Effect of Gamma Irradiation on Formation of Organic Iodide in Iodide and Ketone Mixed Solutions

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The aim of this study is to quantitatively measure the concentration of methyl iodide (CH_3I) and ethyl iodide (C_2H_5I) formed in methyl ketones under gamma irradiation in the range of 0 to 40 kGy. For each 1.0 mM of MIBK and MEK in the presence of NaI under 0 - 40 kGy irradiation, CH_3I was formed in a concentration range of 0 - 1.82μM. The concentration of organic iodide generally increased, as the gamma dose and concentrations of MIBK and MEK increased.

I. INTRODUCTION

In the event of a severe accident in a nuclear power plant, the volatile fission products will be released into the containment from the damaged fuel bundles. It was reported that most of the iodine is accumulated in the sump water through both aerosol particles and a gaseous form.[1] Radioactive iodide can be oxidized into volatile iodine.[2,3] Moreover, under gamma irradiation, organic iodides can be formed as a result of the interaction of radioactive iodine with organic compounds such as paint.[4] Under this condition, the radiolytic decomposition of organic compounds can influence the formation of organic iodides.[5] As one of the organic compounds, the decomposition of MEK has been successfully demonstrated using kinetic models.[5,6] DRIVER et al.[6] found that organic compounds will be decomposed into CO_2 and organic acids, while reducing the pH of the solution. Approximately 90% of 1 mM (mmol/ℓ) MEK was decomposed over 4 kGy of irradiation, with a minimum pH being reached within 1 h.[5,6] They also insisted that radiation rapidly decomposes organic solvents such as MIBK and MEK in the aqueous phase. Although many studies have been carried out on the formation of organic iodides.[4,7,8] Additional studies will be helpful for a better understanding of the effect of gamma irradiation on the formation of organic iodide.

In this paper, we measured the concentration of organic iodide formed in iodide and under various concentrations of methyl ketone mixed solutions after gamma irradiation. We also investigated the major factors affecting the formation of organic iodides.

II. EXPERIMENTAL

The gamma irradiation experiment was carried out at a high gamma irradiation facility. The total dose was controlled to in the range of 0 - 40 kGy, and the temperature of irradiation was at 18º - 20ºC. Four different NaI solutions of 0.1 to 5.0 mM with methyl ketone (MIBK and MEK) were prepared in 20 ml sealed vials. All vials were sealed with a Teflon cap to avoid evaporating the volatile organic iodides. After gamma irradiation, about 5 ml toluene was injected into the sealed vials using a gas-tight syringe. Liquid/liquid extraction was then performed for 1.5 hours to extract organic iodides into toluene phase. After extraction, we measured the concentrations of CH_3I and C_2H_5I dissolved in toluene using GC-MS (Perkin Elmer Clarus680/SQ8T, USA).

III. RESULTS

After 0 - 40 kGy of gamma irradiation of NaI (0.1 - 5 mM) and ketone (1.0 mM MIBK, 1.0 mM MEK) mixed solutions, we found that CH_3I was formed in a concentration range of 0.071- 1.82 μM. As total dose increased, the concentration of CH_3I formed generally increased. Unlike CH_3I, C_2H_5I was difficult to be observed. C_2H_5I was only detected in 5.0 mM MEK with 1.0 mM NaI after irradiation of 16 - 40 kGy. The concentration of organic iodides formed after irradiation increased, as the concentration of MIBK and MEK increased, respectively, in the presence of iodide. We found the concentration condition of MIBK under which CH_3I was formed to be the maximum concentration after irradiation. Consequently, we confirmed that both iodide and methyl ketone (CH_3-CO-) functional groups are the major ingredients for the formation of methyl iodide under gamma irradiation.

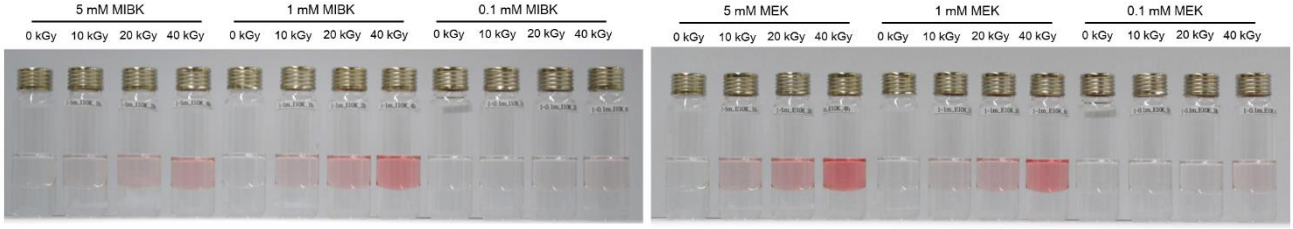

Fig.1 Photograph of vials after 0 - 40 kGy gamma irradiation of 1.0 mM NaI with three-different concentrations of ketone mixed solutions. The temperature in the irradiation laboratory was 18°C. The vials were replaced with new ones after gamma irradiation.

IV. CONCLUSIONS

We determined the concentration of organic iodides formed in iodide and ketone mixed solutions after gamma irradiation (0 to 40 kGy). The concentration of CH_3I increased as the gamma dose, and the concentrations of iodide and methyl ketone, increased. We found the experimental conditions under which the amounts of organic iodides were observed to be the maximum values.

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