

A Study on the Disposal Safety of Radioactive Waste Containing Organic Complexing Agents

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1. Introduction

Organic complexing agents (chelating agents and cellulose), contained in radioactive waste, are generated during the operating and decommissioning of nuclear power plants (NPP), and these agents form organic complexing compounds that accelerate the movement of radionuclides. These organic complexing compounds can adversely affect the safety of the disposal facility. Also, radioactive waste, which is containing organic complexing agents, is inevitably generated by dry active waste (DAW) and decontamination wastewater, etc. which are generated during the operating and decommissioning of NPP.

Chelating agents and cellulose are representative substances that cause the formation of organic complexing compounds. In the current situation, standards to regulate the organic complexing agents are insufficient in Korea and there are no regulatory standards and current status of radioactive waste containing cellulose, unlike chelating agents.

Considering the disposal safety, management of radioactive waste is essential especially, which is containing organic complexing agents. Therefore, to raise the efficiency of the treatment and the disposal of the organic complexing agents, it is necessary to analyze the behavior of the organic complexing agent and the generation of radioactive waste which is containing chelating agents and cellulose. Also based on these analyzes, it is necessary as well to develop a technology for evaluating the treatment and disposal of radioactive waste containing organic complexing agents.

In this paper, to develop the evaluation technology, it had been investigated the occurrence and characteristics of organic complexing agents and domestic regulatory standards.

2. Methods and Results

There are differences between chelating agents and cellulose in the source, type, and form of the generation.

2.1 Characteristics and generation of radioactive waste which is containing chelating agents

Chemical decontamination is performed to improve worker's safety and to prevent the spread of radioactive-

contamination when maintaining, repairing, and decommissioning of NPP. During chemical decontamination, chelating agents such as Ethylenediaminetetraacetic acid (EDTA), Nitritotriacetic acid (NTA), and citric acid, which cause the formation of organic complexing compounds, are used as decontamination chemicals.

Table 1 shows the current products which are containing chelating agents, used in domestic NPP and their amount of usage. Most of the drums of radioactive waste, generated during operation at the NPP, are being stored in the storage facility on the site of the NPP [1]. Among them, the number of drums, that are assumed to contain chelating agents, is 20,015 drums (concentrated waste liquid) and 13,376 drums (waste resin) on March 20, 2020. Also, it is predicted that a larger amount of radioactive waste containing chelating agents will be generated when the NPP is decommissioned.

Table I: Current products, containing chelating agents, and their usage used in NPP

Name	Type	Amount (L)	Period (year)
Kori #1	LA/AT	400~1,000/ 1,200~1,800	'03~'06
Kori #2	LA/AT	800~1,800/ 400~1,600	'05~'07
Hanbit #1	GP100, LA, AT, PWT	800~3,000	'93~'06
Hanbit #2	LA/AT	780~2,500/ 460~2,660	'03~'07

2.2 Characteristics and generation of radioactive waste which is containing cellulose

Cotton, paper, and wood, which are largely composed of cellulose, are generated as medium- and low-level radioactive waste. In domestic, the current status of radioactive waste, containing cellulose, has not been identified yet.

This cellulose is decomposed by isosaccharinic acid (ISA) under strong alkali conditions (pH 12.4) formed by the hydration reaction of cement. ISA combines with radionuclides to form organic complexing compounds. Like chelating agents, these organic complexing

compounds lower the adsorbability of the engineering barrier to radionuclides and dissolves in groundwater, accelerating its migration. Eventually, whole this process causes a negative impact in terms of safety.

According to the data published by SKB in Sweden, various concentrations of ISA occurred according to the reaction conditions (a type of DAW, pH, presence of oxygen, etc.), and it was reported that the maximum concentration of 0.1 M occurred [2].

2.3 Behavioral characteristics of organic complexing compounds

ISA is generated from chelating agent and cellulose, contained in cement solidification or DAW. This ISA is combined with radionuclide and forms organic complexing compounds. The formed organic complexing compounds interfere with the adsorption of radionuclide at barriers (engineering and natural) in the disposal facility. Thereafter, this is likely to leak to the near-field and the far-field along with the groundwater.

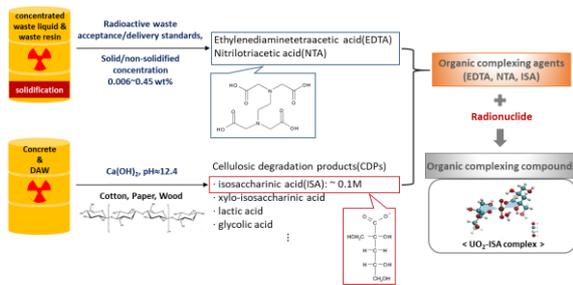


Fig. 1. Generation of organic complexing agents and formation of organic complexing compounds

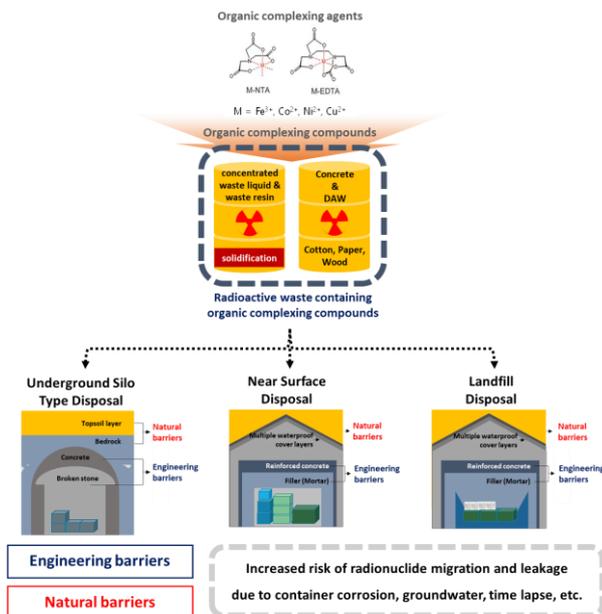


Fig. 2. Radionuclide migration and leakage by organic complexing compounds

2.4 Regulatory standards related to organic complexing agents

In Korea, about substances that threaten the safety of defense waste disposal facilities, the characteristics of the wastes are specified according to the disposal requirements by the Nuclear Safety and Security Commission (NSSC) Notice No. 2017-60 『Delivery Regulations of Medium/Low-Level Radioactive Waste』. Criteria for chelating agents are also specified in the same notice.

As for the regulatory standards related to cellulose, there are no specified notices from NSSC or the safety analysis report (SAR) published by the Korea Radioactive Waste Agency (KORAD).

Table II: Acceptance inspection of radioactive waste in domestic [3]

Inspection item	Criteria	Inspection method
Chelating agents	<ul style="list-style-type: none"> - If chelating agent contains more than 0.1% of the weight of radioactive waste, the chemical name and content must be specified. - If chelating agent contains more than 1%, the waste must be solidified. - If chelating agent contains more than 8%, the waste should not be disposed of. 	<p>Document inspection</p> <p>(Follow the preliminary inspection procedure at the origin place)</p>
Cellulose	None	

As such, standards to regulate the organic complexing agents are insufficient in the domestic delivery regulations and acceptance criteria of medium and low-level radioactive waste. Especially, there are no acceptance criteria and regulations which is related to inspection for cellulose. Therefore, it is necessary to establish specific and actionable levels of regulatory requirements and guidelines.

3. Conclusions

In radioactive waste disposal facilities, organic complexing agents potentially have a bad effect on disposal safety by increasing the mobility of radionuclides. Furthermore, there are insufficient data about the current status of domestic and regulatory standards of cellulose that cause the formation of organic complexing agents.

Therefore, in order to improve the safety and reliability of disposal of radioactive waste which is containing organic complexing agents, the following studies are required continuously.

- Assessment of characteristics about the generation of organic complexing agents
- Establishment of reduction measures about organic complexing agents
- Draw of methods for confirming suitability for disposal of organic complexing agents
- Deriving improvement plan for acceptance criteria related to organic complexing agents
- Construction of the DB by experimental analysis of the influence (solubility, adsorption distribution coefficient) of organic complexing compounds according to external reaction conditions for each radionuclide
- Establishment of a model for radionuclide migration by organic complexing compounds and development of an evaluation system for the safety of disposal

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