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A Study on the Characterization of Polymer Waste Form Incorporated Cs-contaminated Soil Pellet Generating After Soil Washing

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1. Introduction

An accident in a nuclear power plant and its decommissioning process can cause heavy contamination of a large area of land due to release of a huge amount of radioactive materials. In such cases, the soil needs to be decontaminated as soon as possible and the site should be restored. To this end, a soil washing method featuring a fast decontamination process, and a phyllite-based flocculating agent to increase the efficiency of decontamination had been employed [1]. Following this washing process, micro soil contamination in sludge state is generated as a secondary waste, and this is not easy to decontaminate. In this study has characterized this secondary waste so that proper disposal methods can be performed. Therefore, the soil with micro contamination in the sludge state was powdered and pelletized using a roll compaction technology. Subsequently, the polymer waste forms were fabricated by incorporating the pellets, and the characteristics of the waste forms were tested to confirm if they meet the Waste Acceptance Criteria(WAC) of the domestic nuclear material disposal sites.

2. Experiments

2.1 Materials

2.1.1 Contaminated soil

The soil sample used in the current study was collected from a site near a nuclear power plant. The collected soil was dried at room temperature, and size distribution of the soil was analyzed using a vibrating sieve (Daewha Tech, Analysette 3 pro). The reason of used soil particles smaller than 38 μm were used to analyze the radioactive Cs which strongly adsorbs to micro soil particles when exposed to the nature. A flocculating agent (J-AF, Jeon Tech. Co., Ltd) was added to the soil sample in the ratio 10:1, and the sample was further mixed with a 0.1 mmol/L Cs solution with stirring. Next, the sample was dried in a heated drier (Jongro Industrial Co., Ltd., VTEC 75) for 48 hours, pulverized, and powdered. The moisture content was controlled at 7% to make pelletizing easy.

2.1.2 Polymer

The epoxy used in this experiment was purchased from Kukdo Chemical. Moreover, main resin (YD-128), hardener (G-1034), and diluent (LGE) were also used. Due to high viscosity of YD-128 and G-1034, mixing it with the pellets is not easy. Hence, LGE was added to control the viscosity. The ratio of resin to hardener, i.e. (YD-128 : G-1034) was 65 : 35 phr as recommended by the company. The LGE was added as much as 10 wt. % of YD-128 used.

2.2 Polymer waste form

The pellets were fabricated via roll compaction technology under optimum operating conditions, and polymer waste forms were produced by incorporating the pellets into the polymer mix [2]. The amount of pellet was limited to an average of 60 wt.% of the polymer waste. The waste forms were solidified in an oven maintained at 60 ℃ after injecting the polymer. The waste form was removed from the cylindrical mold, and the top surface of the waste form was made parallel to the bottom surface and polished so that the pellets are not exposed.

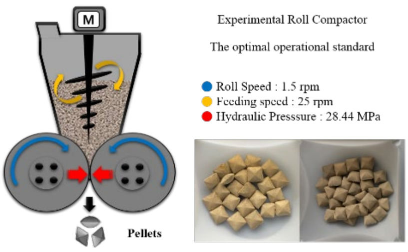

Fig. 1. Manufacturing the pellets using roll compactor.

2.3 Characterization

2.3.1 Compressive strength test

To confirm the structural integrity of the polymer waste forms, a compressive strength test was conducted following KS-F 2405, a standard test for polymer waste forms mentioned in the acceptance standard sheet of domestic nuclear waste disposal sites. Figure 2 shows the photographs of the waste forms before and after the compressive strength test. The compressive strength of the waste form was 29.30-31.20 MPa.

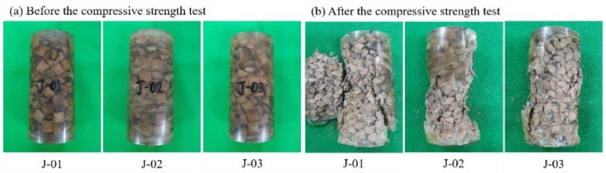

Fig. 2. Images of polymer waste form.
(a) Before and (b) after compressive strength test.

2.3.2 Thermal cycling test

To confirm the heat resistance of the waste forms, a thermal cycling test was conducted. The test was carried out according to ASTM B553 which is specified in the acceptance standard sheet of domestic nuclear waste disposal sites. Figure 3 shows the photographs of the waste form after the thermal cycling and compressive strength tests. The compressive strength of the waste form was 27.00-28.85 MPa.

Fig. 3. Images of polymer waste form.
(a) After thermal cycling test, (b) Compressive strength test after thermal cycling test.

2.3.3 Irradiation test

Generally, an irradiation test is carried out by considering the total accumulated absorption after the waste forms are disposed of permanently. In the present study, the irradiation test was conducted based on the stipulation of the NRC. Figure 4 shows the photographs of the waste form after the irradiation and compressive strength tests. The compressive strength of the waste form was found to be 23.10-29.30 MPa.

Fig. 4. Images of polymer waste form.
(a) After irradiation test, (b) Compressive strength test after irradiation test.

2.3.4 Immersion test

Finally, to confirm the water resistance of the polymer waste forms, immersion test was conducted. Due to the lack of a standard test for water resistance, NRC recommended to conduct the test in association with ANS 16.1, as immersion standard test. Figure 5 shows the photographs of the waste forms after the immersion and compressive strength tests. The compressive strength of the waste form was observed as 28.40-31.90 MPa.

Fig. 5. Images of polymer waste form.
(a) After immersion test, (b) Compressive strength test after immersion test.

3. Conclusions

A study was conducted to treat/dispose the secondary waste generated after soil washing with a view to decontaminating the contaminated soil waste from a large area.

The contaminated soil powder was pelletized via roll compaction technology under optimized conditions, followed by mixing the pellets with polymer mix to form the polymer waste forms. Tests were conducted to evaluate the characteristics of the waste forms and confirm whether they meet the waste acceptance criteria of domestic nuclear waste disposal sites. All the compressive strength values after each characteristic test were above 3.44 MPa. Therefore, the evaluation results showed that all the specimens fabricated in this study satisfied WAC and confirmed their structural integrity.

ACKNOWLEDGEMENT

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