Trapping Characteristics of Cesium Iodide by Aluminosilicate Filters

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1. Introduction

Radioactive cesium (Cs-137), generated by nuclear fission reaction, is present as several chemical forms in spent nuclear fuels. During the pyro head-end process, spent fuels are heat-treated and cesium is released as off-gas [1]. Most species of Cs evaporated from spent fuel are known as metallic Cs (Cs(g)), cesium oxide (Cs_2O(g)), cesium hydroxide (CsOH(g)), and cesium iodide (CsI(g)) [2]. Because of negative health effects of Cs-137, gaseous Cs vaporized from spent fuel must be captured using proper sorbents. At Korea Atomic Energy Research Institute (KAERI), trapping of Cs has been studied by aluminosilicate-based filters, and it was validated that CsOH(g) could be effectively captured by Silica-Alumina (SA) filter [3]. In this contribution, trapping behavior of CsI(g) is investigated.

2. Experimental Section

Trapping experiments were performed using an electric tube furnace with multi heating zones. The SA filters were stacked at trapping zone. As a source of CsI(g), cesium iodide (CsI, 99.999%, Alfa Aesar) was purchased and put in an alumina boat crucible. The crucible was then placed at volatilization zone. The SA filters were thermally elevated at 1,000 °C prior to vaporization of CsI. Then, CsI was heat-treated at 1,000 °C to generate CsI vapors. As carrier gases, air, argon, or 4%H_2/Ar were provided with a rate of 0.8 liter/min. After the trapping experiments, trapping efficiency was obtained by measuring increased mass of the SA filters. It should be mentioned that the increased mass was assumed to that of Cs and O when air was used as a carrier gas, for oxygen in the air was involved in the trapping reaction. Crystalline structure and morphology were examined by X-ray diffraction (XRD) method and scanning electron microscopy (SEM), respectively.

3. Results and discussion

Fig. 1 shows the increased mass in the SA filter after trapping experiments at different carrier gases. As indicated in the graph, CsI(g) is not effectively captured in the SA filter when 4%H_2/Ar was used as a carrier gas. Trapping efficiency of CsI calculated from the increased mass was only 19.5%. On the contrary, it was demonstrated that CsI(g) was effectively trapped in the SA filters when carrier gas was air instead of 4%H_2/Ar. The calculation of trapping efficiency showed that 86.8% of Cs in the volatilized CsI(g) was removed by the SA filters. The significant difference of trapping efficiency is related to the oxygen contained in the carrier gas. As presented in Fig. 2, CsI(g) reacts with the SA filter to form cesium aluminum silicate ($CsAlSiO_4$). A plausible equation of trapping reaction is estimated as follows:

$$CsI(g) + 0.25O_2(g) + 0.5Al_2O_3{\cdot}2SiO_2 = CsAlSiO_4 \quad (1)$$

Therefore, oxygen is required to form the reaction product. When air was used as a carrier gas, oxygen could be readily provided from the carrier gas, resulting in the high trapping efficiency. However, oxygen was not present in 4%H_2/Ar gas, which was a reason of the low trapping efficiency.

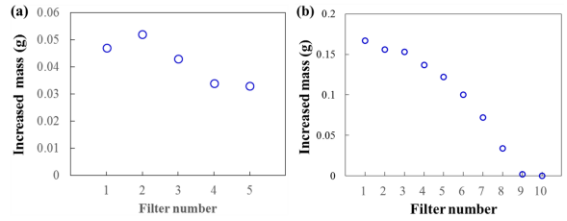

Fig. 1. Trapping of CsI(g) by the SA filters in (a) 4%H_2/Ar and (b) air gas.

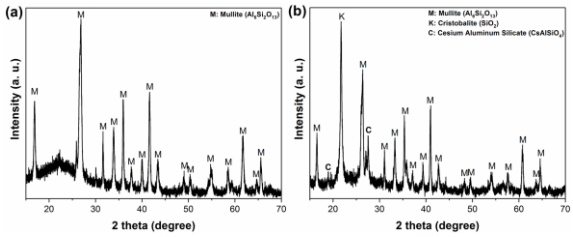

Fig. 2. XRD patterns of the SA filter (a) before CsI trapping and (b) after CsI trapping.

4. Conclusion

Trapping experiments of CsI(g) were performed using the SA filter in different carrier gases. In contrast to CsOH(g), trapping efficiency of CsI was very poor in 4%H_2/Ar gas. However, CsI could be effectively captured when air was used as a carrier gas, which was attributed to the presence of oxygen that is engaged in the trapping reaction. It is expected that the CsI trapping efficiency in 4%H_2/Ar could be improved if oxygen sources are added in the SA filter.

REFERENCES

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