7-4 Preparation of Nitride Fuel in the Pyrochemical Reprocessing of Spent Fuel

—Technological Development of Renitridation of Plutonium Recovered in Liquid Cathode—

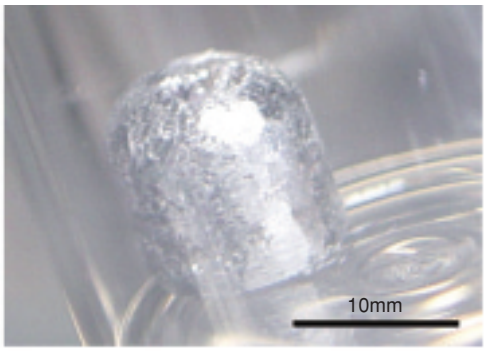

Fig.7-10 Liquid Cd cathode after electrorefining
In the pyrochemical reprocessing of nitride fuel, actinides are recovered in liquid Cd cathode by molten salt electrorefining.

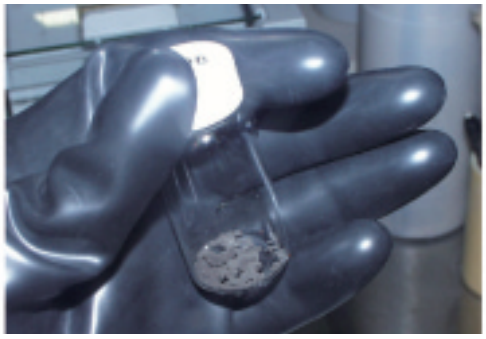

Fig.7-11 PuN powder obtained by nitridation - distillation combined reaction
Experiments are carried out in Ar-atmosphere gloveboxes.

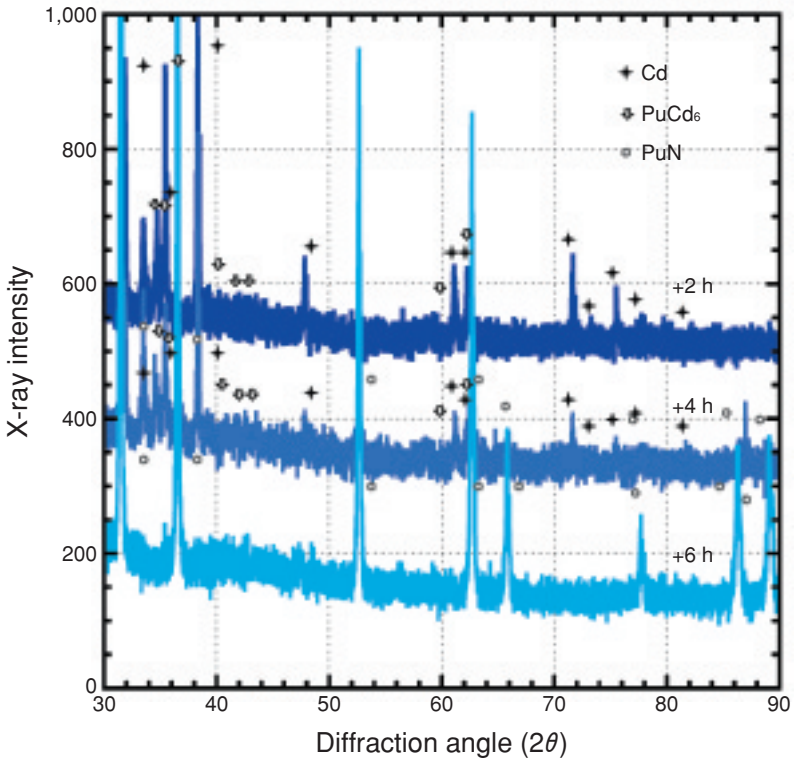

Fig.7-12 Change of X-ray diffraction patterns during the reaction
With the progress of distillation of Cd in the alloy, PuN is formed by the reaction of $PuCd_6$ and N_2 gas. After heating for 6h, almost the single phase of PuN is identified.

R&D on transmutation of minor actinide (MA) by Accelerator Driven System (ADS) is in progress in JAEA in order to lessen the long term radiotoxicity in high level waste and enhance the rational final geological disposal. Nitride fuel containing MA as a principal component is proposed for ADS and a pyrochemical process is proposed for the treatment of spent nitride fuel with high dosage radiation and decay heat. In the pyrochemical reprocessing of nitride fuel, actinides are recovered in a liquid cadmium (Cd) cathode by molten salt electrorefining, followed by renitridation of actinides in Cd for preparation of recycled fuel.

In this study, renitridation of plutonium (Pu) recovered in liquid Cd cathode (Fig.7-10) was developed by the nitridation-distillation combined reaction. In this method, high-purity PuN powder was recovered by heating the Pu-Cd alloy obtained by electrorefining at 973K in N_2 gas stream (Fig.7-11). The nitridation- distillation combined reaction is characterized by the simultaneous nitridation of Pu and distillation of Cd in the same stage. Although the nitridation of Pu in liquid Cd phase is difficult because of high thermodynamic stability, PuN was formed by the reaction of Pu-Cd binary intermetallic compound and N_2 gas during the distillation of Cd. Here the nitridation of Pu also promoted the distillation of Cd (Fig.7-12). According to the experimental results, mass balance of Pu and Cd during the experiments was good, and recovery and recycling of the evaporated Cd will be possible. The nitridation-distillation combined reaction seems to be technologically feasible.

Further, we tried the renitridation of Pu and uranium (U) and small amounts of rare earth (RE) elements contained in the Pu-U-RE-Cd alloy obtained by electrorefining. It was found that Pu and U were converted to mononitride and RE elements were also dissolved in the (Pu,U)N phase. Since RE elements have thermodynamic properties similar to MA in liquid Cd cathode, the nitridation-distillation combined reaction should be applicable to MA-bearing Cd alloy. In addition, preparation of nitride fuel pellets from the recovered nitride powder is planned.

This study was carried out within the task “Technological development of a nuclear fuel cycle based on nitride fuel and pyrochemical reprocessing” entrusted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan.

Reference

Arai, Y. et al., Fabrication and Electrochemical Behavior of Nitride Fuel for Future Applications, Journal of Nuclear Materials, vol.344, 2005, p.180-185.