Thermal treatment for radioactive HEPA filter media generated from nuclear facilities

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1. Introduction

Many radioactive HEPA filter wastes are generated from the high radioactive facilities in operation, improvement and repair, and under decommissioning. Spent filter wastes of about 1,500 drums have been stored in the waste storage facility of the Korea Atomic Energy Research Institute (KAERI) since its operation. In the future, a lot of HEPA filters in high radioactivity will be occurred from pyroprocessing which is treatment facility for used nuclear fuel [1-3]. Therefore, the technology development for the radioactive HEPA filter treatment is necessary for effective management and safe disposal for HEPA filter wastes.

The thermal treatment has been known as one of the most effective technologies for volume reduction and recycling of metallic radioactive wastes [4,5]. In this study, the thermal treatment for radioactive HEPA filter media was conducted for the volume reduction. The volatility and leachability for heavy metals and radionuclides in radioactive HEPA filter media were analyzed to investigate the volatilization during thermal treatment and stability after thermal treatment for safe disposal, respectively. The knowledge gained from this study will aid in the development of thermal treatment for HEPA filter media.

2. Materials and methods

2.1 Volatility tests of radioactive HEPA filter media for heavy metals and radionuclides

Radioactive HEPA filter media from the IMEF facility in KAERI were sampled. The graphite crucible was filled with HEPA filter media. The samples were heated in a muffle furnace at 900°C for 2 h. The thermal treatment was conducted to investigate the volatility of heavy metals (Zn, Pb, Sr, and Cr) and radionuclides (Cs-137 and Co-60) in HEPA filter media. Samples obtained before and after thermal treatment were digested by acid mixture and were analyzed by ICP-OES and AAS for heavy metals. For the radioactivity analysis, radioactive HEPA filter media were cut into pieces and were added to 20 mL MCA bottles.

2.2 Leachability tests of radioactive HEPA filter media for heavy metals and radionuclides

The leachability of individual components was evaluated according to the PCT leaching method, and the leachant was analyzed by ICP-OES and AAS to determine the glass composition (Si, B, Li, and Na), heavy metal content (Zn, Pb, Sr, and Cr), and radionuclide concentration (Cs and Co).

3. Results and discussion

3.1 Volume reduction and volatility test for radioactive HEPA filter media

The proposed thermal treatment was conducted on radioactive HEPA filter media for 2 hours at 900°C. This result indicated that the volume of HEPA filter media decreased significantly due to the thermal treatment (Fig. 1). In addition, thermally treated HEPA filter media were transformed into glassy bulk material, and a stable solid form was obtained (Fig. 1).

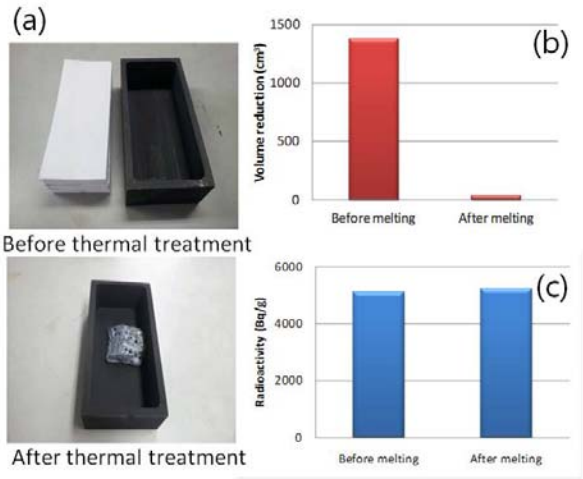

Fig. 1. (a) Radioactive HEPA filter media (b) volume ratio and (c) volatility of Cs before and after thermal treatment for 2 h at 900°C.

Volatility tests were performed for heavy metals and radionuclides in radioactive HEPA filter media to evaluate volatilization during the thermal treatment. In the MCA analysis, the Cs-137 was not volatilized (Fig. 1). The radioactivity of initial Co-60 was relatively low. With respect to the volatility of heavy metals, the results indicated that Zn, Sr, Cr, and Pb did not volatilize during the treatment (Fig. 2).

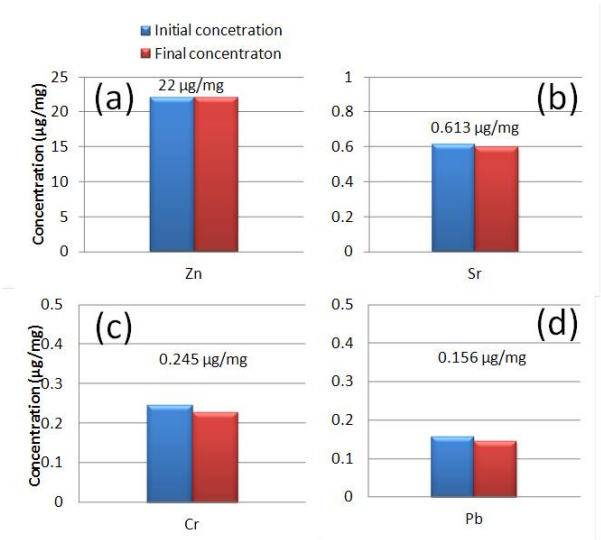

Fig. 2. Concentration of (a) Zn, (b) Sr, (c) Cr, and (d) Pb in radioactive HEPA filter media before and after thermal treatment. Experimental conditions – 900°C for 2 hours.

3.2 Leachability tests of radioactive HEPA filter media

PCT tests of heavy metals and radionuclides in radioactive HEPA filter media were conducted to evaluate the stability of the material after thermal treatment. Table 1 shows the results of PCT leachability tests performed on thermally treated samples. The leach rates of Li, Cs, Pb, Cr, and Co were not detected (Table 2).

Table. 1 Comparison of leaching rate for standard vitrified glass by PCT-7 (g/m^2)

	PNL HLW glass	ANL CWF glass	PNL Standard glass	SRL-EA glass	HEPA filter media
B	0.260	0.060	1.694	8.36	0.301
Li	0.333	0.462	1.344	4.8	ND
Na	0.256	0.126	1.246	6.67	0.095
Si	0.154	0.082	0.399	1.96	0.045
Cs	-	0.063	0.091	-	ND
Sr	-	0.030	-	-	0.061

Table. 2 Comparison of leaching rate for standard vitrified glass by PCT-7 (g/m^2)

	Zn	Pb	Cr	Co
elements	0.00281	ND	ND	ND

In this study, the leach rate of B, Li, Na and Si was lower than that of the other glasses. The leach rate of heavy metals and radionuclides in HEPA filter media was similar compared to the other PCT results, indicating that the heavy metals and radionuclides remained in a stable form after the reaction with the HEPA filter media and thermal treatment.

4. Conclusions

The volume of thermally treated HEPA filter media was significantly reduced, and the filter media was transformed into glassy bulk material. The main heavy metals and radionuclides in radioactive HEPA filter media were not volatilized. The leachability test results showed that the heavy metals and radionuclides remained in a stable form because the radionuclides and heavy metals reacted with HEPA filter media and were transformed into crystalline phase.

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