Actinides Recycle by Pyrochemistry in Nuclear Fuel Cycle

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ACTINIDES RECYCLE BY PYROCHEMISTRY IN NUCLEAR FUEL CYCLE

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ABSTRACT

The pyrochemistry provides a large potential for establishing the nuclear fuel cycle to effectively use fissile materials in fast reactors. The fuel cycle in next generation requires lightening an environmental burden and the strong resistance for proliferation as well as an economic advantage. In order to satisfy the requirement, actinides recycle by a simply designed pyrochemical installation gives us a promising solution. Central Research Institute of Electric Power Industry (CRIEPI) has been engaging to establish the pyro-process fuel cycle technology since early 1980fs. The major devices in the pyro-process include the electrorefining and reductive extraction for collecting actinides in systems with molten chlorides and liquid metals of cadmium or bismuth. The fuel cycle[1], called as pyro-recycling system, include not only the metal fuel cycle for fast reactors [2,3] but also the lithium reduction of oxide for applying metal fuel cycle technology and the conversion of high level liquid wastes to chlorides for recovering actinides.

The electrochemical potentials of actinides and lanthanides were measured for evaluating free energies of formation of chloride in a cell of M/MCln,LiCl-KCl//AgCl,LiCl-KCl/Ag and for obtaining activity coefficients in liquid cadmium by use a cell of M-Cd alloy/MCln,LiCl-KCl/M[4]. The distribution coefficients of actinides and lanthanides measured in LiCl-KCl/Cd and LiCl-KCl/Bi systems give the separation factors between actinides and lanthanides for reductive extraction.

Following the thermodynamic measurements, electrorefining and reductive extraction to recover actinides have been basically developed by lots of experiments used actinide materials for technological implementation of pyrochemistry. The fuel dissolution into molten salt and the uranium recovery on solid cathode for electrorefining have been demonstrated by engineering scale facility with use of spent fuels in Argonne National Laboratory [5] and by a kg scale of installation with use of uranium in CRIEPI [3]. The electrorefining used liquid cadmium cathode indicated to deposit plutonium with an effective collection rate by the joint study of Japan Atomic Energy Research Institute[6]. Recently, the pyroprocess facility, which can afford to treat a gram-scale of americium and hundreds gram of plutonium was installed in the Institute of Transuranium Elements in Germany[7]his facility gives a chance to demonstrate each process of pyro-recycling system by use of an irradiated material and real high-level liquid waste. The lithium reduction of oxides was confirmed to produce a metal of uranium, plutonium, neptunium, americium from each oxide and the mixed alloy from MOX pellet[8] It is undoubted that the electrochemical reduction is also promising to reduce oxides. Concerning on actinide separation from high-level liquid waste, the conversion of nitrate solution to chlorides through oxides has been also established through uranium tests. It is confirmed that more than 99TRU nuclides can be recovered by reductive extraction from simulated materials of high-level liquid waste by TRU tests[9].

Through these studies, the process flow sheets for reprocessing of metal and oxide fuels and for partitioning of TRU separation have been established. The subjects to be emphasized for further development are classified into three categories, that is, process development (demonstration), technology for engineering development, and supplemental technology. CRIEPI also prepared a glove-box facility, in which hundreds grams of plutonium can be managed, to examine the material flow through the lithium reduction step to the distillation step of salt and cadmium with a cooperation of the Japan Nuclear Fuel Cycle Institute.

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