Efficiency of Decontamination Foam With Silica Nanoparticles and Chemical Reagent for Radionuclide Contaminated Surface

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1. Introduction

A large amount of liquid waste is generated from the decontamination that occurs when dismantling nuclear facilities. A process is needed to decrease the amounts of chemical reagents and secondary waste produced during the decontamination process. Decontamination foam is a non-stable, two-phase fluid with aqueous and gas phases representing not more than 10% and 90% of the total volume, respectively. This formulation can significantly decrease the amounts of chemical reagents and secondary waste [1].

The advantage of decontamination foam is its potentially wide application for metallic walls, overhead surfaces, and the elements of complex components and facilities. In addition, foam is a good material for in situ decontamination because it generates low final waste volumes owing to its volume expansion. The application of foam allows for remote decontamination processing using only an injection nozzle and the equipment to generate the decontamination foam, which reduces operator exposure to high radioactivity [2,3].

The decontamination efficiency can be enhanced by improving the contact time between chemical reagents and a contaminated surface through the addition of surfactants and silica nanoparticles into the decontamination foam. In this study, various chemical reagent such as nitric acid and cerium(IV) were added in decontamination foam to decontaminate the corroded specimens contaminated with the radionuclide, Co-60 and Cs-137. We intend to discuss the effect of chemical reagent for the foam stability and decontamination efficiency to develop a new formulation of decontamination foam.

2. Materials and Methods

2.1 Stability test for the decontamination foam

Elotant™ Milcoside 100 (EM 100) is a decyl glucoside (non-ionic surfactant) supplied by LG Household & Health Care in Korea and Zonyl TBS is an anionic sulfonate fluorinated surfactant, purchased from DuPont Company and used without any further purification. Silica nanoparticles (M-5, Cabosil) were selected for testing as stabilizer.

In all tests on the foam stability and structure, the foam height and liquid volume in the foam were measured using a Dynamic Foam Analyzer (DFA-100, KRŰSS, Germany). During foaming, compressed air was passed through a sintered glass frit at the bottom of a cylindrical glass vessel (40 mm inner diameter) containing the solutions and the decontamination foam. The initial liquid volume was 60 ml; the gas flow was 0.2 l/min, and was stopped after 60 s of foaming.

2.2 Dissolution test using decontamination foam

Decontamination foams were prepared using 70 ml of 2 M HNO_3 or cerium(IV) in a 1.0% v/v EM100 surfactant solution containing 1 g silica NPs. Approximately 350 ml of each decontamination foam formulation was generated from a 70 ml solution by injecting nitrogen gas in a 350 ml glass column, with a gas to liquid ratio of 4:1. Various chemical reagent such as nitric acid and cerium(IV) were added with surfactant and silica nanoparticles to decontaminate the corroded specimens contaminated with the radionuclide, Co-60 and Cs-137. The corroded samples were placed in the middle of the glass column and left to react with the decontamination foam for 3 h at room temperature. The radioactive specimens were analyzed both before and after the decontamination tests using a multi-channel-analysis (MCA) device, and a high-purity Ge detector was used to evaluate the radioactivity of the radionuclides.

Table. 1. Composition of decontamination foam and chemical reagents.

	Foam formulation	Chemical reagent
1	1%(v/v) TBS + 1wt.% M-5	2M HNO_3 + 0.5M Ce(IV)
2	1%(v/v) EM100 + 1wt.% M-5	2M HNO_3 + 0.5M Ce(IV)

3. Results and Discussion

3.1 Stability test for the decontamination foam

Figure 1 shows the foam performance index (FPI) as the foam stability had a higher value with TBS surfactant than that with EM100 surfactant, indicating that a TBS surfactant is more suitable for cerium(IV) chemical reagents. Foam stability had a higher value with silica nanoparticles and surfactant (TBS or EM100) in the absence of cerium(IV) than that with silica nanoparticles and surfactant in the presence of cerium(IV), indicating that a cerium(IV) is to reduce the foam stability due to the oxidant reagent for the surfactant.

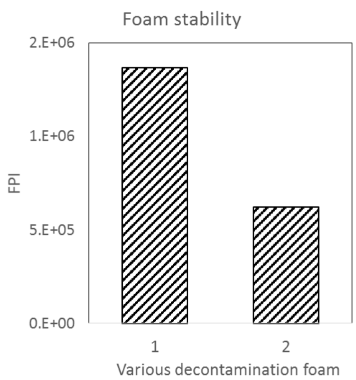

Fig. 1. Foam performances index (FPI) of decontamination foam with 1 wt.% silica nanoparticles and chemical reagent [2 M HNO_3 and 0.5 M Ce(IV)] in 1%(v/v) EM100 or TBS surfactant for 3 hrs.

3.2 Dissolution test using decontamination foam

The decontamination performances of the foams synthesized for this study were investigated in corroded specimens contaminated with the radionuclide, Co-60 and Cs-137. The radioactivity of Co-60 in the specimens was measured both before and after the decontamination test. These results indicated that the decontamination foam of TBS surfactant had a much greater decontamination efficiency for Co-60 than that with EM 100 surfactant. These results indicate that TBS surfactant with silica nanoparticles have a significant effect on the decontamination efficiency when combined with a chemical reagent and silica nanoparticles due to the foam stability and drainage prevention of drainage. Faure's study [4,5] indicates that the rate of oxide dissolution is directly proportional to the foam stability.

4. Conclusions

TBS surfactant with silica nanoparticles are an effective decontamination foam for chemical reagents such as HNO_3 and cerium(IV), resulting in a foam stable against collapse.

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