Removal of Iodide and Iodate Using Layered Double Hydroxides (LDHs) Under Aqueous Condition

Jaehyuk Kang* and Wooyong Um

Division of Advanced Nuclear Engineering, POSTECH, 77, Cheongam-ro, Nam-gu, Pohang, Korea

*jaehyukkang@postech.ac.kr

1. Introduction

Continuous operation of nuclear power plants (NPPs) produces an amount of electric power. However, because radioactive wastes including radioiodine are also generated, the wastes should be carefully managed during NPPs operation. In particular, radioiodine species are required to be more carefully managed because of their long half-lives ($t_{1/2}$ of ^{125}I = 59.40 d and $t_{1/2}$ of ^{129}I = 1.57 x 10^7 y) [1], and toxicity which causes skin burns and thyroid cancer.

In this study, we used synthesized layered double hydroxides (LDHs) to remove iodide and iodate in aqueous condition. LDHs show high anion exchange performance and memory effect to reform their original structure by adsorbing anion after calcination. Our specific objective is to study the removal of radioiodine species in aqueous condition using synthesized LDHs and understand the removal mechanism.

2. Experimental section

2.1 Synthesis of LDHs

LDHs are synthesized using co-precipitation method. Divalent metal(II) chloride and trivalent metal(III) chloride reagents were mixed as concentration ratio of 2:1 and 4:1 in deionized water (DIW). Metal ions are Mg^{2+}, Co^{2+}, Fe^{3+}, and Cr^{3+}. The pH of mixed metal solution was kept about ~12 at room temperature. Then, it was aged at 65 °C under stirring vigorously for 12 h. The resultant suspension was separated by centrifugation. Subsequently, supernatant was decanted into empty vial to obtain only slurry, then it was washed using DIW. Finally, LDHs were dried at 110°C in oven for 12 h. To check memory effect for iodine removal, dried LDHs were calcined at 300, 500, and 700°C for 2 h before use [2].

2.2 Iodine removal test

Kinetic test to conclude removal equilibration time was conducted for 168 h. Stable iodine, ^{127}I (surrogate for radioiodine) solutions were prepared in crimp-top glass amber vials. Iodide and iodate solutions (4 mg/L and pH 4.3-5.8) were prepared and reacted with LDHs at solid to solution ratio of 1 g/L. The samples were covered by the lids and placed in a basic platform shaker (os-3000) for complete mixing at 130rpm. After kinetic test, the aqueous samples were collected at different reaction times (0, 1, 3, 6, 12, 24, 72, and 168 h) and analyzed using inductively coupled plasma mass spectroscopy (ICP-MS, NexlON 300D) to measure iodine concentrations.

3. Results

The results of iodide and iodate removal test are shown in Fig. 1. The iodide removal efficiency by MgFe_Cl_C_21 with calcination became 89.2% within 3 d, whereas MgFe_Cl_NC_21 without calcination showed 6.20% after 3 d. The iodate removal efficiency by CoCr_Cl_NC_41 without

calcination became 97.1% within 3 d, whereas CoCr_Cl_C_41 with calcination showed 17.0% within 3 d.

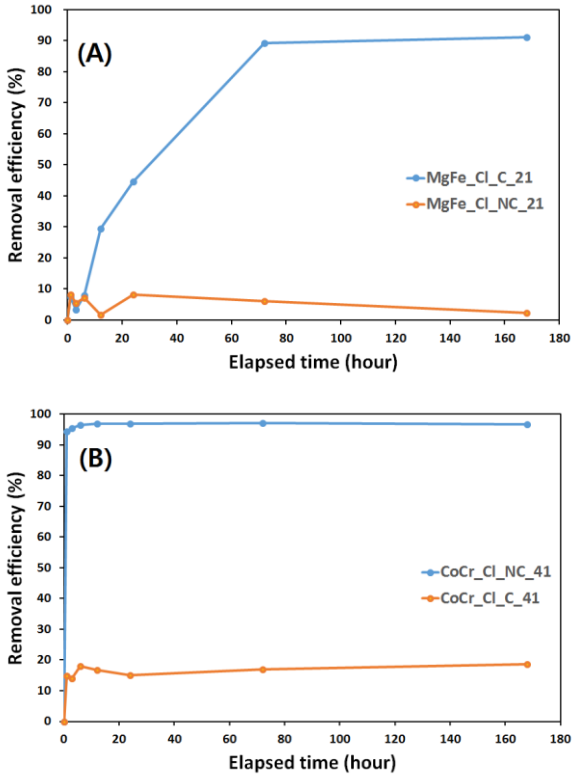

Fig. 1. Results of iodide (A) and iodate (B) removal kinetic test using synthesized LDHs.

4. Conclusions

Iodide was removed by synthesized LDHs with calcination better than synthesized LDHs without calcination. However, iodate was removed by synthesized LDHs without calcination better than synthesized LDHs with calcination. These results suggest that memory effect is important for LDHs to remove iodide, whereas anion exchange is dominant to remove iodate.

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