

Demonstration of Pyropartitioning Process by Using Genuine High-level Liquid Waste

Background

In addition to uranium, plutonium, and fission products (FPs), minor actinide elements (MAs) such as neptunium, americium, and curium are contained, albeit in small quantities, in spent fuels discharged from nuclear power plants. Some isotopes of MAs retain high radioactivity and heat generation for very long period of time. High-level liquid waste (HLLW) generated by the reprocessing of spent fuel is vitrified with borosilicate glass for stabilization, and will subsequently be disposed of in a repository, in which sufficient spacing is required due to the high temperature of vitrified high-level radioactive waste. On the other hand, the quantity of MAs accounting for the majority of heat generation from the spent fuels will increase if plutonium is widely recycled and burnt in future. Consequently, a far greater load is expected to be burdened on the repository. Therefore, reducing the long term radioactivity and heat generation from high-level waste can be attained by partitioning MAs from HLLW, thus reducing the load on the repository.

CRIEPI has been developing a so-called “pyropartitioning process” (Fig. 1) to separate and recover plutonium and MAs from HLLW. The recovered MAs are introduced to metal fuel FBR cycle for transmutation. The feasibility of the pyropartitioning process has been already shown by experiments using simulating HLLW and non-irradiated material. However, it is necessary to demonstrate the process by using the actual material for the development of a new partitioning process.

Objectives

The purpose of this study is to perform a series experiment of denitration, chlorination, and reductive-extraction by using about 500g of genuine HLLW obtained by reprocessing MOX fuel irradiated in a PWR. Then, it aims to demonstrate the pyropartitioning process by recovering MAs in the genuine HLLW into liquid cadmium phase.

Principal Results

1. Recovery of all MAs

At the denitration step in which HLLW (Fig. 2) is converted to oxide, the whole denitration product (Fig. 3) was recovered without any reaction with a crucible made of stainless steel. At the following chlorination step, in which the denitration product is converted to chloride by using chlorine gas, the elements in the HLLW were converted to chlorides in molten salt. At the reductive-extraction step where MAs in the molten salt are extracted into liquid cadmium phase, all of plutonium and MAs were recovered in the cadmium phase (Fig. 4). Accordingly, it was confirmed that no mass loss occurred in each step of the pyropartitioning process.

2. Confirmed separation of MAs from FPs

As shown in Fig. 5, the distribution behaviors of plutonium, MAs including curium, and rare-earth FPs versus uranium at the reductive-extraction were similar to the previous data obtained by using non-irradiated material. Therefore, it was confirmed that the separation of MAs from FPs is possible according to the previous estimation.

Hence, the pyropartitioning process was successfully demonstrated.

Future Developments

We will optimize the process flow sheet based on experimental data and develop engineering technology together with metal fuel FBR cycle development.

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Reference

K. Uozumi, et al., 2009, “Demonstration of Pyropartitioning Process by Using Genuine High-Level Liquid Waste – Reductive-extraction of Actinide Elements from Chlorination Product –”, CRIEPI Report L08011 (in Japanese)

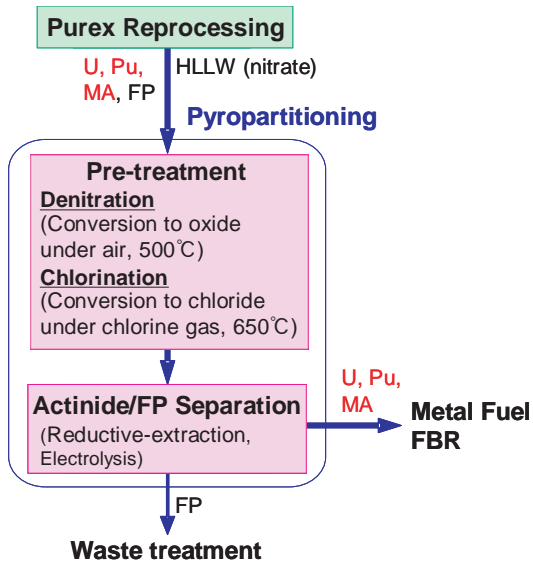


Fig.1 Pyropartitioning process



Fig.2 Genuine HLLW

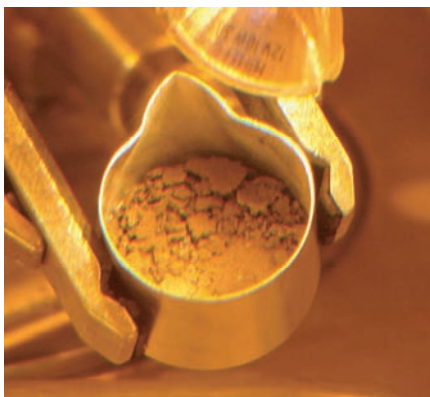


Fig.3 Denitration product

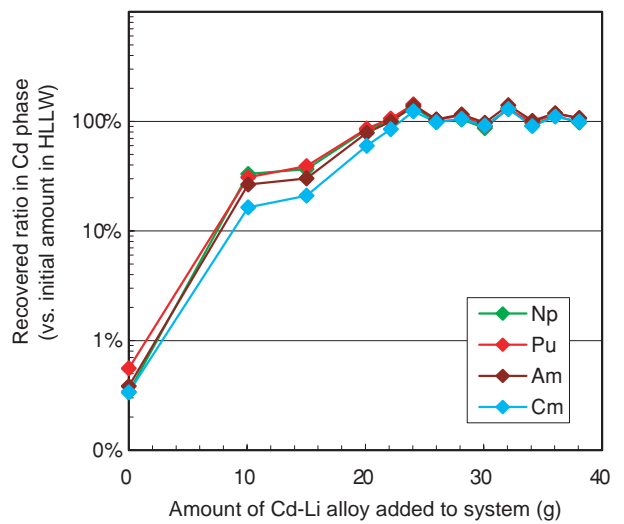


Fig.4 Recovered ratios of TRUs in Cd phase

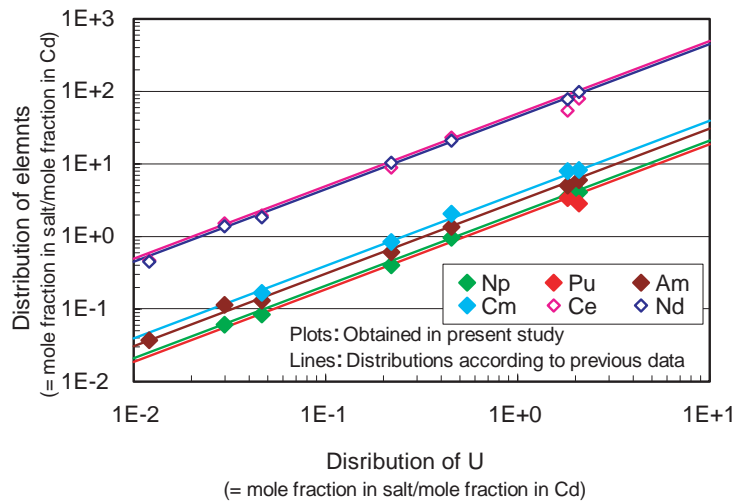


Fig.5 Distribution behaviors of plutonium, MAs, and rare-earth elements versus uranium