{131} to decay to I^{131} . The tellurium was separated from the iodine and xenon activities by a method similar to that used by Glendenin for the preparation of tracer tellurium.⁹

⁸H. Bode, Z. fur Anal. Chem. 144, 90 (1955).

⁹C. D. Coryell and N. Sugarman, "Radiochemical Studies: The Fission Products," Book 3, National Nuclear Energy Series, McGraw-Hill (1951), p. 1613.

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The 50-gram sample of irradiated tellurium was dissolved by immersing it in approximately 15 ml of water and slowly adding 200 ml of concentrated nitric acid. After boiling off the nitric acid, 40 ml of concentrated hydrochloric acid were added and the sample was heated until it was concentrated to about 2 ml. The hydrochloric acid treatment was repeated and followed by a similar treatment with a 40-ml portion of concentrated hydrobromic acid. After the solution was evaporated to dryness the residue was dissolved in 300 ml of 3 M hydrochloric acid.

The resultant clear tellurous acid solution was heated to boiling and saturated with sulfur dioxide. The precipitated tellurium was collected in a sintered Pyrex crucible and washed with 3 M hydrochloric acid, followed by water and acetone. In this manner tellurium containing Te^{127} and Te^{129} isotopes was obtained as a purified product.

Radioactive tellurium hexafluoride was prepared from 20 grams of the radioactive tellurium metal. The element was placed in a one-liter nickel reaction vessel. Fluorine at a pressure of about 2500 mm in another one-liter vessel was then condensed into the reaction vessel, using liquid nitrogen as a coolant. The finely divided tellurium reacted immediately to form tellurium hexafluoride. The coarsely ground tellurium used in the inactive experiments had reacted vigorously with gaseous fluorine at room temperature, but at times a ten to fifteen-minute induction period was noted before the reaction started.

After the reaction was completed and the vessel had been brought to room temperature, the tellurium hexafluoride was condensed by cooling the vessel with liquid nitrogen. The system was then evacuated to less than 1 mm to insure the removal of unreacted fluorine and non-condensable gases. The reaction vessel was heated to room temperature and the tellurium hexafluoride was distilled into a 500-ml nickel storage vessel.

The process was repeated until all the tellurium had reacted. In order to purify further the tellurium hexafluoride, it was all condensed into the reaction vessel with liquid nitrogen and the vessel was evacuated to less than 1 mm. The liquid nitrogen was replaced with dry ice in trichlorethylene and the tellurium hexafluoride was distilled back to the storage vessel, which was cooled with liquid nitrogen.

Apparatus

The apparatus has been described in Part I. It was modified so that a 25-ml Fluorothene tube was attached to the 304.5-ml gas measuring vessel with only one valve and a short line intervening. The close proximity of the Fluorothene tube to the gas measuring vessel was necessary to insure quantitative condensation of the tellurium hexafluoride into the Fluorothene tube which was used as a cold trap. It was found that long lines and extra

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valves acted to impede the flow of tellurium hexafluoride at low pressures. A second Fluorothene tube was attached close to the first to form a simple distillation apparatus. The nickel lines and valves were heated to 75°C in order that bromine trifluoride could be transported from one part of the apparatus to another without condensation, except in the cooled receivers.

Analytical Procedure

Tellurium was determined gravimetrically in a manner similar to the method of Vogel.¹⁰ A 3 M hydrochloric acid solution containing the tellurium and about 5 grams of hydrazine was heated to boiling on a hot plate, and sulfur dioxide was bubbled through the solution. The hot solution was filtered and the precipitated tellurium was collected on a previously weighed, sintered Pyrex crucible of fine porosity. The filtrate was resaturated with sulfur dioxide to insure complete precipitation of the tellurium. The metal was washed with 3 M hydrochloric acid and ethyl alcohol. The crucible was dried in a vacuum oven at 110°C and the sample was weighed as tellurium.

Hydrolysis of Tellurium Hexafluoride

According to Prideaux¹¹ the hydrolysis of tellurium hexafluoride to form telluric acid is slow, and overnight contact is necessary to obtain a quantitative hydrolysis. Our observations confirmed these findings. Only a small percentage of a given volume of tellurium hexafluoride reacted with a 3 M hydrochloric acid solution in 30 minutes, as indicated by the decrease in pressure. Contact of tellurium hexafluoride with 3 M hydrochloric acid for a period of 15 hours yielded a solution containing 94 ± 1 per cent of the tellurium hexafluoride, as indicated by tellurium analysis of the solution. This was sufficiently accurate for the tracer studies employed in this research. Samples of tellurium hexafluoride, usually containing about 0.5 gram of tellurium, were condensed in a 25-ml Fluorothene tube using liquid nitrogen as a coolant. The frozen samples were placed in a quart polyethylene bottle containing 200 ml of 3 M hydrochloric acid. The bottle was tightly capped and placed on a wrist action shaker overnight. After 15 or more hours a sample was taken for chemical or radiochemical analysis. Mixtures of tellurium hexafluoride and bromine trifluoride were hydrolyzed in the same manner except for the use of a two-quart polyethylene container.

¹⁰A. I. Vogel, "A Textbook of Quantitative Inorganic Analysis, Theory and Practice," Longmans Green and Co., (1951) p. 442.

¹¹E. B. R. Prideaux, J. Chem. Soc. 89, 320 (1906).

Radiochemical Analysis

Samples for beta counting were obtained by evaporating 1 ml or less of solution in a concave glass cup of 1-ml capacity. Coincidence and background corrections were made. The average deviation of duplicate samples was 2.3 per cent with a maximum deviation of 5 per cent of the total counts. In order to check the counting procedure and the recovery of active tellurium from Fluorothene tubes, solutions containing known tellurium activity were added in different amounts to Fluorothene tubes. The activity was washed from the tube with hot 3 M hydrochloric acid in the same manner as the unknown samples were to be handled. The recovery of the activity ranged from 97.9 to 103 per cent in the counting range of 50 to 5000 counts per minute.

Experimental Results - Partial Reduction of Tellurium Hexafluoride Due to Internal Conversion

The radiochemical separation of Te^{129} by the reduction of tellurium hexafluoride to a non-volatile species was observed by Williams⁵ to occur at tellurium hexafluoride pressures of 5 to 10 mm. Using the growth of the beta activity in the volatile fraction after separation, he computed that 45 to 55 per cent of the gamma transitions resulted in tellurium hexafluoride reduction. In the following experiments we demonstrated that similar results are obtained at higher pressures.

An experiment was performed to determine the activity of the tellurium prior to separation of the nuclides through internal conversion. Radioactive tellurium hexafluoride at about 250 mm pressure was condensed from a 304-ml nickel vessel at 25°C into a 25-ml Fluorothene tube that was cooled with liquid nitrogen. The sample was hydrolyzed and the beta activity per gram of tellurium, as shown in Table III, was obtained. The counting data for Sample 1 are tabulated as a function of the elapsed time in days after the hydrolysis. Sample 2 is a duplicate hydrolysis. Sample 3 is a similar hydrolysis of tellurium hexafluoride to which 3 ml of bromine trifluoride were added. The deviation of this sample from the others is within the experimental error. These values were used as standards for indicating the secular equilibrium beta counts per gram of tellurium hexafluoride.

In order to determine the extent of Te^{127} and Te^{129} separation from tellurium hexafluoride at higher pressures, a known amount of tellurium hexafluoride was condensed into a Fluorothene tube, which was heated to 25 or 75°C. Time was allowed for the Te^{127} and Te^{129} growth as indicated in Table IV. The volatile fraction was condensed into another tube and the non-volatile residue was dissolved with several portions of hot 3 M hydrochloric acid, which were made up to a known volume and sampled for counting. The beta counting rate was obtained at intervals and plotted

in Figure 1 against elapsed time after the separation. It can be seen from the rapid decay of the non-volatile fractions that they are mainly a mixture of the non-metastable forms Te^{127} and Te^{129} rather than a secular equilibrium mixture of Te^{127m} and Te^{129m} . This indicates that chemical decomposition due to internal conversion has actually taken place. The curves were extrapolated to zero time to obtain the counts of reduced Te^{127} and Te^{129} in the non-volatile fraction at the time of separation of the volatile tellurium hexafluoride and the reduction product.

Table III

TOTAL BETA ACTIVITY IN HYDROLYZED RADIOACTIVE
TELLURIUM HEXAFLUORIDE

Sample No.	Time in Days After Hydrolysis of Sample	Sample Weight, (g Te)	Beta Counts/(min)(g Te)
1	0	0.535	5.2×10^7
	3		4.7×10^7
	8		4.5×10^7
	11		4.4×10^7
2	1	0.522	5.3×10^7
3 ^a	12	0.485	4.9×10^7

^aSample No. 3 contained 3.0 ml of bromine trifluoride.

In Table IV the counts per minute per gram of non-volatile tellurium in the 25-ml tube after separation are compared with the counts per minute per gram of tellurium before separation. The ratio of the former to the latter multiplied by one hundred gives the percentage of Te^{127} and Te^{129} separated by the reduction of tellurium hexafluoride as a result of the internal conversion of the gamma rays. The beta activity of one sample of tellurium hexafluoride was allowed to come to secular equilibrium at 75°C and was separated at this temperature in order to compare it with a similar beta growth and separation in the presence of bromine trifluoride. The amount of Te^{127} and Te^{129} separation appears to be dependent on the growth time. The per cent separation for the longest growth time is of the same order of magnitude as Williams' results.⁵ Sample 7a is the volatile fraction of Sample 7, hydrolyzed and counted 48 hours after the separation. The beta count agreed within experimental error with the value before separation.

After 1472 minutes, the non-volatile fraction from Sample 4 decayed to 620 counts per minute. This activity may be attributed to the 9.3-hour activity of Te^{127} , since the 72-minute activity of Te^{129} would have been

Table IV

SEPARATIONS OF Te^{127} AND Te^{129} DAUGHTERS IN TELLURIUM HEXAFLUORIDE

Sample No.	Growth Time ^(a) (hr)	Temp (C)	Wt of Sample (g Te)	Calculated Pressure (mm Hg)	Initial Activity TeF_6 Before Separation (beta counts/(min)(g Te))	Non-Volatile Fraction ^(b)	
						After Separation (beta counts/(min)(g Te) Initially Present)	Per Cent Daughter Separation
4	76	25	0.314	1810	5.16×10^7	1.78×10^7	34
5	65	25	0.304	1770	3.85×10^7	1.15×10^7	30
6	21	25	0.289	1710	5.05×10^7	3.08×10^6	6
7	17	75	0.300	2480	4.71×10^7	1.23×10^6	2
7 ^{a(c)}						4.34×10^7 ^(c)	

^(a)Time tellurium hexafluoride stored in vessel.

^(b)Counts obtained by extrapolation to time of separation.

^(c)Volatile fraction of Sample No. 7 after separation.

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dissipated by this time. This information was used to obtain the decay curve of Te^{127} shown as a broken line in Figure 2. The Te^{127} activity was subtracted from the total activity at various times to obtain the Te^{129} activities shown in Table V and plotted on Figure 3. The half-life of 74 minutes for Te^{129} obtained from the graph agrees with the literature values,^{12,13} indicated in Table V. These experiments show conclusively that tellurium hexafluoride is decomposed by internal conversion of the gamma rays.

Table V

DECAY OF Te^{127} and Te^{129} SEPARATED FROM
TELLURIUM HEXAFLUORIDE

Time After Separation (min)	$\text{Te}^{127} + \text{Te}^{129}$ (beta counts/min) Observed	Te^{127} (9.3 hr) (beta counts/min) Calculated	Te^{129} (beta counts/min) By Difference
0	5.60×10^3	3.87×10^3	1.73×10^3
50	4.81×10^3	3.65×10^3	1.16×10^3
100	4.16×10^3	3.43×10^3	0.73×10^3
150	3.67×10^3	3.22×10^3	0.45×10^3
200	3.30×10^3	3.04×10^3	0.26×10^3
250	3.02×10^3	2.84×10^3	0.18×10^3
300	2.78×10^3	2.67×10^3	0.11×10^3

Half-Life Te^{129} - 74 minutes (See Figure 3)

Literature Value Te^{129} 72, 70,(12) 74(13)

Separation of Tellurium Activity from Bromine Trifluoride and the
Effect of Bromine Trifluoride on the Separation of Te^{127} and Te^{129} .

It was desirable to show whether separation of non-volatile Te^{127} and Te^{129} would occur in bromine trifluoride and to determine what activity would remain behind in a partial or total volatilization of bromine trifluoride when mixed with radioactive tellurium hexafluoride.

¹²J. M. Hollander, I. Perlman, and G. T. Seaborg, Rev. Mod. Phys. 25, 469 (1953).

¹³M. C. Day, Jr., G. W. Eakins, and A. F. Voight, Phys. Rev. 100, 796 (1955).

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Samples 8 and 9, containing tellurium hexafluoride and bromine trifluoride in the amounts shown in Table VI, were completely distilled at 75°C from a Fluorothene tube in which beta growth had been allowed for the time indicated. The beta counts per minute per gram of tellurium after separation were compared with similar counts before separation, which were obtained from the standard hydrolyzed tellurium hexafluoride. Sample 8 showed no activity remaining. Sample 9, which had a longer growth time, had only a small percentage of the activity remaining and it decayed in a manner similar to the separated daughter activity. This indicates that bromine trifluoride is capable of oxidizing the reduced tellurium fragments about as fast as they are formed by the internal conversions. It also proves that no non-volatile compound is formed between bromine trifluoride and tellurium hexafluoride.

Samples 10 and 11 contained similar mixtures of tellurium hexafluoride and bromine trifluoride in Fluorothene tubes. Fifty per cent of the bromine trifluoride was distilled out of the tube with essentially no reflux. Only a very small fraction of the activity was found in the hydrolyzed residue. This indicates that tellurium activity can be separated by distillation from bromine trifluoride and that there is no stable complex formation in the liquid.

Residual Tellurium Activity from Uranium Hexafluoride-Tellurium Hexafluoride Mixtures

A mixture of tellurium hexafluoride and uranium hexafluoride as shown for Sample 12 in Table VI was completely distilled from a Fluorothene tube. The residual activity was small and it decayed out in the same manner as the separated tellurium daughter activity. From this it can be assumed that no non-volatile complex or compound was formed from the components of the mixture.

Conclusions

The partial reduction of tellurium hexafluoride to a non-volatile form by internal conversion reactions was confirmed. The non-volatile species were shown by beta decay measurements to contain the non-metastable nuclides Te^{127} and Te^{129} . It was demonstrated that bromine trifluoride reoxidizes this non-volatile material to volatile tellurium hexafluoride. The separation of radioactive tellurium from bromine trifluoride was found to be practical. No non-volatile compound or complex appeared to be formed from mixtures of uranium hexafluoride and tellurium hexafluoride.

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Table VI

RESIDUAL BETA TELLURIUM ACTIVITY

Sample No.	Growth Time in Tube (hr)	Mixture	Per Cent Volatilized	Temp (C)	Before Separation, beta counts/(min)(g Te)	Time After Separation (hr)	After Separation, beta counts/(min) (initial g Te)	Per Cent Activity Remaining
8	17	1.01 g TeF ₆ 6 g BrF ₃	100	75	4.67×10^7	1	0	0
9	64.5	0.91 g TeF ₆ 6 g BrF ₃	100	75	4.52×10^7	0	1.86×10^4	0.041
						1	1.61	
						1.2	1.34	
						7.1	8.6×10^3	
						62.0	8×10^2	0.002
10	2	0.95 g TeF ₆ 6 g BrF ₃	50	75	4.52×10^7	21.5	6.26×10^4	0.14
						45	3.81×10^4	0.084
11	2	0.95 g TeF ₆ 12 g BrF ₃	50	75	4.30×10^7	88	$<4 \times 10^2$	<0.0009
12	2	0.93 g TeF ₆ 10 g UF ₆	100	75	4.48×10^7	2	4.26×10^4	0.095
						16.5	5.0×10^3	0.011