

Chemical Decontamination of Concrete Waste Generated from NPP Decommissioning

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1. Introduction

Concrete is the main building material of nuclear power plant (NPP) and other nuclear facilities. It is the most common radioactive waste in the decommissioning of NPP along with metal wastes which account for more than 70 % of total solid wastes [1, 2].

Given that the NPP decommissioning in Korea in the future could result in a huge amount of radioactive concrete waste, the optimal treatment for decontaminating concrete waste is required in advance and an efficient development of concrete decontamination technology is necessary.

2. Materials and Methods

2.1. Simulated Concrete Preparation

Concrete samples were prepared using Portland cement with sand, aggregates, deionized water, and fly ash at the ratio of 0.21, 0.37, 0.24, 0.13, and 0.05 in the batch. After mixing period, the slurry was poured into a mold (5cm diameter and 10 cm height) and cured in the desiccator for 28 days. To make concrete samples contaminated by cobalt nitrate hexahydrate and cesium nitrate, 0.4 mL (10 ppm) of individual solution was spiked at a depth of 0.7 cm from the surface using a syringe before curing.

Then concrete samples were conducted for thermal deterioration at 550°C and 650°C for 1 hour in the furnace [3]. After thermal treatment, concrete samples were crushed by hammer to separate cement paste from the aggregates in the concrete. In the decontamination experiment, the crushed concrete samples less than 1 mm in diameter were used.

2.2. Chemical Decontamination

Chemical decontamination experiments were conducted for concrete samples treated at different temperatures (550°C and 650°C) using a solid to solution ratio of 500 g L⁻¹ with several different chemical decontamination agents. To find an optimal decontamination agents and the best decontamination efficiency, cobalt-contaminated concrete samples were tested using 5 M HNO₃, 5 M HCl, 5 M H₂SO₄, 1 M C₂H₂O₄, and 0.1 M EDTA, while 5 M HNO₃, 5 M HCl, 5 M H₂SO₄, or 0.3M (NH₄)₂C₂O₄·2H₂O was used for cesium-contaminated concrete samples under different reaction times (4, 12, and 24 hours).

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

3. Results and Discussions



Fig. 1. Prepared concrete sample spiked by Co or Cs (Top) and separation of concrete pastes from aggregates (Bottom)

Fig. 2 and Fig. 3 showed the results of chemical decontamination efficiency for different decontamination agents used.

In the cobalt decontamination test results (Fig. 2), inorganic acid showed higher decontamination efficiency than organic acid. The highest decontamination efficiency was found for the concrete sample treated at 550°C and decontaminated by 5 M HCl. In the cesium decontamination test results (Fig. 3), both 550°C and 650°C thermally treated concrete samples showed near 100 % decontamination efficiency when sulfuric acid (5M) was used. Strong acids are useful to produce hydrogen ions and attack the oxides of contaminants (Co and Cs) for breaking up the oxide structure. However, more careful process should be conducted to handle these strong acids.

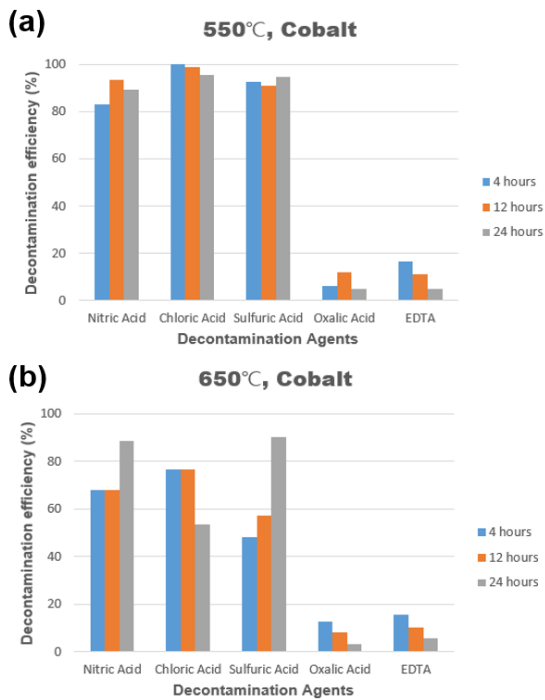


Fig. 2. Cobalt decontamination efficiency under the different decontamination agents and reaction times for the thermal treated concrete samples at different temperatures (a) 550°C and (b) 650°C.

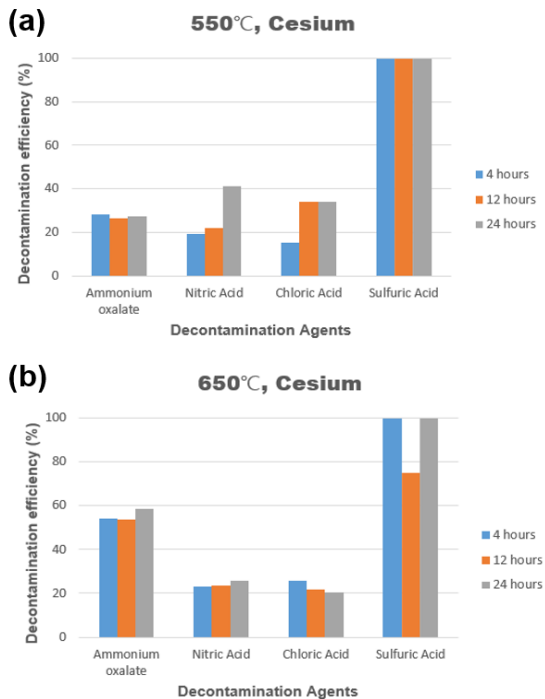


Fig. 3. Cesium decontamination efficiency under the different decontamination agents and reaction times for the thermal treated concrete samples at different temperatures (a) 550°C and (b) 650°C.

4. Conclusion

This study investigated to find the optimum chemical decontamination conditions using contaminated concrete samples by cobalt and cesium. The cobalt-contaminated concrete showed good decontamination efficiency in inorganic acids, especially when 5 M HCl was used. The cesium-contaminated concrete showed good decontamination efficiency by 5 M H₂SO₄. Based on these results, both thermal treatment and chemical decontamination process can reduce the volume of concrete wastes from NPP decommissioning.

5. Acknowledgement

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