

Evaluation of Gaseous Radioactive Iodine Uptake by a New Hybrid Adsorbent

Byung-Seon Choi^{a*}, Seon-Byeong Kim^a, Jeikwon Moon^a

^aKorea Atomic Energy Research Institute (KAERI), P.O.Box 150, Yuseong, Daejeon, 305-600, Republic of Korea

*Corresponding author: bschoi@kaeri.re.kr

1. Introduction

In case of nuclear explosion, nuclear terrorism or nuclear accident, radioactive gases such as ¹³¹I (half-life: about 8 days), ¹²⁹I (half-life: about 17 million years) and ¹³⁷Cs are generated. In particular, radioactive iodine is a major nuclide of the most hazardous fission products. Radioactive iodine generated from various nuclear facilities are partially converted radioactive organic iodide, such as methyl iodide, by react with organic matter coating on the environment. Because radioactive iodine among these gaseous wastes has radiological harm on the human body and environment, it has been considered that this gas must be removed below restriction of release even in the case of normal operating and accident conditions. Therefore, numerous studies for the removal of radioiodine from various nuclear facilities have been performed with various adsorbents and chemicals.[1-5]

There has been some concern regarding the use of TEDA-impregnated activated carbon as an adsorbent for radioactive iodine removal. However, the TEDA-impregnated activated carbon has limitation to trap ¹³¹I generated from high humid conditions, such as the gas mask, due to the rapid drop of the removal efficiency of activated carbon at this condition.

Extensive studies in our laboratory were focused to perform to develop new hybrid adsorbents which are designed to be applied to the multi-functional gas mask under the high humidity condition up to 95%.

2. Experimental and Test Methods

The removal tests of a new adsorbent at high humidity condition were conducted by ASTM standard test method, ASTM D3803-89[14]. This standard covers test method for establishing the capability of new and used activated carbon to remove gaseous radioactive iodine and iodine compounds from air and gas streams. This test determines the penetration of only CH₃¹³¹I through TEDA impregnated activated carbon and a new adsorbent under normal contaminated operating condition (30°C and 95% relative humidity). Test conditions of radioactive methyl iodide using a new adsorbent are the same as that of TEDA impregnate activated carbon by using test facility shown in Figure 1. Individual components of this facility consist of four systems, such as gas supply system and humidity control section, sample and

backup bed assemblies, iodine supplying system. All test beds are designed in accordance with ASTM D-3803 in all dimensions. The sample bed canister is single unit of the depth specified in the test and is assembled from separate 50mm deep canisters. Total bed depth of sample canister constructed with stainless steel is 50mm, and bed inside diameter is 50mm. Two backup beds are installed to trap completely radioactive methyl iodide penetrated through test bed. We also modified the operating conditions for a new adsorbent performance test based on the MIL-DTL-32101 listed in Table 1.

Table 1. Test condition based on ASTM D-3803 and MIL-DTL-32101.

Parameters	Pre-equilibrium (First 16 hrs)	Equilibrium, Challenge and Elution
Temperature, °C	30±0.5	30±0.5
Relative humidity, %	92 ~ 96	93 ~ 95
Flow rate, l/min	10 ~ 25	10 ~ 25
- Face velocity, m/min	12.2±0.3	12.2±0.3
Absolute pressure, kPa	101 ± 5	101 ± 5
CH ₃ ¹³¹ I concentration, mg/m ³		1.75 ± 0.25
Test duration		
- Pre-equilibration, hr	16 ± 0.1	
- Equilibration, hr		1.0
- Challenge, hr		1.0
- Elution, hr		1.0



Fig. 1. Test equipment of radioactive CH₃¹³¹I removal.

3. Results and Discussion

Removal capacity of methyl iodide on new adsorbent was evaluated as the function of humidity and the used precursors. Figure 2 show the removal performance of organic iodine by new adsorbent(adsorbent A) under high humid air (RH 95%) condition. As a result, the breakthrough was reached very short time and the removal efficiency was also not reached of 99.99% even though initial adsorption rate of organic iodine was fast. In order to increase the breakthrough time at the methyl iodide removal efficiency of 99.99% or more, another adsorbent(adsorbent B) was developed by additionally supporting the amine having the lipophilic characteristic. Figure 3 shows the breakthrough curves of methyl iodide on adsorbent B. It showed that the removal performance of methyl iodide was reached more than 99.99% and also increased the breakthrough time. As a result of carrying hydrophobic amine on adsorbent B, the moisture retained in the pores in the water pretreatment step was removed from the adsorption test of methyl iodide. It was also confirmed that no methyl iodide was detected during the test time (over 400 minutes) under high humid condition(RH 95%).

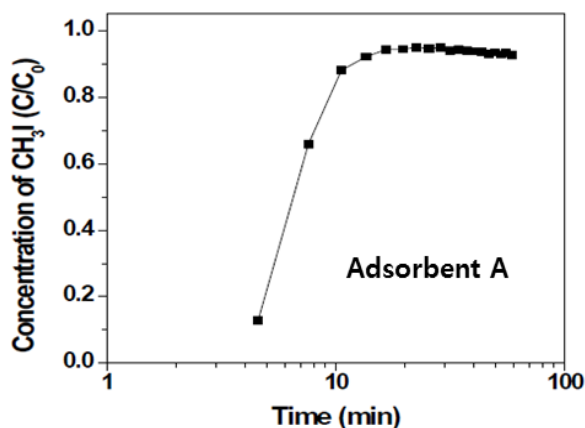


Fig. 2. Breakthrough curves of methyl iodide adsorption on adsorbent A under 95% RH

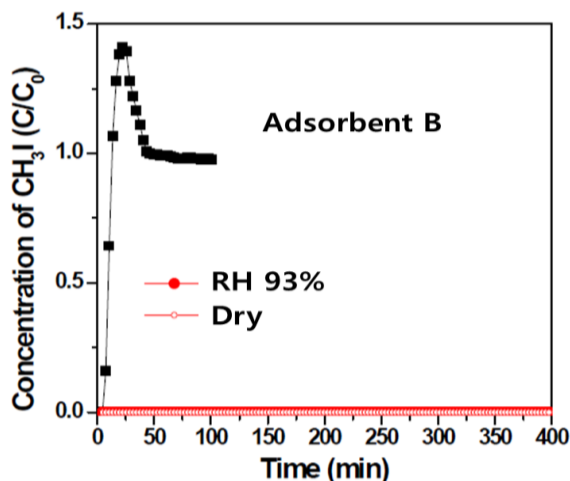


Fig. 3. Breakthrough curves of methyl iodide adsorption on adsorbent B under 95% RH

4. Conclusion

In this study we have established the system requirements for the radioactive iodine removal test based on the ASTM D3803 and MIL-DTL-32101. The manufactured system has been simplified through a variety of preliminary tests so that the optimal evaluation test can be performed. This system can be used to evaluate the removal performance of the adsorbents for gaseous radioactive iodine. The newly developed adsorbents for iodine removal were evaluated the removal efficiency under the given test procedure. As a results, adsorbent B showed the excellent performance in removal of methyl iodide (>99.99%) at a high humid condition up to 95% RH. It is considered that the moisture retained in the pores in the water pretreatment step was removed from the adsorption test of organic iodine by introducing hydrophobic amine on adsorbent B.

REFERENCES

- [1] Pence, D. T.; Staples, B. A. In Proc. 13th AEC Air Cleaning Conference, CONF-740807, Atomic Energy Commission, Washington DC, 1974, 157.
- [2] International Atomic Energy Agency, Design of Off-gas and Air Cleaning System at Nuclear Power Plant, 1987, IAEA Tech. No. 274.
- [3] Wilhelm, J. G.; Furrer, J. In CEC Seminar on Radioactive Effluents from Nuclear Fuel Reprocessing Plants, Kernforschungszentrum, Karlsruhe, Federal Republic of Germany, 248, 1977.
- [4] Bellamy, R. H. Nucl. Safety, 1974, 15, 16. [4] K.A. Burrill, "A Possible Mechanism for Corrosion Product Transport and Radiation Field Growth in a Pressurized Water Reactor Primary Circuit," Nuclear Technology, Vol. 29, (1997).
- [5] Wren, J. C.; Moore, C. J.; Rasmussen, M. T. Nuclear Technology, 125, 28-39, 1999.

ACKNOWLEDGEMENT

The authors would like to express their appreciation to the National Research Foundation of Korea (NRF) for the award of a grant (NRF-2017M2A8A5015144) funded by the Ministry of Science and ICT (MSIT) of the Republic of Korea, in support of the authors' work through the Nuclear Research and Development Program.