LOS ALAMOS SCIENTIFIC LABORATORY

OF THE UNIVERSITY OF CALIFORNIA ○ LOS ALAMOS NEW MEXICO

THE PREPARATION OF PLUTONIUM ALLOYS IN THE REDUCTION PROCESS

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THE PREPARATION OF PLUTONIUM ALLOYS IN THE REDUCTION PROCESS

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ABSTRACT

Homogeneous binary alloys of plutonium with aluminum, iron, cobalt, nickel, copper and uranium have been prepared in the reduction process. The method is not applicable for plutonium-zirconium or plutonium-cerium alloys.

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INTRODUCTION

Plutonium metal of high purity and yield is prepared by the calcium reduction of plutonium tetrafluoride using iodine as a booster.[1] Alloys of uranium with molybdenum[2] and niobium[3] have been prepared using the equivalent process with uranium tetrafluoride. More recently, the preparation of plutonium-aluminum alloys by aluminum-cryolite reduction process[4] and by the aluminum reduction of plutonium trifluoride and of aluminum dioxide[5] have been reported.

The preparation of alloys of plutonium with aluminum, iron, cobalt, nickel, copper, zirconium, uranium and cerium in the plutonium tetrafluoride process is reported below.

PROCEDURE

In the metal reduction process plutonium tetrafluoride is intimately mixed with calcium metal and iodine. Iodine is used in a 1 to 10 molar ratio with plutonium. Calcium (-10 +40 mesh U. S. Standard sieve size) is added in an amount sufficient for both the plutonium tetrafluoride and iodine reaction plus a 25 percent excess. The mixture is poured into a magnesia crucible located inside a steel pressure chamber. The annular space between the ceramic crucible and the pressure chamber is tightly packed with magnesia sand to protect the crucible against thermal shock. The pressure chamber is sealed, evacuated and made inert with argon. The assembly is then placed inside an induction coil and the charge heated by induction heating. The plutonium tetrafluoride is reduced to elemental plutonium.

The methods used to introduce the alloying element into the plutonium tetrafluoride-calcium-iodine charge are by the direct addition of the element, either as a fluoride compound or as metallic powder or chips, into the calcium and iodine before mixing with the plutonium tetrafluoride, and by the loading of metallic powder or chips into the ceramic crucible before the premixed reduction charge is introduced.

PLUTONIUM-ALUMINUM ALLOY

Plutonium-aluminum alloys varying in aluminum content from 0.27 to 0.97 weight percent (w/o) have been made by adding 8-mesh aluminum pellets to the plutonium tetrafluoride prior to mixing. On a 350-g. scale the reduction yields have been greater than (>) 98.5 w/o and the aluminum yield has been within 0.03 w/o of the added concentration.

PLUTONIUM-IRON ALLOY

Plutonium-iron alloys ranging in iron content from 2.28 to 2.55 w/o have been produced in kilogram quantities. The most convenient method for the production of this alloy is by the direct addition of coarse iron powder to the plutonium tetrafluoride. Reduction yields of >99 w/o and iron concentrations within 0.01 w/o of the added amount have been obtained in this system.

PLUTONIUM-COBALT ALLOY

Cobalt metal turnings added to the ceramic crucible are used to produce 3.25 w/o cobalt-plutonium alloys. On a 350-g. scale, cobalt concentration within 0.16 w/o of the added amount and reduction yields of >99% have been achieved.

PLUTONIUM-NICKEL ALLOY

Kilogram quantities of plutonium-nickel alloys have been made. Similar to the cobalt alloy, nickel metal turnings are added to the ceramic crucible to produce a 3.39 w/o nickel-plutonium alloy on a 350-g. scale. Reduction yields of >98 w/o and a nickel concentration within 0.11 w/o of the added amount are readily produced.

PLUTONIUM-COPPER ALLOY

Plutonium-copper alloys containing 2.5 w/o copper have been produced on a 160-g. scale by adding 8-mesh copper pellets to the plutonium tetrafluoride. Copper concentration within 0.28 w/o of the added amount and 99 w/o reduction yields have been achieved.

PLUTONIUM-URANIUM ALLOY

Both plutonium-rich (65 w/o) alloys of uranium and uranium-rich (85 w/o) alloys of plutonium have been prepared on a 160-g. scale. These alloys are prepared by mixing the tetrafluoride compound of each element with calcium and iodine. Metal yields of >97 w/o have been obtained. In the uranium-rich alloy the plutonium concentration was exact, whereas in the plutonium-rich alloy the plutonium concentration was 2.4 w/o high.

PLUTONIUM-ZIRCONIUM ALLOY

Plutonium-zirconium alloys have been produced by adding zirconium metal to the magnesia crucible and by adding zirconium tetrafluoride to the plutonium tetrafluoride, calcium and iodine. On a 200-g. scale, reduction yields of >97 w/o were achieved. Chemical analysis for zirconium on multiple samples of the buttons showed concentrations from 0.53 to 0.78 w/o zirconium as compared to 0.75 w/o added.

PLUTONIUM-CERIUM ALLOYS

A cerium-rich alloy (62 w/o) of plutonium has been made on a 360-g. scale by mixing cerium tetrafluoride with plutonium tetrafluoride, calcium and iodine. The button produced was well formed but porous. A cerium yield of 53.1 w/o and a reduction yield of >79 w/o was obtained.

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