Reaction of cesium molybdate with silicon oxide coating on stainless steel 304 at 700°C

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Abstract: Cesium silicate, $Cs_2Si_4O_9$, was detected after cesium molybdate (Cs_2MoO_4) was deposited on silicon oxide (SiO_2) coating on SUS. In this study, the reaction behavior and the diffusion mechanism of cesium molybdate into SiO_2 coating on the SUS304 substrate at 700°C will be analyzed.

Keywords: Cesium molybdate, silicon oxide, stainless steel 304, reaction, oxidation, severe accident

1. Introduction

Because of the volatile property, the vaporization behavior of cesium (Cs) and its compounds is one of the most critical issues in nuclear reactor accidents. Cesium hydroxide (CsOH) evaporates at about 400 °C, and cesium molybdate (Cs_2MoO_4) evaporates at about 964 °C, the evaporation of both compounds is unavoidable. Therefore, in the next generation reactor, it is necessary to consider minimizing the number of cesium releases outside.

Recently, many research focused on the reaction of Cs in both forms, CsOH and Cs_2MoO_4, on stainless steel (SUS). Di Lemma et al. [1] declared that Cs might react to silicon (Si) to form cesium silicates or with both Si and iron (Fe) to form cesium iron silicates. This means that SiO_2 could be used to trap Cs. However, in Do et al. [2], with the presence of Cs_2MoO_4, in humid conditions, the oxidation rate of SUS could be faster. Therefore, the reaction between Cs compounds, SiO_2, and SUS must be clarified. In this study, we analyze the possible reaction when Cs_2MoO_4 is deposited on SiO_2 coated on SUS304 at 700 °C in humid conditions.

2. Experimental method.

Cs_2MoO_4 was placed at 1300 °C in a platinum (Pt) boat. The SiO_2/SUS304 specimens (10×10×0.5 mm) were placed in a horizontal alumina tube, behind Cs_2MoO_4, where the temperature was about 700 °C. Pt sheets were placed next to SiO_2/SUS304 to obtain the reaction product. From one side of the alumina tube, Ar gas containing H_2O, heated at 70 °C was injected and flowed through the tube, carried the Cs_2MoO_4 vapor to deposit on the SiO_2/SUS304 specimens. The oxidation time of interest was 1 hr. After heating, the surface of the samples was analyzed by X-ray diffraction and micro-Raman spectroscopy. The elemental distribution was performed by the electron probe microanalyzer (EPMA).

3. Results

On EPMA mapping, it is recognized that cesium silicates have been formed, but it is still not determined the compound since it exists in amorphous form. In addition, in cross-section analysis, cesium silicate was also found under the oxide iron. From the analysis of the Pt surface, which was placed right next to SiO_2/SUS specimen, the deposit was not only Cs_2MoO_4 but also cesium silicate. This phenomenon is explained by the evaporation of Cs_2O, which come from the decomposition of Cs_2MoO_4, and the carrying of cesium silicate. This also helps the iron oxide diffuse to the surface.

References

[1] F.G. Di Lemma, K. Nakajima, S. Yamashita, M. Osaka, Surface analyses of cesium hydroxide chemisorbed onto type 304 stainless steel. Nuclear Engineering and Design. 305 (2016) 411.

[2] T.M.D. Do, S. Sujatanond, T. Ogawa. Deposition behavior of cesium molybdate on type 304 austenite stainless steel in severe accident. Nuclear Science and Engineering. 196 (2022) 584.