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ISOTOPIC POWER FUELS MONTHLY STATUS REPORT FOR MAY 1972

Eugene Lamb

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ISOTOPES DEVELOPMENT CENTER

ISOTOPIC POWER FUELS MONTHLY STATUS REPORT FOR MAY 1972

Eugene Lamb

Isotopes Division

JUNE 1972

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ISOTOPIC POWER FUELS MONTHLY STATUS REPORT FOR MAY 1972

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CURIUM-244 FUEL DEVELOPMENT

(Division of Space Nuclear Systems Program 04 30 05 03)

Curium-244 Oxide Fuel Development and Properties

Heat Capacity of $^{244}Cm_2O_3$

Various tools necessary to handle the $^{244}Cm_2O_3$ heat capacity sample were made, and a trial run for loading the sample into the experimental apparatus was successfully carried out. The experimental run will be initiated following minor adjustment to the instrumentation.

Vented Capsule Fuel Form Study

The installation of a high-temperature, high-vacuum furnace for the testing of fuel forms in vented capsules was started. The test is to simulate and study the effects of space-like conditions on the fuel form of a prototype vented capsule. The helium release characteristics of the fuel form will be determined, and the residual atmosphere in the furnace and the possible vapor species from the fuel form will be measured. Following the exposures at temperature, the specimens will be sectioned and examined for compatibility effects. The test facility enclosed in a shielded alpha glove-manipulator cell consists of a Brew-type furnace, a turbomolecular pump, and a quadrupole mass spectrometer for analyses of gaseous and vapor species.

Curium-244 Cermet Fuel Development and Properties

This task involves the preparation of sized $^{244}Cm_2O_3$ particles for use in cermets and the determination of ranges of fabrication parameters for noble metal—$^{244}Cm_2O_3$ cermets. The preparation of cermets requires sized particles of Cm_2O_3 which are incorporated into the metal matrix to form the composite fuel. Of the several methods available to produce sized particles, the ion-exchange procedure offers the potential advantages of efficient utilization of ^{244}Cm without recycle, adaptability to manipulator cell operation, and simplicity of procedure.

Our aim is to develop cermet fuel forms with the most desirable combination of properties and to reduce the in-cell development requiring curium. We are specifically attempting to structure the cermet to provide for helium release.

Preparation of Sized $^{244}Cm_2O_3$ Particles

Difficulties were encountered which were caused by variations in commercial ion-exchange resins. The two resins which had been previously used successfully were Rexyn 102H and IRC-72. In a recently purchased batch of Rexyn 102H the particles differed appreciably from the old resin in physical form and in ion-exchange capacity. Tests with the resin were abandoned. A new batch of IRC-72 was the same in appearance and in nominal capacity; however, many of the beads were observed to break in both the loading and the carbonization steps. This difficulty had not been encountered in earlier tests with certain exceptions. The beads of a batch of very highly bonded material had been badly broken and beads which had been initially in the NH_4^+ form tended to break during carbonization. It also had been found that the presence of oxygen during carbonization caused all types of beads to break.

The breaking of beads during loading was eliminated by a change in procedure to eliminate agitation during loading. A loading apparatus was developed which operates on the principle of the coffee percolator in which the solution percolates through a bed of the resin. The beads do not break during loading when this apparatus is used.

The carbonization cycle was observed using a hot stage microscope. It was found that breaking always took place in the temperature range of 460-500°C. The breaking was always violent, and pieces were hurled across the microscope stage. In some cases escaping vapor could be seen. Rapid shrinkage of the beads also occurs in this temperature range. It was concluded that when the beads shrink the permeability of the outer surface is reduced. The pressure of the organic vapors generated by the decomposition of the organic material in the interior of the bead causes breaking. It was found that breaking could be reduced to a low level if the loaded resin were held at a temperature of 430-450°C for 2 or more hours before the critical temperature range is reached. The resin can be heated rapidly (40-50°C per min) to 430°C without damage. This is true whether the resin is wet or dry at the beginning.

When breaking occurs because of the presence of oxygen there is no violent action, but cracks simply appear. Beads often separate into several pieces which may or may not remain partly attached. This breaking apparently is caused by internal stresses.

It has been found that the presence of a trace of carbon in Gd_2O_3 beads interferes with sintering. In air sintering, this made no difference since all carbon was destroyed. However, when a vacuum hot-press furnace was used, poor results were obtained unless the sample was oxidized with great thoroughness ahead of time. One hour at 900°C in air was not sufficient. This fact necessitates a change in the planned hot-cell equipment. Carbonization and oxidation in a nichrome-wound furnace had been planned. This was to be followed by sintering in a vacuum hot-press furnace. It now seems likely that a silicon carbon element furnace will be used for carbonization, oxidation, and sintering. Further sintering, however, might be required in the vacuum hot-press furnace because of the higher temperature required.

Helium Release from Cermets

Tests to determine the effect of alpha damage on the helium permeation of metals were initiated.[1] After 4 weeks of exposure of aluminum in contact with $^{244}Cm_2O_3$, no measurable permeation of aluminum by helium has been observed. A new test material, molybdenum foil, will be used in the next experiment.

Cermet Test Program

Strength deterioration and reduced helium permeability of $^{244}Cm_2O_3$-bearing cermets upon aging are of particular concern to the development of a cermet fuel form. We are investigating these effects in Mo–ThO_2 compacts.[1] During this reporting period, the aging of the simulant material at 1500°C was interrupted for 2 weeks because of a defective rheostat. To achieve the desired thermal treatment, aging of these specimens will be extended to June 5, 1972. Evaluation of the simulant material aged at 1200°C and $<2 \times 10^{-5}$ torr for 1000 hr is in progress.

Metallography of Curium Source Test Fuel

The x-ray diffraction study of the fuel sample from the Curium Source Test was terminated. The study showed that the fuel was $^{244}Cm_2O_3$. However, due to high radiation levels from the ^{244}Cm no conclusion as to impurities or concentration could be made.

Impact Testing of Heat Source Materials

Sabot Heaters

The toggle brackets for the sabot heater electrical connections were installed in the impact gun gas chamber, and a heater has been tested in the gun. The following data were recorded during this test:

Time (min)	Heater Power (W)	Temperature of Heater Cavity (°C)[a]
0	50	—
10	100	—
20	150	—
40	200	—
55	225	750
65	225	810
80	250	870
90	270	915
120	270	982
130	270	1010

[a]Measured with optical pyrometer.

[1]Eugene Lamb, *Isotopic Power Fuels Monthly Status Report for March 1972*, ORNL-TM-3796, Oak Ridge National Laboratory.

The impact gun sabot gripper was energized with the heater at the maximum temperature to test the system at temperature. Gas could be heard escaping around the sabot during the test, and only 150 psig gas pressure could be maintained on the system with the gas regulator wide open. The gun was disassembled, and the gripper was dimensionally inspected. A 0.006-in. permanent distortion was found in the center of the gripper indicating that the gripper and gun had expanded more than had been anticipated. It had been expected that the gripper and gun body would expand only an insignificant amount because of the large heat sink of the gun, its large external surface area, and good thermal conductivity. However, this appears not to be the case, and a test series is being conducted to determine the expansion that we should expect to see in the gripper mechanism at various temperatures. The following data were recorded in two of these tests:

Test No.	Heater Power (W)	Temperature of Heater (°C)		ID of Gripper (in.)		OD of Heater (in.)	
		Cavity	Jacket	Hot	Cold	Hot	Cold
1	270	975	207	2.777	2.769	2.765	2.749
2	150	750	140	2.774	2.769	2.759	2.749

The 0.012- and 0.015-in. clearances between the sabot and gripper are too large for the gripper to seal effectively. The most probable impact temperature for curium fuel materials is 700°C, therefore, new sabot heaters are being sized for these conditions. As other tests are made at differing temperatures, the sabot heaters will be sized for the different temperatures.

Two manufacturers of thermal insulation for the sabot heaters responded to a request for cost estimates on 100 of these items. Johns-Manville Corporation submitted an estimate of $28.35 per insulation cup using Min-K 2000* and Union Carbide submitted an estimate of $10.00 per insulation cup using Zircai.** An order for 100 insulation cups was placed with Union Carbide in mid-May.

Velocity Measurement System

The laser beam velocity measurement system has been completed and has proven satisfactory during calibration tests. The system is now being installed for testing with the impact gun.

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*Johns-Manville Corporation trademark.
**Union Carbide Corporation trademark.

Curium Heat Source

The 1000-W curium heat source is to be removed from its storage container and the curium fuel recovered. Several tools for opening the storage container and removing the fuel from the tungsten capsule have been fabricated. Work on opening the storage container is scheduled to begin in June.

APPENDIX I

Curium-244 Inventory

Weights are in terms of ^{244}Cm isotope in elemental form. Raw material is received from Savannah River Laboratory as $^{244}CmO_{2-x}$ powder and is stored in that form.

Cumulative Receipts and Usage	Curium-244 (g)	
Cumulative Receipts from SRL		2488
Allocated to 04 Heat Source Program		2148
Current Use in ORNL Test Program	(379)	
Analytical Samples from Test Program	(1)	
Shipped to Lovelace Foundation	(10)	
Shipped to SRL for Analysis	(2)	
Test Program Residues for Recycle	(83)	
Discarded to ORNL Tank Farm	(6)	
Raw Material Inventory, 04 Heat Source Program		1667
Allocated to 05 Transuranium Program		340
Transferred to TRU	(109)	
Shipments to Other Sites	(27)	
Transferred to Target Fabrication Group	(5)	
Raw Material Inventory, 05 Transuranium Program		199
Total Raw Material Inventory on May 31, 1972		1866

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