

A Study on the Post-Treatment Process of Decontamination Waste of Nuclear Power Plant System

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1. Introduction

Decontamination of the radiologically contaminated system is essential for dismantling or maintenance of nuclear power plants to least the radiological exposure of workers. Chemical decontamination is mainly carried out to dissolve the metal oxide film containing a radionuclide formed inner side of the nuclear power plant system. In the dissolution of metal oxide, it combines typically oxidation and reduction to deal with the dissolution of Cr-rich and Fe-rich oxide respectively.

In HyBRID process, different from the other processes found in many applications using organic acid, only contains inorganic chemicals, which enables the secondary waste to be treated with precipitation process minimizing ion-exchange resin [1]. After decontamination of HyBRID process turns to second stage of process which treats decontamination solutions to be precipitated by the addition of $\text{Ba}(\text{OH})_2$. Any metal ions including radionuclides except potassium ions are removed by this process and the decomposition of N_2H_4 follows by the addition of H_2O_2 .

In this study, the removal characteristics of metal and sulfate ions in the simulated post-decontamination solution and the decomposition characteristics of N_2H_4 were evaluated through the precipitation process with $\text{Ba}(\text{OH})_2$ addition and it will be utilized in the design and development of post-treatment process.

2. Preparation of simulated post-decontamination solution

The simulated decontamination wastewaters to be used in decomposition and precipitation were prepared. The detailed composition is shown in Table 1.

Table 1. Chemical components and concentration of post-decontamination solution

	Components	Concentration [ppm]
SP-HyBRID decontamination agents	KMnO_4	1,000
	H_2SO_4	3,630
	N_2H_4	1,856
	CuSO_4	80
Metal ions	Fe, Cr, Ni, Cu, Zn, Co	50-200 (respectively)

3. Removal and decomposition of contaminants in simulated waste solution

The removal of metal and sulfate ions was carried out by the precipitation of $\text{M}^{++}(\text{OH})_x$ and BaSO_4 with the addition of $\text{Ba}(\text{OH})_2$. Before the experiment, $\text{Ba}(\text{OH})_2$ solution was prepared by dissolving its powder in 80 ml of distilled water by heating at 80°C in consideration of the property that $\text{Ba}(\text{OH})_2$ does not dissolve homogeneously in water at room temperature. The concentration of added $\text{Ba}(\text{OH})_2$ was determined at the level of 0.98 of the those of sulfate ion and it was mixed at the rate of 500 rpm.

The N_2H_4 decomposition experiment was performed to compare the residual concentration by H_2O_2 injection while adjusting the pH from 3 to 12 using $\text{Ba}(\text{OH})_2$ considering the characteristics of

N₂H₄, respectively. At this time, the stirring speed was changed to 100-500 rpm, and the influence of the stirring speed was also evaluated. The concentration of N₂H₄ and sulfate remaining in the solution after the precipitation and decomposition was analyzed by UV spectroscopy and metal ions after precipitation was measured by the ICP-OES.

4. Results and discussion

The metal and sulfate ions in the simulated decontamination waste solution by Ba(OH)₂ addition were effectively removed. Especially, it was confirmed that the metal ions can be removed to the satisfactory level of drinking water quality standards even if the concentration of each metal ion increases from 50 to 200 ppm (Table 2).

Table 2. Concentration of reagents after precipitation process

Analyzer	Items	Concentration of metal ions (ppm)				Detection limit (ppm)	Drinking water standards (ppm)
		50	100	150	200		
UV-VIS spectroscopy	SO ₄	ND	1	1	8	2	200
	K	165	147	165	178	0.0079	12
	Mn	ND	ND	ND	ND	0.0003	0.05
	Fe	ND	ND	ND	ND	0.01	0.3
ICP-OES	Cr	ND	ND	ND	ND	0.04	0.05
	Ni	ND	ND	ND	ND	0.0037	0.01
	Cu	0.75	0.1175	0.0683	0.0784	0.0072	1.0
	Zn	0.01	0.0406	0.0057	0.0055	0.0015	3.0
	Co	ND	ND	ND	ND	0.0032	-
ICP-MS	Co	6×10 ⁴	-	-	-	1.7×10 ⁻⁶	-

The decomposition of N₂H₄ in simulated decontamination wastewater was confirmed to be most effective at around pH 9 as shown in Fig 1. This is because N₂H₄ at pH 9 or higher keeps its composition as N₂H₄ in the solution but changed to N₂H₅⁺ at the acidic condition [2]. Since the decomposition reaction with H₂O₂ is more effective in N₂H₄ form, and therefore the decomposition rate increased at higher pH.

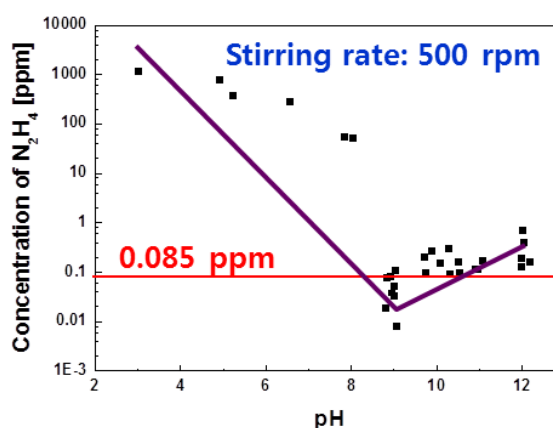


Fig. 1. Characteristics of N₂H₄ decomposition with pH change.

5. Conclusions

Removal of post-decomposition waste water of the reactor coolant system can be effectively performed by combining the precipitation process using Ba(OH)₂ and the decomposition process using N₂H₄ using H₂O₂. This process may reduce the final volume of secondary waste up to level of 30% of those generated from the process using ion exchange. The removal of all metal ions except potassium ion and sulfate salt remained in HyBRID were confirmed by precipitation and filtration. A series of scaled up experiments will be conducted in the future to elucidate the proposed combinatorial process to be reliable.

REFERENCES

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