Continuous H_2O and CO_2 Sequestrated Kr-85/Xe Isotopes Sampling System Using a Hollow Fiber Membrane Module

Young Gun Ko *, Hyuncheol Kim, Hajin Song, Jeonghyeon Ryu, Sang-Do Choi, Jong-Myoung Lim, Wanno Lee
Environmental Radioactivity Assessment Team, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero, Yuseong-gu, Daejeon 34057, Korea
**Corresponding author: ygko@kaeri.re.kr*

1. Introduction

A Budesamt für Strahlenschutz - Institute of Atmospheric Radioactivity (BfS-IAR, Germany) system is the only commercialized system to analyze the very low radioactivity of ^{85}Kr (beta emitter, E_{max}: 687 keV, half-life: 10.76 years) in the atmosphere [1]. To determine the radioactivity of ^{85}Kr in the atmosphere, the sequestration of moisture and CO_2 is essential at the air sampling step because they inhibit the Kr adsorption on the activated charcoal in an air sampling module. At the step, air including Kr flow into and adsorbed in the adsorption module cooled with liquid N_2. The moisture and CO_2 in air can stop up pores of the activated charcoal in the temperature liquid N_2 because they exist in solid state in the temperature. The significant weakness of the BfS-IAR system is that only one sample can be obtained each air sampling. In this study, hollow-fiber membrane module, a heat exchanger, an automatic air-flow distribution system, a thermostat bath and a new adsorption module were fabricated to develop the automated Kr-85 and Xe isotopes sampling system.

2. Methods and Results

The automated air sampling system consists of combination of air compressor, a heat exchanger, a hollow-fiber membrane module, a multi-position valve (MPV) system, several adsorption modules and a cooling chamber.

An attenuated total reflectance Fourier transform infrared spectroscopy (ATR FT-IR) was performed using a Frontier spectrometer (PerkinElmer) equipped with a diamond coated KRS-5 crystal (PerkinElmer, Universal Diamond ATR) to analyze the hollow-fiber membrane. The morphologies of the activated charcoal and the hollow-fiber membrane were examined using a field emission gun scattering electron microscopy (FEG-SEM) (Inspect F50, FEI) at 10 kV. Specific surface area and pore size of the activated charcoal (merck) were measured using TriStar II 3020 (micromeritics). The compact size of the automated air sampling system was also designed

3. Results and Discussion

In the photo and FEG-SEM images of the hollow-fiber membrane (Fig. 1), 60 μm of wall thickness and 240 μm of inner diameter of the cylindrical shape was clearly observed.

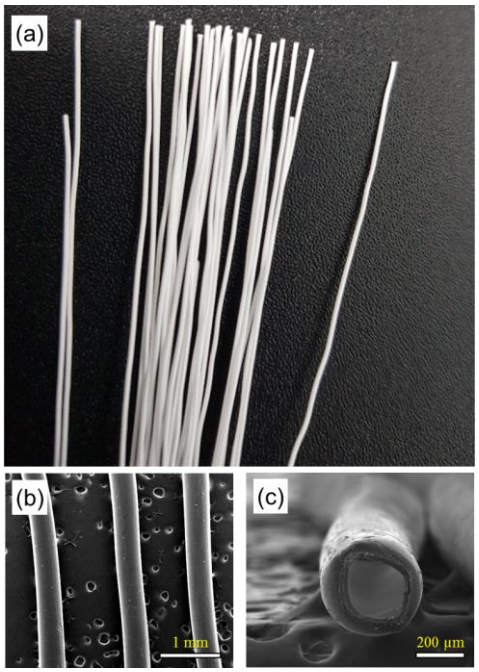

Fig. 1. (a) Photo and (b,c) FEG-SEM images of the hollow-fiber membrane.

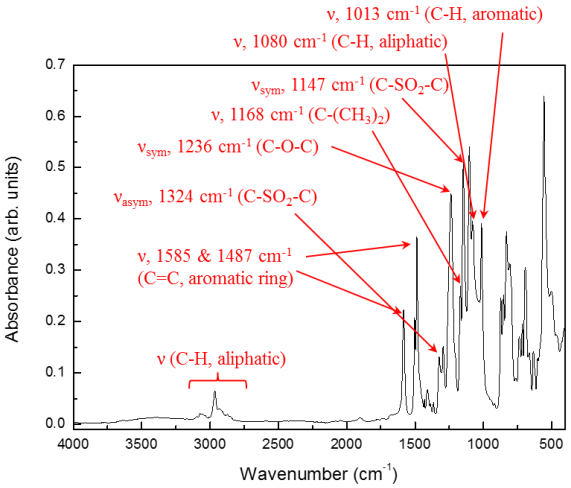

Fig. 2. ATR FT-IR spectrum of the hollow-fiber membrane.

ATR FT-IR spectrum (Fig. 2) revealed that the hollow-fiber membrane was prepared polysulfone (Fig. 3)

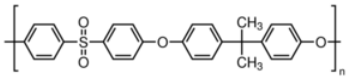

Fig. 3. Chemical structure of polysulfone.

Fig. 4 shows how to pack the bundle of hollow-fiber membranes to make the H_2O and CO_2 sequestration module.

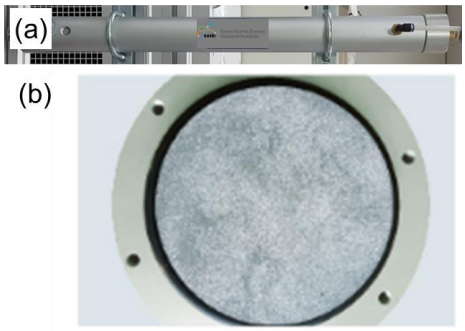

Fig. 4. (a) Longitudinal and cross-sectional photo images of the hollow-fiber membrane module.

The separated gases by hollow-fiber membrane module are displayed in Fig. 5.

Fig. 5. Gas separation by the hollow-fiber membrane module.

The size, specific surface area and pore diameter of the used activated charcoal are 0.3 ~ 0.5 mm, 1005 m^2/g and 5.2 nm, respectively (Fig. 6).

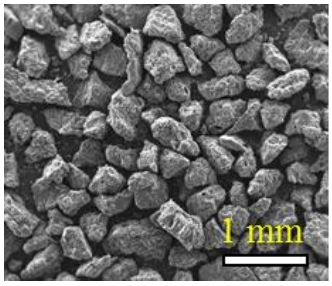

Fig. 6. FEG-SEM image of the activated charcoal.

The compact size of continuous H_2O and CO_2 sequestrated Kr-85/Xe isotopes sampling system was designed as shown in Fig. 7. 8 of adsorption modules for air-sampling were equipped in the system to obtain air samples continuously.

Fig. 7. Compact size of continuous H_2O and CO_2 sequestrated Kr-85/Xe isotopes sampling system.

4. Conclusions

In this study, the compact size of continuous H_2O and CO_2 sequestrated Kr-85/Xe isotopes sampling system was demonstrated by the combination of a hollow-fiber membrane module, a heat exchanger, an automatic air-flow distribution system, a thermostat bath and new adsorption modules. The used hollow-fiber membrane and activated charcoal were analyzed by FEG-SEM, ATR FT-IR and BET. The sequestration efficiency of moisture and CO_2 in the air sample was also tested. The initial purpose of the development of system was to use for the determination of radioactivity of radioactive noble gases. At the end of the development of the system, it is also expected that the system can be used to sequestrate the radioactive noble gases in the atmosphere.

REFERENCES

[1] M. Aoyama, K. Fujii, K. Hirose, Y. Igarashi, K. Isogai, W. Nitta, H. Sartorius, C. Schlosser, W. Weiss, Establishment of a Cold Charcoal Trap-Gas Chromatography-Gas Counting System for ^{85}Kr Measurements in Japan and Results from 1995 to 2006, Technical Reports of the Meteorogical Research Institute No. 54, Meteorogical Research Institute, Japan, 2008.