Adsorption and Immobilization of Cs by Aluminosilicate and Cold Sintering

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1. Introduction

This study proposes the stabilization and immobilization of simulated Cs using amorphous aluminosilicate and cold sintering. Over the time different types of waste materials are being produced by human activities and radioactive waste is considered as the most hazardous among all. In the radioactive waste generated from different activities, cesium is the most abundant radionuclide with high mobility. Water is the main source of Cs mobility into the environment[1]. A number of studies were carried out for the adsorption and immobilization of Cs and materials containing silicate or aluminosilicate phases are considered as good candidates[2].

In this study we propose the use of amorphous aluminosilicate as Cs adsorbent and the immobilization of dried as spent adsorbent through cold sintering. We propose the use of amorphous aluminosilicate as adsorbent as well as the immobilization matrix for the first time.

2. Materials and Method

2.1. Synthesis of Amorphous Aluminosilicate

Amorphous aluminosilicate was synthesized following the organic-free method described by Koike et al[3]. The synthesized aluminosilicate was X-ray amorphous with three dimensional tetrahedaral network structure. In the first step, aluminosilicate gel with Si/Al ratio of 3 was synthesized by mixing the sodium silicate solution (solution A) with the aluminum sulphate solution (solution B). Solution B was added to solution A under continuous stirring and the final pH of the solution was adjusted about 8. The synthesized aluminosilicate gel was filtered by a centrifuge and washed with deionized water. Finally, the gel was dried at 90 ºC for 24 hrs using a vacuum oven.

The amorphous aluminosilicate adsorbent was prepared by crushing the dried gel using pestle and mortar. Initial characterization of the adsorbent was done by XRD. Figure 1 shows the XRD patterns of the synthesized aluminosilicate and the amorphous nature of the adsorbent is clearly shown.

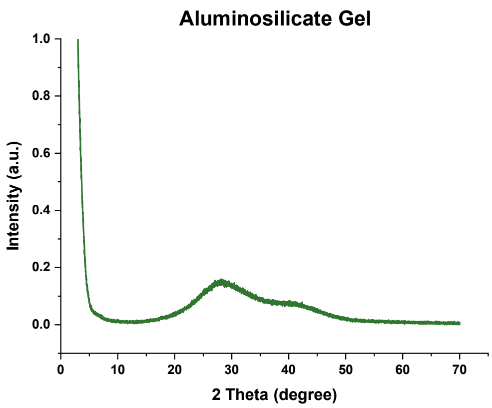

Figure 1: XRD patterns of the synthesized amorphous aluminosilicate gel.

2.2. Adsorption and Immobilization

Cs adsorption and removal test was carried out using 10 ppm Cs concentration solution in deionized water. The used adsorbent dosage was 0.2 g / 10 ml and the contact time was 24 h. The adsorption test was carried out at room temperature and the pH of the system was not regulated. The as-spent adsorbent was separated after 24 h using a centrifuge, dried at 90 °C for 24 h in a vacuum oven.

ICP-MS analysis was carried out before and after the adsorption test to measure the Cs removal and to calculate the removal efficiency of the amorphous aluminosilicate.

The immobilization of the simulated Cs-adsorbed dried aluminosilicate, for the first time, was carried out using cold sintering. Cold sintering was carried out at 200 ºC under 500 MPa uniaxial pressure for 10 min holding time[4]. The cold sintered samples were characterized for density, porosity and microhardness. SEM of the cold sintered samples was also carried out to analyze the microstructure.

3. Results and Discussion

The amorphous aluminosilicate showed very good simulated Cs removal efficiency of 85%. Cold sintering is an appropriate option for the non-volatile and efficient immobilization of radioactive waste. The cold sintered samples exhibited a very good microhardness of 3 GPa. The measured apparent density was 2.05 ×

10^3 kg/m^3 with 0.8 % open porosity. Figure 2 shows the SEM image of the fractured surface of the cold sintered sample.

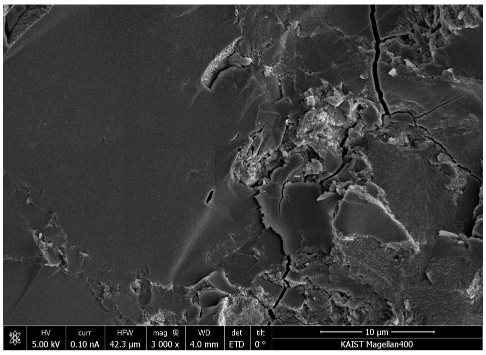

Figure 2: Fractured surface SEM image of the cold sintered amorphous aluminosilicate.

The detailed experimental work is being carried out to optimize the removal efficiency of the amorphous aluminosilicate. In this regard, the adsorption parameters including adsorbent dose, pH, contact time and temperature are being optimized. This study provides the first example of removal using amorphous aluminosilicate synthesized via non-organic route and very low temperature immobilization of dried Cs adsorbed amorphous aluminosilicate by cold sintering.

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