Mechanical and Chemical Treatment for the Volume Reduction of Radioactive Concrete Waste from Decommissioned Nuclear Facilities

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1. Introduction

Different types of radioactive wastes are generated during the decommissioning of nuclear facilities. Concrete is one of the major radioactive wastes from the decommissioning process and the total amount of radioactive concrete is divided by a regulation standard. Korea enforces strong regulatory standards for classification, treatment and radioactive waste disposal; with a high disposal cost of approximately 12,500$/200L drum. The high cost is a compelling reason why we need to reduce the volume of the radioactive concrete to be sent for disposal. In the case of concrete, most radioactive nuclides are in the cement component. By separating the cement and aggregate, we could collect the non-radioactive parts to meet regulation criteria for free release. Therefore, a huge volume reduction of the radioactive concrete waste could be achieved.

In this study, our aim was to evaluate the separation efficiency of aggregate and cement from concrete waste using a mechanical and chemical process sequentially.

2. Materials and Methods

In the experiment, we simulated contaminated concrete by using 10~40mm diameter crushed concrete from a waste management company and submerged the concrete in a chemical reagent solution until it dried naturally through evaporation (~1 month). The solution contained Co, Sr, Cs dissolved in the Deionized water (18.6MΩ, Millipore) by using CsCl, $SrCl_2 \cdot 6H_2O$, $CoCl_2 \cdot 6H_2O$(Aldrich)

		<StepI> Mechanical Process [Heating and Grinding]		**<StepII>** Chemical Process [Acid or Alkaline dissolution]
Simulated contaminated concrete [Co, Cs, Sr]	→		→	

2.1 Mechanical process

During the heat treatment, ~200g of concrete was heated at 400~700℃ for ~120 minutes using a muffle furnace(MF-12GH, JEIO-TECH) followed by natural cooling. After, the concrete was ground using a ball mill(LM-BD4530, LK LAB KOREA). The heat-treated concrete was placed in a mill pot (Porcelain,500ml) with grinding balls (Alumina, D:0.5~40mm) or without and rotated at 300rpm mill roller speed for less than 24hrs. After grinding, the aggregate was separated from the fine cement powder using a 1mm test sieve. Mass analysis confirmed the quantity of each classification range. Chemical component analysis of the aggregate surface was performed using EDS (X-flash, Bruker), at this time oxygen was eliminated from the EDS results.

2.2 Chemical process

Aggregate dissolution was performed by using 0.4M HCl and the ratio of solid and liquid was 1g/10ml at 300rpm stirring speed for 2 hours. Aggregate surface post-dissolution was analyzed using SEM (4400M, SEC) with the remaining components like Cs, Sr, Co, Ca on the surface analyzed using EDS. In addition, the content of cement and simulated contaminated components in the dissolved solution were analyzed by using ICP-OES(PQ-9000, Analytic jena)

3. Results and discussion

Table 1 is a composition of the simulated contaminated concrete by EDS. Calcium from the cement and Si from the aggregates were the main components. Simulant contaminants (Co, Sr, Cs) were adsorbed in the concrete.

Table 1. EDS results of the simulated contaminated concrete

Element	Atomic percent (%)	Element	Atomic percent (%)
Ca	37.97	Mg	6.13

Si	22.47	Co	11.96
Al	11.15	Sr	5.42
Fe	1.89	Cs	0.94
K	2.07		

3.1 Mechanical process

Table 2 is the EDS results of the treated simulated contaminated concrete over 1mm solid. Over 50% of Co and Sr were removed from the aggregate after heating and grinding treatment. The reason is most of the contaminants were in the cement, heat treatment broke the cement structure and reduced the bonding strength between the cement and aggregate. But some cement remained with the aggregate surface and needed to be removed for free-release

Table 2. EDS results of the aggregate from the simulated contaminated concrete by heating and grinding treatment.

Element	Atomic percent (%)	Element	Atomic percent (%)
Ca	40.4	Mg	5.02
Si	30.74	Co	3.88
Al	11.66	Sr	2.27
Fe	1.98	Cs	0.9
K	3.14		

3.2 Chemical process

Table 3 is the EDS results of the aggregate from simulated contaminated concrete after acid dissolution. In the results, most of the Ca was removed along with Co, Sr and Cs by acid dissolution which made it possible to free-release the aggregate. The removal of Co and Cs showed significant increases in efficiency following the chemical process method.

Table 3. EDS results of the aggregate from the simulated contaminated concrete after acid dissolution.

Element	Atomic percent (%)	Element	Atomic percent (%)
Ca	6.19	Mg	5.77
Si	52.53	Co	0.72
Al	21	Sr	1.79
Fe	6.56	Cs	0.38
K	5.05		

4. Conclusion

This study was to treat radioactive concrete to achieve a volume reduction by using a mechanical and chemical process. In the case of concrete, heat treatment first weakened the bond between the cement and aggregate but could not completely remove the contaminants. The chemical process, by using an acidic solution, removed the residual Ca along with the remaining contaminants. Therefore, a huge volume reduction could be achieved by applying a mechanical and chemical process sequentially.

5.Acknowledgement

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