Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Infection of aerosol concentration on the radon decay products fractions

To cite this article: Mostafa Y A Mostafa *et al* 2019 *J. Phys.: Conf. Ser.* **1410** 012080

Infection of aerosol concentration on the radon decay products fractions

Mostafa Y A Mostafa[1,3], Hyam N B Khalaf [1,3], M Zhukovsky[1.2]
[1]Ural Federal University, Yekaterinburg 620002, Russia
[2]Institute of Industrial Ecolog, Ekaterinburg, Russia
[3]Minia University, Faculty of Science, Department of Physics, El-Minia, Egypt

Abstract. In this work, an experimental setup has been constructed to study the effect of aerosol concentration on the size distribution and unattached fraction of radon decay products. The experiments are conducted with 2 m^3 standard radon chamber under controlled conditions (aerosol concentration, temperature and humidity). Number concentration and size distribution of aerosols inside radon chamber are measured with a Diffusion Aerosol Spectrometer (DAS 2702M, range from 5 nm to 10 μm). The activity size distribution of radioactive aerosols is estimated with diffusion battery. Number distribution diameter at low aerosol concentration has interval 50-100 nm. When additional aerosols injected to the radon chamber, distribution peak shifted to large diameters 70-150 nm at high aerosol particle concentration. At high aerosol concentration the unattached fraction fell sharply to 10-15% of the total activity compared to 50-70% when the aerosol concentration is low. The ratio between the fractions of the unattached and attached is in the range from 0.9 to 1.2 at low aerosol concentration. At high aerosol concentration, this ratio becomes from 0.09 to 0.14.

1. Introduction

The size distribution of radon-222 decay products consists of ultrafine clusters with median diameters below 4nm (unattached activity) and decay products associated with ambient aerosol particles in size range 100 and 1000 nm (attached activity) [1]. The ultrafine clusters or unattached activity fraction generated with the birth of Po-218 from radon-222. During the short half-lives time of radon decay products, they react and attach to surrounding aerosol. In this case the aerosol concentration and size distribution have a significant effect on radon decay products.

The unattached fraction is deposited nearly completely in the respiratory tract during inhalation, where as 80% of the attached are exhaled without deposition [2,3]. In ambient air, the amount of unattached activities up to about 10% of the total activity. This value present about 50% of the total radiation dose[1–3]. Therefore, it is necessary to determine the size of the unattached fraction of radon decay products and the effect of surrounding aerosols.

In this work, the effect of aerosol concentration on the size distribution and unattached fraction of radon decay products is studied. Aerosols are generated in standard radon chamber. The size distribution and unattached fraction of radon decay products are measured at low and high aerosol concentration with known size parameters.

2. Method

The experimental work was carried out with standard radon box 2 m^3[4–6]. Before start the experiments, there were no additional sources of aerosols in the box. Therefore, the dispersion composition of aerosols inside the box was primarily determined by the natural processes of aerosol formation in the air inside the box with radon gas and its decay products.

The diffusion aerosol spectrometer (DAS 2702M) is used to measure the aerosol concentrations and the particle size spectrum, covering a range of sizes from 5 nm to 10 µm. Also, the total concentration, air temperature, humidity and atmospheric pressure are given in the output file[5,7]. The aerosols parameters are measured continuously with flow rate 0.5 l/min. Additional aerosol particles are injected with especial aerosol source. Aerosol was released from e-cigarette with using smoking machine with flow rate 1 l/min. More details about the used e-cigarette can be found in these papers [4–8].

The activity size distributions of ultrafine fraction (≤ 200 nm) are measured with screen diffusion battery (SDB). The SDB has been used with 10 brass elements for measuring radioactive aerosol size distribution in the range from 1 to 100 nm. This SDB followed by three analytical filters (AFA-RSP-20) to catch all other sizes.

Alpha activities on the elements of diffusion battery and the analytical filters are consequently measured with scintillation alpha radiometer during 30 min after the finishing of the sampling. Then radon equivalent equilibrium concentration (EEC) of radon at the moment of finishing of the sampling was calculated by the modified Kuznets methods [9]. The activity size distributions are estimated from the alpha energy spectrum analysis of SDB modes obtained by using mathematical method, expectation maximization method of Maher and Laird (EMM)[10,11].

3. Results

Number Size distribution of the investigated aerosol (0-200 nm) at low and high aerosol concentrations presented in figure 1. These results are measured with DAS. At low aerosol concentrations, the number median diameter, NMD, has range from 50-70 nm with broad size. This value shift to 70-150 nm in the case at high aerosol concentration. The difference of size distribution is clear with the effect of high aerosol concentration.

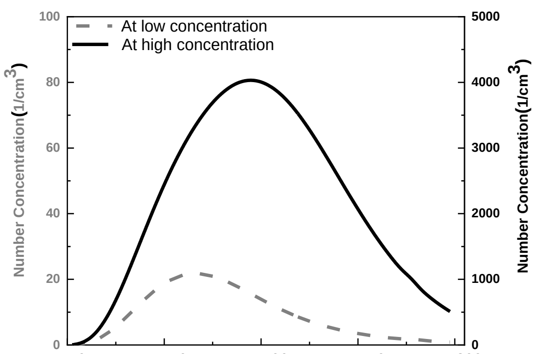

Figure 1. Number Size distribution of the ultrafine investigated aerosol. The left scale for low aerosol concentrations and the right one for high concentrations

Activity Size distribution at low and high aerosol concentrations measured with SDB is presented in figure 2. These results demonstrated that at the low aerosol concentration 50-70 % of radon decay product activity connected with aerosol particles with AMTD ~ 1 nm (so-called unattached fraction). Additionally, a mode with a diameter of ~ 10 nm was registered with small fraction. After aerosols injection in the experimental radon box, the activity of unattached fraction with AMTD ~ 1 nm is sharply decreased to zero due to attachment process of radon decay products with injected aerosols. At high aerosol concentration, activity size distribution mode with AMTD ~ 10-20 nm is observed with half relative activity of the unattached fraction of 1 nm in the case of low aerosol concentration. The residual activity is collected with backup analytical filters with size more than 200 nm which out of the SDB range.

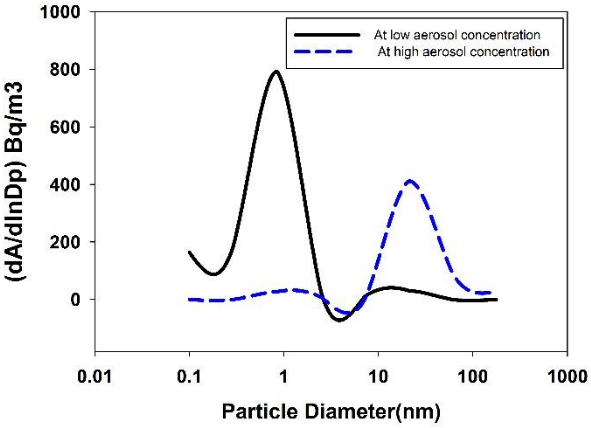

Figure 2. Activity Size distribution with SDB, at low and high aerosol concentrations.

Radon Equilibrium Equivalent Concentration, EEC, at low and high aerosol concentration is calculated and compared. Figure 3 shows EEC at low and high aerosol concentration using diffusion battery and 3 AFA-RSP filters for attached (at filters) and unattached (SDB) radon decay products. These results are the average of 10 series of experiments. The total activity is divided equally at low aerosol concentration the ratio between attached fraction nearly 1. While the aerosols add into the radon chamber the, high aerosol concentration, fraction of unattached not more 10 % compared to 50-70 % at low aerosol concentration. Ninety presents of the total activity are collected in the analytical filters. Its mean that at high aerosol concentration the chance of attachment of radon decay products is very high. Although, there is no additional aerosols source inside radon chamber, but the activity size distribution with median diameters more than 200 nm have ~ 50 % of the total activity. This mean that the gross of particles inside the box has different factors not only aerosol concentration.

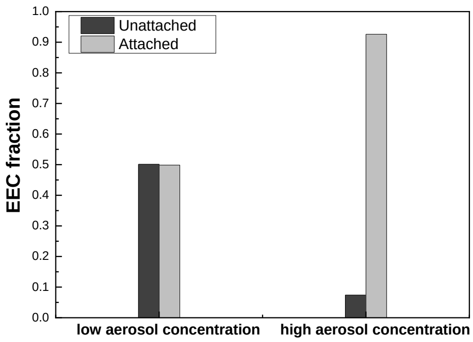

Figure 3. The radon Equilibrium Equivalent Concentration, EEC, at low and high aerosol concentration using diffusion battery and 3 AFA-RSP filters.

4. Conclusions

- At high aerosol concentration, fraction of unattached radon decay products not more 10 % compared to 50-70 % at low aerosol concentration
- 1 nm size mode of radon decay products completely disappear due to the attachment process at high aerosol concentration
- At high aerosol concentration the chance of attachment of radon decay products is very high.
- Although, there is no additional aerosols source inside radon chamber, but the activity size distribution with median diameters more than 200 nm have ~ 50 % of the total activity.
- The ratio between the fractions of the unattached and attached is in the range from 0.9 to 1.2 at low aerosol concentration and becomes from 0.09 to 0.14 at high aerosol concentration.
- To understand the movement and distribution of radon decay products, whole activity size distribution measurement system should be established with size range from 1nm to 10 µm.

References

[1] Yuness M, Mohamed A, AbdEl-hady M, Moustafa M and Nazmy H 2015 Effect of indoor activity size distribution of222Rn progeny in-depth dose estimation *Appl. Radiat. Isot.* **97** 34–9

[2] Yuness M, Mohamed A, Abd El-Hady M, Moustafa M and Nazmy H 2015 Indoor Activity of Short-Lived Radon Progeny as Critical Parameter in Dose Assessment *Solid State Phenom.* **238** 151–60

[3] Yuness M, Mohamed A, Nazmy H, Moustafa M and Abd El-hady M 2016 Indoor activity size distribution of the short-lived radon progeny *Stoch. Environ. Res. Risk Assess.* **30** 167–74

[4] Khalaf H N, Mostafa M Y A and Zhukovsky M 2019 Effect of electronic cigarette (EC) aerosols on particle size distribution in indoor air and in a radon chamber *Nukleonika* **64** 31–8

[5] Khalaf H N, Mostafa M Y A, Vasyanovich M and Zhukovsky M 2019 Comparison of radioactive aerosol size distributions (Activity, number, mass, and surface area) *Appl. Radiat. Isot.* **145** 95–100

[6] Khalaf H N B, Mostafa M Y A and Zhukovsky M 2018 Radiometric efficiency of analytical filters at different physical conditions *J. Radioanal. Nucl. Chem.*

[7] Nazmy H, Mostafa M Y A and Zhukovsky M 2018 Particle Size Distribution of E-Cigarette Aeroso ls in Indoor Air *J. Radiat. Nucl. Appl. An Int. J.* **3** 111

[8] Khalaf H N B, Mostafa M Y A and Zhukovsky M 2019 Radioactive aerosol permeability through Russian radiometric analytical (PF) filters *J. Radioanal. Nucl. Chem.* **319** 1283–9

[9] Nazaroff WW. 1980 An improved technique for measuring working levels of radon daughters in residences. *Health Phys.* **39** 683–8

[10] Zhukovsky M, Rogozina M and Suponkina A 2014 Size distribution of radon decay products in the range 0.1-10 NM *Radiat. Prot. Dosimetry* **160** 192–5

[11] Rogozina M, Zhukovsky M, Ekidin A and Vasyanovich M 2014 Thoron progeny size distribution in monazite storage facility *Radiat. Prot. Dosimetry* **162** 10–3