

Removal of Corrosion Oxide Film Using Acidic and Reductive Decontamination Foams

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1. Introduction

Foam decontamination process has a potentially wide application in the removal of contaminants from large components with complex shapes or large area or large volumes. This process can be applied to any direction regardless of walls, floors and ceilings, and basically it has the advantage of generating less secondary wastes [1]. It is also easy to perform remote decontamination using injection or spray nozzles and equipment to generate the foam. However, foam decontamination has a disadvantage of relatively low decontamination factor (DF) [2]. In order to overcome this problem, it is suggested to introduce a decontamination foam containing an aggressive chemical agent and to increase the stability of the foam to increase the contact time between the decontamination foam and the contaminated surface [3].

In this study, the removal performance of nickel ferrite (NiFe_2O_4) film coated on the surface of stainless steel 304 was investigated as one of the models of fixed contamination using acid and reductive decontamination foams with various kinds of added chemicals and acidity of complex fluid.

2. Materials and Methods

2.1 Preparation of Decontamination Foam

The decontamination foams used in this study were prepared by combining surfactants, silica nanoparticles, inorganic acids such as HNO_3 , H_2SO_4 and HF, and reductive chemical reagent, HyBRID developed for primary cooling system of NPP [5, 6].

In order to evaluate the removal performance of the oxide film, two kinds of decontamination foams such as acidic foam (AF) and reductive foam (RF), were prepared and summarized in Table 1.

2.2 Performance Test with Decontamination Foam

The oxide removal performance tests were carried out by applying various decontamination foams as shown in Table 1 to the simulated specimens coated with nickel ferrite as a model fixed corrosion oxide film.

Table 1. Composition of Various Decontamination Foams

Foam Type	Chemical Composition
AF-1	1wt% EM100 ¹⁾ + 1wt% M-5 ²⁾ + 2M HNO_3 (pH \approx 0.7)
AF-2	1wt% EM100 + 0.5M HF + H_2SO_4 (pH=3)
AF-3	1wt% EM100 + 0.5M HF + 0.5M HNO_3 (pH \approx 1.2)
RF-1	1wt% EM100 + HyBRID ³⁾ (pH=3)
RF-2	1wt% EM100 + HyBRID + 0.2M HF (pH=3)
RF-3	1wt% EM100 + HyBRID + 0.5M HF (pH=3)

1) Nonionic surfactant, ELOTANT Milcoside 100, C08-10 alkyl polyglucoside

2) CAB-O-SIL[®] M-5 Fumed Silica Nanoparticle

3) 50 mM N_2H_4 + 0.5 mM Cu^{2+} (pH 3 adjusted by H_2SO_4)

The nickel ferrite coated specimens having a thickness of 500 nm were prepared by the E-beam evaporator system using the oxide target with the same composition at a deposition rate of 0.7 Å/s under the condition that the degree of vacuum was maintained at 3×10^{-6} torr and then annealed at 600°C in an argon atmosphere.

The oxide removal performance test was carried out in an experimental apparatus consisting of a decontamination foam generator and a foam filling column. After the simulated specimens coated with nickel ferrite were placed in the foam filling column followed by filling with the decontamination foam through the foam generator. As the drainage is continuously generated from the liquid film of the filled foams, the volume of the solution discharged to the lower end of the foam filling column is increased. Therefore, the solution accumulated at the lower end of the filling column at intervals of 20 minutes is recirculated to the foam solution make-up tank. A new decontamination foam prepared via a foam generator was fed to the bottom of the foam filling column. As a result, the dry foam at the top of the filling column is pushed out and filled with new foam. This is called cyclic foam filling process. The oxide removal performance was improved by keeping the physicochemical properties of the decontamination foam substantially constant by

applying cyclic foam filling process.

The oxide removal performance of the oxide coated specimens was evaluated by measuring weight loss before and after decontamination.

3. Results and Discussion

For the removal of nickel ferrite film coated on the stainless steel specimen at 500 nm thickness using acidic decontamination foam, the oxide film was completely dissolved within 2 hours by strong acidic decontamination foam, AF-3 mixed with 2 M nitric acid and 0.5 M hydrofluoric acid. On the other hand, only *ca.* 3% of the oxide film was dissolved during the same time period by strong acidic decontamination foam, AF-1 containing only 2 M nitric acid.

Under the milder conditions of acidic and reductive decontamination foam, the nickel ferrite film hardly dissolved in the reductive decontamination foam, RF-1, containing only HyBRID reagent. On the contrary, the oxide film completely dissolved within 3 hours not only in the acidic decontamination foam, AF-2, containing 0.5 M HF with pH 3 adjusted by sulfuric acid but also in the reductive decontamination foam, RF-3, composed of a mixture of 0.5 M HF and HyBRID reagent as shown in Fig. 1.

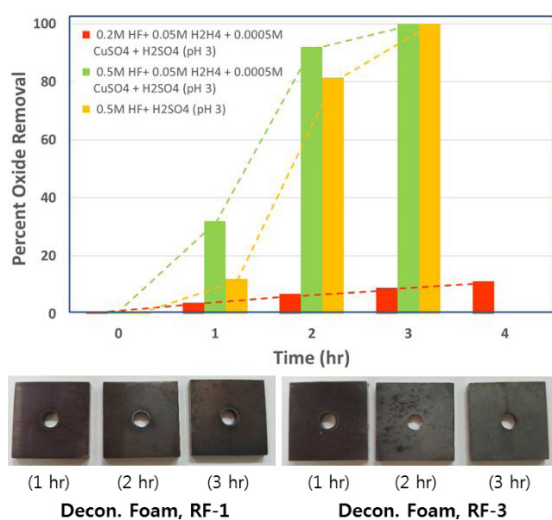


Fig. 1. Comparison of the Removal Performance of Nickel Ferrite Coating Specimens in the Mild Acidic and the Reductive Decontamination Foams.

The difference between the decontamination foams AF-2 and RF-3 lies in the presence or absence of HyBRID reagent. The reductive decontamination foam RF-3, which contains HyBRID reagent, has a much higher initial dissolution rate of oxide film than

the acidic decontamination foam, AF-2.

4. Conclusion

In the dissolution removal of the nickel ferrite oxide film by the decontamination foams, the performances of the mild acidic decontamination foam and the reducing decontamination foam were confirmed. Through this, it was confirmed that it is possible to secure the easiness of decontamination by replacing the existing strong acidic decontamination foam, and at the same time, it is also beneficial from the viewpoint of secondary waste treatment.

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