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RESEARCH ARTICLE

DETECTION EFFICIENCY OF ALPHA PARTICLES EMITTED BY ^{222}Rn AND ^{222}Rn PROGENY (^{218}Po AND ^{214}Po) IN THE AIR OF THE DIFFUSION CHAMBER UNDER THE INFLUENCE OF AN ELECTRET

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ABSTRACT

Detection efficiency of alpha particles emitted by radon-222 in the air of the diffusion chamber under the influence of an electrets have been carried out by using solid state nuclear track detector LR-115, type II. Electrets are the electrostatic equivalent of permanent magnet, having a permanent surface charge resulting in a surface potential that may be several KV. Electrets were used to attract radon progeny formed in a cylindrical shape diffusion cup where solid state nuclear track detector LR-115, type II was placed for the measurement of radon concentration. In this way the sensitivity of detector could be increased by bringing progeny just in front of detector in more convenient measuring geometry. It was found that the detection efficiency of α-particle emitted by radon only in the air of diffusion chamber increases with the distance at 5.45 Mev for five hours and ten hours respectively where as the detection efficiency of α-particle emitted by radon progeny in the air of diffusion chamber decreases with the distance at 6.49MeV and7.59MeV for five hours and ten hours respectively. Influence of distance between electret and detector on sensitivity of such equipment has been investigated theoretically. It was also found that in the analysis that the radon progeny ^{218}Po and ^{214}Po just have the same detection efficiency of 25% when the electret is closed to the LR-115 detector.

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INTRODUCTION

Radon (^{222}Rn) monitoring has become a global phenomenon due to its health hazard effects on population and therefore more attention has been paid in the recent years to the problem of ^{222}Rn. It is a radioactive gas that is present in trace amounts almost everywhere on the earth. It emanates from rocks, soils and gets distributed in the groundwater as well as in the lower atmosphere. Recent epidemiological evidence suggests that inhalation of radon decay products in domestic environments could be a cause of lung cancer (ICRP, 1993; UNSCEAR, 1993; Lubin *et al.,* 1995; NRC, 1999; WHO, 2007, 2008). It gives rise to considerable awareness of the^{222}Rn problem. Various methods are available for the measurement of radon (^{222}Rn) concentration. A traditional technique used to measure the radon abundance is the diffusion chamber. Diffusion chamber were often used for the measurement of radon concentration by using the solid state nuclear track detector CN-85(LR-115, type II).LR-115, type II SSNTD is considered more suitable and more advantageous than other commonly used solid state nuclear track detector (CR-39) known as Allyl-diglycol-carbonate ($C_{12}H_{18}O_7$). The use of CN-85 (LR-115, Type II) detector with diffusion chambers is the most reliable nuclear track methodology to measure the radon concentration. In order to prevent the entry of radon progeny, dust and humidity within the chamber, a filter membrane was used at the top of the chamber and making it pure radon measuring device. Detection efficiency of radon measurements with CN-85 LR-115, Type II) detector depends on different parameters such as detector size, manufacturing, chamber dimensions, shape of the chamber &detector and etching conditions (Nikezic *et al.,* 2004). Electrets are the electrostatic equivalent of permanent magnet, having a permanent surface charge resulting in a surface potential that may be several KV. Electrets ion detectors which contain an electro-statically charged Teflon disk are widely used for long-term radon measurement. Ions generated by the decay of radon strike and reduce the surface voltage of the Teflon disk. By measuring the voltage reduction, the radon concentration can be calculated. The amount of voltage drop on the electret provides an accurate correlation to the number of ions collected and hence the concentration of the alpha emitting isotope like radon (Khan 1975) and hence the concentration of the alpha emitting isotope like radon (Kasper, 1999). Electrets enable passive collection of progeny atom, making radon measurements independent on active devices. In this paper the detection efficiency of alpha particles emitted by radon (^{222}Rn) and radon progeny (^{218}Po and ^{214}Po) in air of the diffusion chamber under the influence of an electrets have been studied.

Experimental technique: The block diagram of the diffusion chamber is shown in figure 1. It is conical in shape and closed the top with some permeable filter material. The detector is positioned in such a way that only the radon gas diffuses into the chamber while the radon-thoron progeny, dust, humidity and water vapor are stopped by the thin film. This type of diffusion chamber is often used for the measurement of radon concentration (Nikezic *et al.,* 1997, 2002, 2004). The base and top radius of the chamber are respectively R_1= 2.5 and cm R_2 = 3.4cm.The height of the chamber H= 8.4cm was taken. The CN-85 (LR-115, Type II) detector film is made of a 12 µm thick red dyed cellulose nitrate emulsion coated on a 100 µm inert plastic base. It is extremely sensitive to alpha particles under energy of 4 MeV, to heavy ions and fission fragments but it is insensitive to photons with density varying from 1.3 to 1.6. NaOH is the chemical etchant normally used for CN-85 (LR-115, Type II). Electrets and a piece of 2.5 cm×2.5cm CN-85 (LR-115, Type II) detector was placed in conical shape diffusion chamber used for the measurement of radon concentration (Nakahara et al 1980). Radon enters into the chamber through the filter paper and decays within it. Elecret were used to attract radon progeny formed in a diffusion cup. In this way the sensitivity of the detector could be increased by bringing progeny in front of detector in more convenient geometry. The dependence of detection efficiency the distance between CN-85 (LR-115, Type II) detector and the electrets was considered in this paper.

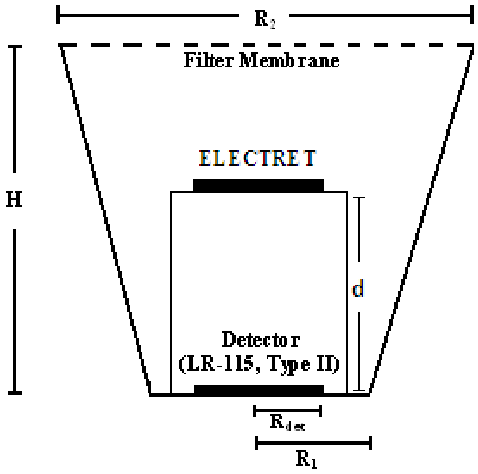

Figure 1. Diffusion chamber with the CN-85 (LR- 115, Type II) detector and Electret

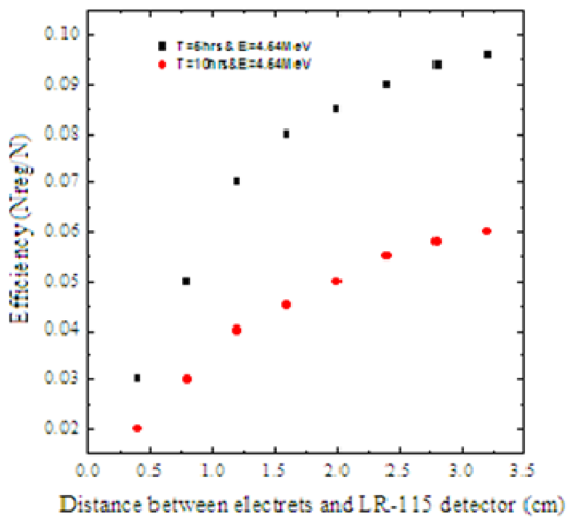

Figure 2: Variation of detection efficiency α-alpha particles emitted by ^{222}Rn only as a function of the distance between the electrets and LR-115 detector

RESULTS AND DISCUSSION

Experimental setup shown in the figure 1 was used in order to determine the detection efficiency of the radon and its progeny. In this type of setup electrets acts as a barrier for radon measurements preventing that some alpha particles emitted by radon itself and reach the detector.

Table1. Observed Detection efficiency of ^{222}Rn only for different distances between electrets and LR-115detector

Distance between electret &detector (cm)	Efficiency(Nreg/N) E = 5.45MeV	
	T=5hrs	T=10hrs
0.4	0.030	0.020
0.8	0.050	0.030
1.2	0.070	0.040
1.6	0.080	0.045
2.0	0.085	0.050
2.4	0.090	0.055
2.8	0.094	0.058
3.2	0.096	0.060

Table 2. Observed detection efficiency of ^{222}Rn progeny for different distances between electret and LR-115 detector

Distance between Electret & detector	Efficiency(Nreg/N)			
	E = 6.49MeV		E = 7.59MeV	
	T=10hrs	T=5hrs	T=10 hrs	T=5hrs
0.0	0.210	0.210	0.210	0.210
0.5	0.100	0.150	0.175	0.175
1.0	0.050	0.100	0.140	0.140
1.5	0.025	0.075	0.100	0.110
2.0	0.012	0.050	0.060	0.080
2.5	0.006	0.030	0.050	0.075
3.0	0.000	0.010	0.030	0.060
3.5	---	0.00	0.020	0.050
4.0	---	---	0.010	0.040
4.5	---	---	0.005	0.025
5.0	---	---	0.000	0.022
5.5	---	---		0.019
6.0	---	---		0.00

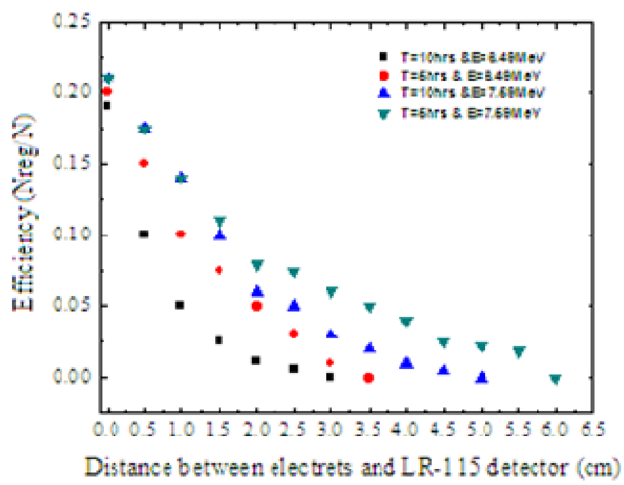

Figure 3. Variation of detection efficiency of α- particles emitted by radon progeny as a function of the distance between electrets and LR-115 detector

The dimensions of the diffusion chamber used in the present study was taken as with the base radius R_1=25 cm, top radius R_2= 3.4 cm and height H= 8.4 cm. The solid state nuclear track detector CN-85 (LR-115, Type II) detector and the filter membrane were placed on the bottom and across the top of the diffusion chamber respectively. When a radon enters into the diffusion chamber through the filter membrane, it is decay into it and short-lived products (progeny) are formed. One fraction of them decays into the air of the diffusion chamber, second fraction is deposited on walls of the chamber, while a third once is attracted by strong electric field of electret and deposited on it. It was found that the detection efficiency of the radon and its progeny depends on the distance between the electrets and solid state nuclear track detector (LR-115, type II).As the distance between electret and detector decreases, the detection efficiency smaller and smaller because of large screening and vice versa. Detection efficiency for the radon only was calculated for different distances between the detector and the electrets for different etching times. The detection efficiency of radon only as a function of distances between the elctret and solid state nuclear track detector (LR-115, type II) for different etching time 5 hours and 10 hours at energy 5.45MeV are given in the table1 and shown graphically in figure 2.

For the detection of alpha particles whether it is deposited or not on the electrets, computer software was used. Initially, it was found that the detection efficiency for radon only increases as the distance between the detector and electrets and after that it becomes constant. There is opposite behaviour have been also found for radon progeny ^{218}Po and ^{214}Po.The detection efficiency for radon progeny^{218}Po and ^{214}Po decreases with the increase of distance between electrets and LR-115 detector. The detection efficiency for radon progeny progeny ^{218}Po and ^{214}Po only as a function of distances between the elctret and LR-115, type II detector for different etching time 5 hours and 10 hours at energies 6.49MeV and 7.59 MeV was given in the table 2 and it is shown graphically in figure3.It was found that in the analysis that the radon progeny ^{218}Po and ^{214}Po just have the same detection efficiency of 25% when the electrets is closed to the LR-115, type II detector. This detection efficiency is significantly smaller than expected 50%. This is due to fact that the critical detection angle 60^0 was taken in our calculation with respect to the detector surface so that a large number of randomly emitted particles will be between 60° and 90° than between $0^0$and 60^0.

Conclusion

Experimental arrangement shown in the figure 1 was used to determine the detection efficiency of the radon and its progeny. In this type of arrangement electrets acts as a barrier for radon measurements preventing that some alpha particles emitted by radon itself and reach the detector. The observed values of detection efficiency of α-particle emitted by radon only and its progeny are given in the table 1&2 respectively. It was found that the detection efficiency of α-particle emitted by radon only in the air of diffusion chamber increases with the distance for etching time five hours and ten hours respectively at energy 5.45 Mev where as the detection efficiency of α-particle emitted by radon progeny in the air of diffusion chamber decreases with the distance for etching time five hours and ten hours respectively at 6.49MeV and7.59MeV. So by suitable choice of the distance between electret and LR-115detector one can perform optimization of this kind of device.

It is assumed that in the analysis that all progeny atoms were attracted and deposited onto the electrets but the attraction efficiency might be different and much smaller than hundred percent as it depends on the discharging rate. It was also found that in the analysis that the radon progeny ^{218}Po and ^{214}Po just have the same detection efficiency of 25% when the electrets is closed to the LR-115, type II detector.

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