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ScienceDirect

Procedia Chemistry 21 (2016) 365 – 370

Procedia Chemistry

5th International ATALANTE Conference on Nuclear Chemistry for Sustainable Fuel Cycles

Flexible Waste Management to Increase the Effectiveness of Minor Actinide P&T Technology

Tetsuo Fukasawa[a]*, Yaohiro Inagaki[b], Tatsumi Arima[b], Seichi Sato[c]

[a] *Hitachi-GE Nuclear Energy, Ltd., 3-1-1 Saiwai, Hitachi 317-0073, Japan*
[b] *Kyshu University, 744 Motooka, Nishi, Fukuoka 819-0395, Japan*
[c] *Fukushima National College of Technology, 30 Aza-Nagao, Tairakamiarakawa, Iwaki 970-8034, Japan*

Abstract

Partitioning and transmutation (P&T) technologies have been developed for minor actinides (MA) to reduce the high level waste (HLW) volume and long-term radiotoxicity. Although the MA P&T can reduce the potential radiotoxicity effectively by 1-3 orders of magnitude, the actual operation of P&T requires several tens of years for developing elemental technologies of nuclide separation, MA containing fuel fabrication, transmutation and their practical systematization. The high level liquid waste (HLLW) containing MA is presently vitrified immediately after spent fuel reprocessing, stored about 50 years at surface facility and will be disposed of at deep geological repository. Vitrified HLW form works as an excellent artificial barrier against nuclides release during storage and disposal. On the other hand, it is difficult to recover MA from the form. So the present waste management scheme has an issue of MA P&T technology application until its deployment, which will produce much amount of vitrified HLW including long-lived MA without P&T application. Thus the authors proposed the flexible waste management method to increase the effectiveness of the MA P&T. The system adopts the HLLW calcination instead of the vitrification to produce granule for its dry storage of about 50 years until the MA P&T technology will be applicable. The granule should be easily dissolved by the nitric acid solution to apply the typical aqueous MA partitioning technologies to be developed. This paper reports the purpose of the study, the feasibility evaluation results for the calcined granule storage and the evaluation results for the environmental burden reduction effect.

Peer-review under responsibility of the organizing committee of ATALANTE 2016

* Corresponding author. Tel.: +81-294-55-4319; fax: +81-294-55-9909.
E-mail address: tetsuo.fukasawa.gx@hitachi.com

Peer-review under responsibility of the organizing committee of ATALANTE 2016
doi:10.1016/j.proche.2016.10.051

Keywords: Flexible waste management; MA P&T; Environmetal burden reduction; Radiotoxicity; Repository area

1. Introduction

Japan's national Strategic Energy Plan[1] decided by the Cabinet in 2014 mentioned that the accumulation of spent nuclear fuels is a global problem to be solved (to steadily make efforts to deal with) as a responsibility of the current generation without passing the problem on to future generations. Reprocessing of the spent fuels is one of the countermeasures to solve this issue. Reprocessing can not only reduce the spent fuels but also make the effective utilization of uranium resource, which is quite important from the viewpoint of energy security for the resource lacking countries like Japan. On the other hand, reprocessing generates high level radioactive waste (HLW) of which proper management is necessary and Government of Japan decided to promote the research and development (R&D) for the reduction of its volume and radiotoxicity by such technologies as partitioning and transmutation and for the safety enhancement of its disposal.

Potential radiotoxicity of the HLW is smaller than that of spent fuel due to the utilization of Pu in the spent fuel and can be decreased further (about 1/10 ~ 1/1000) by the partitioning and transmutation (P&T) of minor actinides (MA) in the HLW[2]. The MA have relatively long half-lives and their P&T technology is particularly effective for the reduction of long-term radiotoxicity (after 100 years and beyond).

Various P&T technologies have been actively developed by various organizations in many countries. Japan considers prototype fast breeder reactor "Monju" as the international research platform for the development of P&T technologies to reduce the waste volume and radiotoxicity. Realization of the P&T needs to finish each technology development for partitioning of MA, fabrication of MA containing fuel and transmutation by fast neutrons, and their harmonization as an efficient P&T system. In this concern each P&T technology is still in the phase of basic research and its confirmation, and will take long-term for the P&T realization[2,3].

In Japan's nuclear fuel cycle the spent fuels are reprocessed to recover uranium (U) and plutonium (Pu) which are recycled in LWR. As the P&T technology has not been established yet, the HLLW with MA will be vitrified immediately after reprocessing, cooled about 50 years in the surface storage facility and finally disposed of at the deep geological repository. Although vitrified HLW (glass matrix) has a high artificial barrier property to prevent the nuclides migration, recovery of MA from the vitrified HLW is too difficult to apply the P&T technologies established in the future.

In order to solve this issue, the authors have proposed the flexible waste management method and basically investigated its applicability and effects. This paper mainly reports the environmental burden reduction effects.

2. Outline of the flexible waste management method

Figure 1 shows the outline of the flexible waste management method (system) proposed.

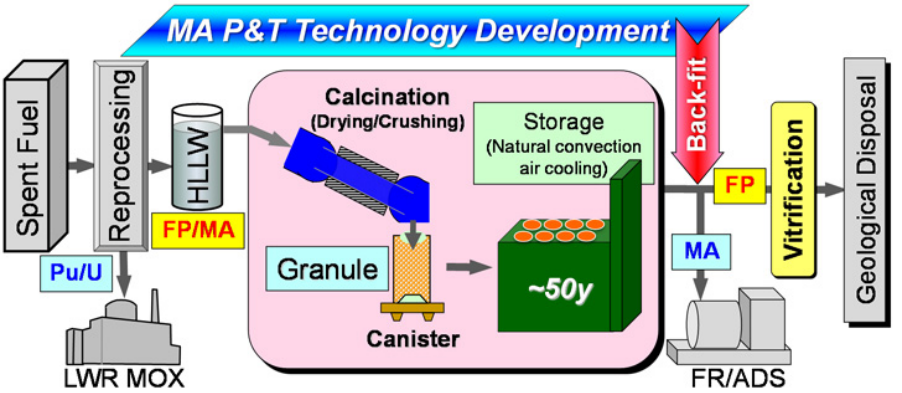

Fig. 1. Outline of the flexible waste management system