Reprocessing of Spent Nitride Fuel by Chemical Dissolution in Molten Salt – Results on Plutonium Nitride Containing Inert Matrix Materials–

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Abstract

Nitride fuel cycle for the transmutation of long-lived minor actinides (MA) has been developed in Japan Atomic Energy Agency (JAEA) under the double-strata fuel cycle concept. The transmutation system proposed by JAEA is a Pb–Bi cooled sub-critical accelerator driven system (ADS) with ^{15}N-enriched Pu-MA mixed nitride fuels containing about 70 mol% ZrN as inert matrix material. In the currently-proposed pyrochemical process of the spent nitride fuel, actinides are dissolved in LiCl-KCl eutectic melts and selectively recovered into liquid Cd cathode by molten salt electrorefining. The recovered actinides are converted to nitrides by the nitridation-distillation combined method, in which the Cd alloys containing actinides are heated in nitrogen gas stream. However, this process has some disadvantages such as (1) the decrease in the anodic dissolution rate of actinide nitride by addition of the inert matrix materials, (2) the generation of the nitride products with different composition: the product from electrorefining process and that from the processing of the anode residues, and (3) treating large amount of Pu and MA including the inventory of them in the electrorefiner.

In the present study, the innovative process combining the chemical dissolution of spent nitride fuel into molten chloride and the multi-stage counter current extraction of actinide elements from the molten chloride media with liquid Li-Cd alloy is newly considered. In the chemical dissolution of the spent nitride fuel, the actinide nitrides are dissolved into molten LiCl-KCl eutectic salt as chlorides by chemical reaction with the oxidizing agents such as $CdCl_2$. The residue materials are processed into a metal waste form in the flow diagram. The molten salt containing actinide chlorides is transferred to the multi-stage counter current extraction of actinide elements from the molten chloride to liquid Cd using Li as a reductant. The actinides recovered in Cd are converted to nitrides by the nitridation-distillation combined method. The major advantages of this process are (1) the improvement in processing rate, (2) the homogenization of the composition of the nitride products, and (3) the reduction of the amount of actinide elements treated in the reprocessing process. In the presentation, the experimental results of the chemical dissolution of plutonium mononitride containing the inert matrix materials (ZrN and TiN) are to be introduce.

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