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R&D Activities based on Fast Reactor Cycle Technologies for Transmutation of TRU and LLFP by JNC

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Abstract

Research and development(R&D) activities on partitioning and transmutation of trans-uranium nuclides (TRU) and LLFP and future R&D program in JNC were summarized. Feasibility design studies have been conducting to investigate the characteristics of a fast reactor core with TRU and LLFP transmutation. It was reconfirmed that the fast reactor has a strong potential for transmuting TRU and LLFP, effectively. R&D for establishing partitioning process of TRU apart from the high-level radioactive wastes have been carried out. By several counter-current runs of the TRUEX process using highly active raffinates, a process flow sheet capable of selective partitioning of actinides and fission products was newly developed. JNC has settled a new R&D program concerning partitioning and transmutation of long-lived radioactive waste based on recommendation of check & review for OMEGA program performed by the Ad Hoc Committee under the Atomic Energy Commission of Japan (AEC). The R&D program is composed of the design studies and development of element technologies (fabrication, irradiation) in the "Feasibility Studies" on commercialized fast reactor system and the basic studies with experiments (nuclear data, reactor physics, fuel property, etc.) to establish database and analytical tools for the TRU- and LLFP- containing fuel and core design.

1. INTRODUCTION

Some of trans-uranium nuclides (TRU: Np, Am, Cm) and long-lived fission products (LLFP: I-129, Tc-99, etc.) contained in residual waste produced by reprocessing have extremely long-term radiotoxicity. The issue of radioactive waste generation, as one of the crucial issues of fission energy use, has to be improved in the scenario for the handling of the long-lived radiotoxicity.

One of the excellent features of fast reactors is its good neutron economy. Utilizing the excess of neutrons enables us to construct flexible nuclear cycle system including reactors and fuel cycle facilities such that they breed or burn plutonium in consideration of plutonium balance, transmute TRU and LLFP for reducing radiotoxicity and enhance safety and non-proliferation features.

JNC has been performing the R&D on Partitioning and Transmutation (P&T) technologies in the framework of the development of the Advanced Fuel Recycle Systems combined fast reactors. This paper describes the R&D activities on P&T of TRU and LLFP and future R&D program in JNC.

2. R&D ACTIVITES ON P&T TECHNOLOGIES

2.1 Partitioning Technologies for TRU and LLFP

A dual solvent extraction (SX) system has been proposed for enhanced governance of TRU in the spent fuel for the coming back-end fuel cycle. In the JNC's scheme, actinides (U, Pu, Np) are separated from dissolver solution by the PUREX process. Residue of them and all of TRU (Am and Cm) are additionally recovered from the high level liquid waste (HLLW) by the TRUEX process using a CMPO (O ϕ D[IB]CMPO : Octyl [phenyl] -N, N-diisobutyl carbamoylmethyl phosphine oxide) - TBP mixed extractant. By such TRU recycling, high radioactive toxicity sustained in the ultra long terms of the vitrified HLLW is expected to be shortened to permit the human being's supervision.

2.1.1 TRU Partitioning by TRUEX System

Among more than 20 partitioning methods, CMPO-TRUEX method was primarily nominated by JNC so far, because it meet well with several partitioning requirements. Major advantage on CMPO is defined that it will not require additional dilution of HLLW due to its high TRU extractability still in highly concentrated nitric acid media, hence that will be helpful to design simpler reprocessing process.

Actual R&Ds have been pursued at the hot lab. in the CPF (JNC's Chemical Processing Facility in Tokai-mura) using real HLLW (HAR from PUREX tests with "Joyo" FR spent fuels, and concentrated HLLW from commercial reprocessing at "TRP" with LWR spent fuels). Five TRUEX runs and two TRU/Ln separation runs were carried out so far. Major lessons from the results of the hot runs are summarized as follows[1),(2)] ;

(i) TRU-nuclides were successfully separated from highly active raffinate by improved TRUEX flowsheet with SF(Separation Factor)$>10^3$,where they were fractionally stripped depended with their valences by contacting with a series of salt-free reagents.

(ii) Separation of Am from light Ln^{3+} (La~Nd) was achieved by "SETFICS(Solvent Extraction for Trivalent f-elements Intra-group Separation in CMPO-complexant System) " method using DTPA with SF more than several tens. About 80% of Ln was separated from Am.

2.1.2 FPs Partitioning by Electrolytic Extraction System

Incentives on FPs partitioning in the spent fuel are summarized that (i) partitioning of LLFP (Tc-99, Pd-107, Se-79, etc) for transmutation, (ii) ion partitioning (Ru-106, Tc-99) to increase total DFs of the SX process, (iii) elemental recovery of rare metals (Ru, Rh, Pd, Tc,