Size Measurements of Radon Decay Products by Diffusion Method

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Abstract

Particle size of radon decay products is very important for dose evaluation. Dose conversion factor (DCF) from concentration to effective dose strongly depends on the particle size[1]. Comparing with attached fraction of radon decay products, the DCF of unattached fraction is very high in a nanometer region. In order to get the size data with adequate resolution, we tried to refine the graded screen array (GSA) method. In the chamber experiments, the mean diameter (MD) for unattached fraction was observed slightly less than 1 nm with small geometrical standard deviation (GSD) of 1.1 and the high size resolution was confirmed. The GSA method was also conducted in the field measurements. Here we show our new configurated GSA and the results of size measurements.

Introduction

Radon is an inert gas, but its decay product is solid and behaves as an airborne particle. The behavior is easily influenced by circumstances. Initially, the decay product is free atom in the air. But it is so small that it easily attach to aerosol particles. The attaching fraction depends strongly on the size and concentration of carrier aerosol particles. A typical size distribution of the decay products is bi-modal as shown Fig. 1. The smaller mode, ranging from 0.5 to 3 nm, is commonly referred to as the "unattached" fraction of the decay products, while the larger mode, from 50 to 300 nm, consists of decay products attached to aerosol particles. They are called "attached fraction". It is well known that DCF depends on particle size of radon decay products. Thus the size information is very important for evaluation of exposure dose.

Materials and Method

In order to measure a size distribution of ultra-fine particle such as radon decay products, GSA method had been studied. In general, coarse screens with less than 100 mesh are used in the upper stage of GSA[2, 3]. But they are not always good for sizing of the "unattached" fraction in a nanometer range. In this study screen configuration was refined for wide size range and high sensitivity. As shown in Fig. 2, our GSA has four screen stages of 135, 200, 400 and 635 mesh and one backup filter stage. Even when *Reynolds* number in screen flow is kept below one for laminar flow, sampling flow rate of 12 litter/min was retained for the effective screen size of 37 mm in diameter. In order to verify a reliability of GSA unfolding, numerical experiments were made for various combinations with particle sizes and intensities, simulating actual environments. And also other GSAs used in EML and ITRI, U.S.A. were evaluated for comparison. In the second step, chamber experiments were made in artificial environments. Radon/aerosol chamber at NIRS was used with or without carrier aerosols. Finally, field experiments were made in relaxation room for having a glass of water supplied from radon spa. As radon emanates from the dropping water, high concentrations of the unattached fraction are expected there.

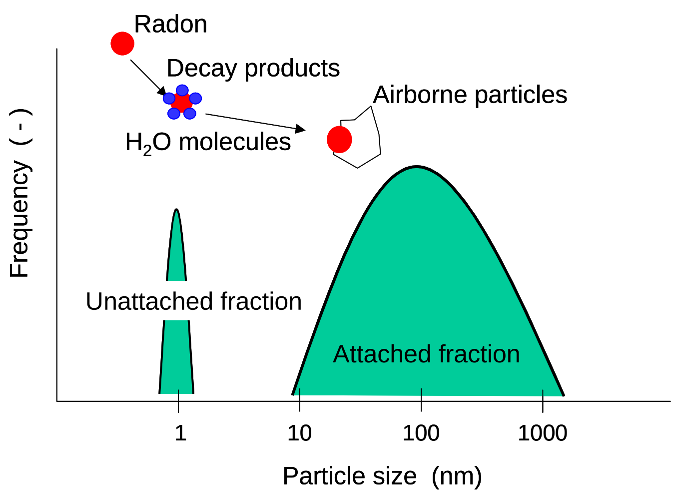

Fig. 1 Formation of radon decay products

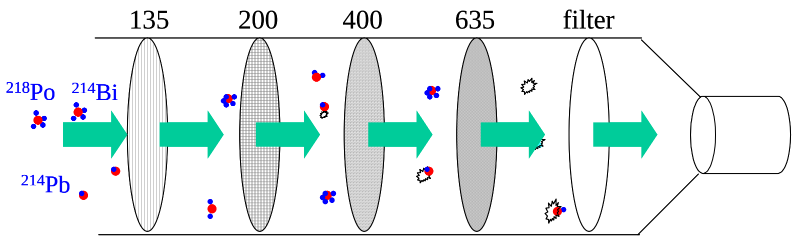

Fig.2 Configuration of NIRS's GSA

Results and Discussion

1) Numerical experiments: Our GSA showed good sizing performance except when particle size of the attached fraction was relatively small and its intensity was weak. Both size distributions of the unattached and the attached fraction were well reconstructed. It means that the reliability of our GSA has been verified.

2) Chamber experiments: Clear bi-modal size distribution of radon decay products was observed, and MD for the unattached fraction was found to be slightly less than 1 nm with small GSD of 1.1. Even in a low radon concentration around 150 Bq/m3, activity-weighted size distributions were obtained for each nuclide of radon decay products. Considering the action level of indoor radon concentration in ICRP Publ. 65, the concentration is valuable.3) Field experiments: As expected before measurements, high concentration of the unattached fraction was observed. Most of the activity was derived from Po-218, and those of Pb-214 and Bi-214 were not so much. But in the attached fraction the activities were almost the same among each nuclide. In all three nuclides, bi-modal size distributions were observed as shown in Fig. 3. The basic shape of size distribution was similar with that in chamber experiment.

Conclusion

1) Newly configured GSA was developed for particle sizing of radon decay products in a wide range from nanometer to sub-micrometer.

2) Bi-modal size distribution, consisted of the attached and the unattached fraction of radon decay products, was measured with high size resolution.

3) Size information of the GSA contributes to accurate estimation of exposure dose due to radon decay products.

References

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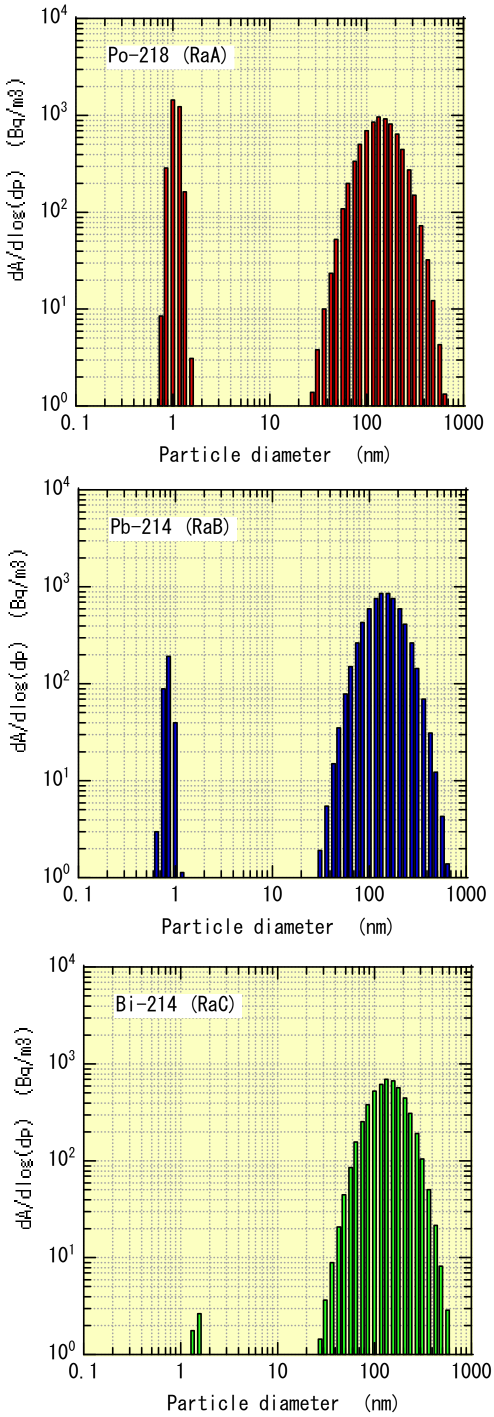

Fig.3 Size distributions of radon decay products