Post-Irradiation Examination of ^{237}Np Targets for ^{238}Pu Production

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INTRODUCTION

In support of the Oak Ridge National Laboratory (ORNL) ^{238}Pu program, a number of irradiation tests have been performed. For one particular test, two arrays—each containing seven neptunium-loaded targets—were irradiated at the Advanced Test Reactor (ATR) in Idaho to examine the influence of multi-target self-shielding on the products. The arrays were located in the same irradiation facility but were axially separated to minimize the influence of one array on the other. After completion of irradiation and shipment back to ORNL, the targets were chemically processed to measure the residual neptunium, total plutonium production, ^{238}Pu production, and ^{236}Pu concentration. The amount and isotopic composition of fission products were also measured.

DESCRIPTION OF THE ACTUAL WORK

The array targets consisted of aluminum tubing that contained three NpO_2–Al pellets and a dosimeter package. The pellets were prepared by mixing the desired amount of NpO_2 with aluminum powder and then pressing the mixture to the desired dimensions and density. The dosimeter package consisted of a NpO_2 wire that was contained within a vanadium can.

Seven of the targets were loaded with 10 vol % NpO_2 pellets, while the other seven were loaded with 20 vol % NpO_2 pellets. The bottom half of each target contained an aluminum tube spacer that acted as a plenum for fission gas expansion.

The 14 targets were shipped to the Idaho National Engineering and Environmental Laboratory, where they were loaded into an aluminum basket, thereby forming two arrays. The arrays were irradiated for two cycles in the ATR.

Nine of the targets (four from the 10 vol % array and five from the 20 vol % array) were processed using a two-stage dissolution process, which consisted of first dissolving the aluminum in a caustic solution and then dissolving the remaining actinides and fission products in an acid solution. The caustic decladding solution and acid product solution were sampled and analyzed by a gamma scan, a gross beta scan, a gross alpha scan, and inductively coupled plasma–mass spectroscopy. Analysis for ^{236}Pu was performed via a 2-thenoyltrifluroacetone (TTA) extraction of the acid product solution, which was then followed by a 96-h alpha count. Based on the analytical results, a material balance was performed to determine the amounts of ^{238}Pu, ^{236}Pu, total Pu, ^{237}Np, and fission products that were recovered in the dissolution process.

RESULTS

To provide some insight into the effect of position and target self-shielding, results were evaluated in terms of the relative power. The relative power for each target was calculated by dividing the neutron flux at a target by the average flux in the region.

Several trends that reflect the different fluxes (and target self-shielding) at the various target positions were evident. The percentage of neptunium that is converted to plutonium increases with relative power—ranging from about 10 to 16 mol %. The results for the 10 and 20 vol % targets are similar. The ^{238}Pu production, as a percentage of total plutonium, generally decreases with increasing relative power, ranging from about 85 to 90 wt %. The specification for ^{238}Pu production is 82 wt %, as of the date of processing. Again, the 10 and 20 vol % targets provided similar results. The ^{236}Pu concentration at discharge tends to decrease with increasing relative power. Additionally, the ^{236}Pu production is higher in the 20 vol % pellets than in the 10 vol % targets. The ^{236}Pu production in the pellets ranged from about 3 to 6 ppm. The specification for ^{236}Pu is 2 ppm, as of the date of processing. Hence, these targets would require a cooling period of 1.7 to 4.5 years.