A Method for Cobalt and Cesium Leaching from Glass Fiber in HEPA Filter

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1. Introduction

A great amount of radioactive waste has been generated during the operation of nuclear facilities. Recently, the storage space of a radioactive waste storage facility in the Korea Atomic Energy Research Institute (KAERI) was almost saturated with many radioactive wastes. So, the present is a point of time that a volume reduction of the wastes in a radioactive waste storage facility needs. There are spent HEPA filter wastes of about 2,226 sets in the radioactive waste storage facility in KAERI. All these spent filter wastes have been stored in accordance with their original form without any treatment. Up to now a compression treatment of these spent HEPA filters has been carried out to repack the compressed spent HEPA filters into a 200 liter drum for their volume reduction. Frame and separator are contaminated with a low concentration of nuclide, while the glass fiber is contaminated with a high concentration of nuclide. So, for the disposal of the glass filter to the environment, the glass fiber should be leached to lower its radioactive concentration first and then must be stabilized by solidification and so on. Therefore, it is necessary to develop a leaching process of glass fiber in a HEPA filter. Leaching is a separation technology, which is often used to remove a metal or a nuclide from a solid mixture with the help of a liquid solvent.

2. Methods and Results

In this section some of the techniques used to model the detector channel are described. The channel model includes a SiC detector, cable, preamplifier, amplifier, and discriminator models. In order to reduce the radioactive concentration of glass filter, the leaching experiments by the four methods were carried out as follows. The removal efficiencies of nuclides from glass fiber were measured. Finally, an optimum method for glass fiber leaching was selected through analysis of leaching experiment results.

In this experiment, 2.32 g of glass fibers in a glass column was leached with 150ml of 4.0 M HNO_3-0.1M Ce(IV) solution at a flow rate of 0.6 L/hr, which was mainly contaminated with ^{60}Co, ^{134}Cs, and ^{137}Cs. The liquor was recirculated to the packed column after filtration and passage through the anode compartment of an electrolytic cell to regenerate the Ce(IV). All the materials of construction exposed to the Ce(IV) solution were either glass, polyethylene, or teflon. 4.0 M HNO_3-0.1M Ce(IV) solution was heated to 100°C using a hot plate. The original radioactive concentrations of nuclides in the contaminated glass fibers were measured by Multi-Channel Analyzer (MCA). During electrochemical experiment, 5ml of 4.0 M HNO_3-0.1M Ce(IV) solution was sampled per 1hr, 2hr, 3hr, and 5hr. The 4.0 M HNO_3-0.1M Ce(IV) solution after electrochemical leaching for 5hr was filtered. The glass fibers remaining on the filter cloth were dried and the radioactive concentrations of nuclides in glass fibers were measured by MCA for analysis of their removal efficiencies from glass fibers.

2.1 Electrochemical leaching by 4.0 M HNO_3-0.1M Ce(IV) solution

Results of repetition electrochemical leaching by 4.0 M HNO_3-0.1M Ce(IV) solution were shown in Fig. 1. Initial concentration of ^{60}Co was 65.5 Bq/g. The removal efficiency of ^{60}Co from glass fiber after leaching by 4.0 M HNO_3-0.1M Ce(IV) solution for 1 hour was 93.8%. That of ^{60}Co after leaching for more than 2 hours maintained a constant value, namely, 93.8%. On the other hand, the removal efficiencies of ^{134}Cs and ^{137}Cs increased with the time lapse. Initial concentrations of ^{134}Cs and ^{137}Cs were 41.9 Bq/g and 495.4 Bq/g. Finally, the removal efficiencies of ^{134}Cs and ^{137}Cs from glass fiber after leaching for 1 hour were 43.2% and 46.0%. Those of ^{134}Cs and ^{137}Cs after leaching for 2 hours were 72.2% and 68.4%. Those of ^{134}Cs and ^{137}Cs after leaching for 3 hours were 85.8% and 81.8%. Those of ^{134}Cs and ^{137}Cs after leaching for 5 hours were 96.4% and 93.6%.

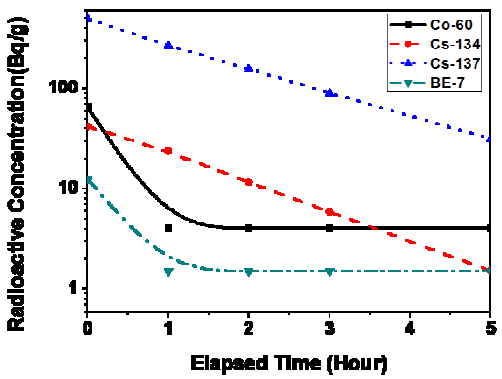

Fig.1. Radioactive concentration during leaching by 4.0 M HNO_3-0.1M Ce(IV) solution

2.2 Repeat chemical leaching by 4.0 M HNO_3 solution

Results of repeat chemical leaching by 4.0 M HNO_3 solution were shown in Fig. 2. Initial concentration of ^{60}Co was 128.4 Bq/g. The removal efficiency of ^{60}Co from glass fiber after leaching by 4.0 M HNO_3 solution for 1 hour was 81.3%. That of ^{60}Co after leaching by one repetition was 98.4%. That of ^{60}Co after leaching by two repetitions was 99.2%. That of ^{60}Co after leaching by three repetitions was 99.9%. Also, initial concentration of ^{134}Cs and ^{137}Cs were 34.3 Bq/g and 1015.3 Bq/g. The removal efficiencies of ^{134}Cs and ^{137}Cs from glass fiber after leaching for 0.5 hour were 92.7% and 96.2%. Those of ^{134}Cs and ^{137}Cs after leaching by a repetition were 95.3% and 99.1%. Those of ^{134}Cs and ^{137}Cs after leaching by two repetitions were 99.8% and 99.8%. Those of ^{134}Cs and ^{137}Cs after leaching by three repetitions were 100% and 99.9%. Finally, the residual radioactive concentrations of ^{60}Co, ^{134}Cs, ^{137}Cs, and ^{109}CD in glass after leaching for 4 hours by three repetitions were 0.1 Bq/g, 0.0 Bq/g, 0.1 Bq/g, and 0.0 Bq/g, which were below radioactive clearance concentration level for self disposal of HEPA glass fiber.

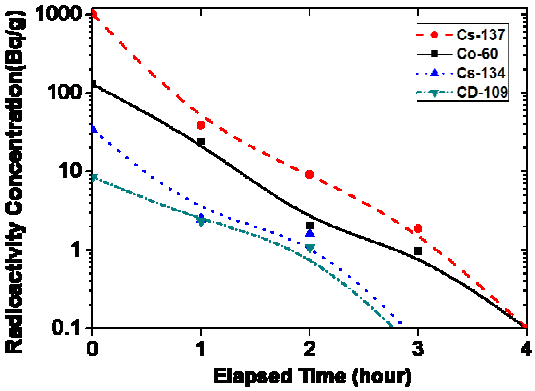

Fig. 2. Radioactive concentration during repetition leaching by 4.0 M HNO_3 solution

3. Conclusions

Results of electrochemical leaching of HEPA glass fiber by 4.0 M HNO_3-0.1M Ce(IV) solution showed that the removal efficiency of ^{134}Cs, ^{137}Cs, and ^{60}Cs from glass fiber after 5 hours was 96.4%, 93.6%, and 93.8%, respectively. Also, results of repeat chemical leaching of glass fiber by 4.0 M HNO_3 solution showed that the removal efficiencies of ^{134}Cs, ^{137}Cs, and ^{60}Cs after 4 hours of three repetitions were 99.9%, 100%, and 99.9%, respectively, and their radioactivities were below 0.1 Bq/g. Consequently, the repeat chemical leaching method by 4.0 M HNO_3 solution was considered as an optimum one for the removal of cesium and cobalt from HEPA glass fiber for self disposal.

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