Decontamination of Concrete Waste Generated From Nuclear Power Plant Decommissioning With Different Organic Solvents

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1. Introduction

Contaminated radioactive concrete waste is one of the main issues in Nuclear Power Plant (NPP) decommissioning, because of its large amount and volume. Therefore, many countries are trying to reduce the volume of radioactive concrete/cement wastes.

However, the methods of decontamination process are all different in each country. For example, CITROX process uses a mixture of oxalic acid (2.5wt%) and dibasic ammonium citrate (5wt%) [1]. CORD process mainly uses oxalic acid, and CAN-DECON process which modified the CITROX process, uses ethylenediaminetetraacetic acid(EDTA), oxalic acid, and citric acid with mass ratio of 2:1:1 [2].

In this regard, Korea also needs to establish the most efficient decontamination process before starting the Go-ri 1st NPP decommissioning. Therefore, this study was conducted to find optimal decontamination condition for concrete waste with various concentrations of organic acids.

2. Materials and Methods

2.1 Simulated Concrete Coupon

Simulated concrete coupons were made with 37 g of sand, 24 g of aggregates, 21 g of Portland cement (Type I/II), 13 g of DI water and 5 g of fly ash. After complete mixing, concrete slurry was poured into a paper mold (5 cm diameter and 10 cm height) and cured for a week with high relative humidity condition (80~90%).

Cobalt nitrate hexa-hydrate ($Co(NO_3)_2 \cdot 6H_2O$) and cesium nitrate ($CsNO_3$) were used to contaminate the concrete coupons. During curing, about 10,000 ppm of Co or Cs solution (0.4 mL of each) was spiked individually into the concrete coupons at a depth of 0.7 cm from the outer surface, using a glass syringe.

2.2 Thermal Deterioration

In our previous [3] study, 1 hour of deterioration at 550°C was found to be the optimal thermal treatment condition. After thermal deterioration, the samples were crushed by hammer to separate the cement paste from concrete aggregates. Concrete pastes were completely mixed for the homogeneity before use.

2.3 Chemical Decontamination

Nitric acid solution with pH 2 (DI water 40 mL + 70 uL of Nitric acid 60%) was used for based solution. To find an optimal decontamination condition, EDTA, oxalic acid, and citric acid were prepared and tested. Decontamination experiments were carried out with a concentration of 500, 1000, 2000, 4000 ppm of each organic solvent. An additional 8000 ppm was also carried out, similar to the CAN-DECON process.

After decontamination experiments, the released amounts of Co and Cs were analyzed by Inductively coupled plasma mass spectroscopy (ICP-MS).

2.4 Characterization

X-Ray Diffraction (XRD) was used to identify the type of minerals from the concrete paste. Scanning Electron Microscope (SEM) was used to observe the surface morphology of concrete paste. Fourier Transformed Infrared Spectroscopy (FT-IR) was used to analyze the changes in chemical bonds.

3. Results and Discussions

3.1 Concrete Preparation and Deterioration

After the thermal deterioration at 550°C, concrete coupons showed severe cracks on their surfaces and the color of concrete also changed to bright.

Fig. 1. Thermal treatment at 105°C (left) and 550°C (right).

3.2 Concrete Paste Separation

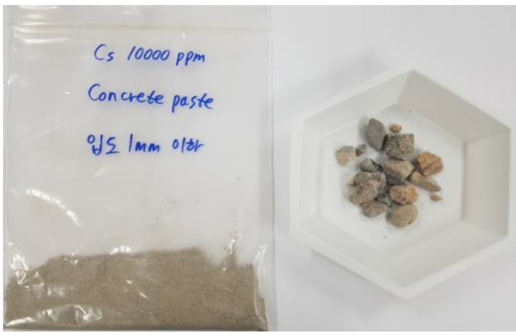

Fig. 2. Separation of concrete pastes and aggregates.

Over 95% of concrete aggregates were recovered (initial input mass: 24 g, recovered mass: 23 g~23.5 g) after the separation.

3.3 Chemical Decontamination

We could see that different types of organic acids should be used depending on the type of target nuclides. Concentration of each organic acid also has affected the efficiency of decontamination.

Table 1. Organic acids additives

	Concentration (ppm)				
EDTA	500	1000	2000	4000	8000
Oxalic acid	500	1000	2000	4000	
Citric acid	500	1000	2000	4000	

From the results, we could set the optimum organic acid type and its concentration for the best efficiency.

4. Conclusion

This study was carried out to find the optimum decontamination conditions by changing the concen trations and times of various organic acids that are commonly added to existing decontamination processes such as CITROX, CAN-DECON and CORD. The results of this study will increase our understanding of chemical decontamination process to reduce the volume of concrete wastes generated from the NPP decommissioning.

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