Concentration measurement of volatile iodine species formed by thermal decomposition of iodate salt

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1. Introduction

In the event of a severe accident at a NPP, a large amount of radioactive aerosols could be released from the irradiated fuels [1-4]. Iodine oxides among the volatile radioactive aerosols have been reported to convert into I$_2$ under operating conditions of passive autocatalytic recombiner (PAR), and then the I$_2$ may adsorb on catalysts and reduce the performance of PAR [1-4]. Therefore, in order to suppress the performance degradation of PAR at high temperature and understand the behavior of iodine species at high temperature, it is necessary to understand the thermal decomposition behavior of iodate.

In this study, we investigated the thermal decomposition behavior of NaIO$_3$, one of the iodine salts (IO$_x$), under various conditions. And the effects of H$_2$ and H$_2$O on the decomposition behavior were analyzed by measuring the volatile iodine species. Our experimental results showed that the I$_2$ and NaI were easily formed by the decomposition of the iodates under our experimental conditions. The amounts of I$_2$ formed at 550°C were about 1.3 times more compared to those formed at 650°C.

2. Experimental and Results

2.1 Experimental

All chemical reagents were analytical grade. NaIO$_3$ (≥ 99%, Sigma-Aldrich), The biphasic reagents and alkaline solution were made from toluene (≥ 99.8 %, Sigma-Aldrich), HNO$_3$ (70 %, Sigma-Aldrich), deionized water (≥18.2 MΩ-cm, EMD-Millipore) and NaOH (≥ 97%, Sigma-Aldrich).

The thermal decomposition system used in the experiment is composed of 4 parts. First, gas supplies parts including MFC (mass flow controller) and humidifier. Second, furnace parts including quartz boats for loading sample. Third, iodine species capturing parts using biphasic gas scrubbers. Fourth, outlet line is then terminated by gas scrubbers filled with a diluted alkaline solution to trap other gaseous species. The schematic diagram of the decomposition system is shown in Fig. 1.

2.2 Concentration of I$_2$ formed from thermal decomposition NaIO$_3$

We investigated the effects of H$_2$ and H$_2$O on the formation of volatile I$_2$ at high temperature. At 400°C under all gas conditions, no iodine species could be observed in biphasic gas scrubbers. Whereas the amounts of I$_2$ at 550°C were up to 1.3 times more compared to those formed at 650°C. Exceptionally, the I$_2$ amount formed at 650°C with H$_2$O condition a little increased more compared to that at 550°C with H$_2$ condition (dry condition).

2.3 Concentration of I- and water-soluble iodine species formed from thermal decomposition NaIO$_3$

![Fig. 2. Amounts of I$_2$ formed from decomposition of NaIO$_3$ at different temperature and gas conditions](image-url)
We investigated the effects of H₂ and H₂O on the formation of water-soluble iodine species (I⁻, IO, IO₃⁻) at high temperature. At 400°C under all gas conditions, no iodine species were detected in biphasic gas scrubbers. Other iodine species were detected at the temperature above 550°C, and the major species of the other iodine species were evaluated to be I⁻ by using UV-VIS spectrophotometer and ICP-MS.

At 550°C, a very small amount of I⁻ was detected. On the other hand, at 650°C, a relatively large amount of I⁻ was formed. In particular, the amount of I⁻ formed under H₂ (reducing) condition was greater than that under air (oxidizing) condition. The amount of I⁻ formed at H₂O condition was relatively increased compared to those under other conditions.

![Graph showing the amount of I⁻ formed from decomposition of NaIO₃ at different temperature and gas conditions.](image)

3. Conclusions

We investigated the thermal decomposition behavior of NaIO₃ under various conditions. The differences of I₂ amounts were explained by using different decomposition paths of NaIO₃ depending on the composition of gases and temperature. And the differences of I⁻ amounts were also explained in a similar way.

\[4\text{NaIO}_3 \rightarrow 2\text{Na}_2\text{O} + 2\text{I}_2 + 5\text{O}_2 \quad (> 510°C) \quad (1)\]
\[2\text{NaIO}_3 \rightarrow 2\text{NaI} + 3\text{O}_2 \quad (> 460°C) \quad (2)\]

On the presence of steam, thermal decomposition reaction of the first path (eq. 1) is more dominant. On the other hand, on the presence H₂, I₂ can be converted into I⁻. The formation of iodine species from thermal decomposition were complexly affected by temperature and gas compositions.

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REFERENCES