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ChargingE-perm for radon measurements

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HIGHLIGHTS

- Poling charging method was used to recharge the electret detectors.
- Applying the chosen parameters were enough to reuse recharged electrets.
- Similar response was obtained when compared with CR-39 for radon measurements.

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ABSTRACT

Recharging of commercial E-perm electret detectors used for radon measurement has been investigated. The E-perm was recharged using the poling charging method where a high voltage is applied on a metal nozzle to polarize the electret material. The optimum parameters to recharge the electrets were 5 kV charging voltage and 7 mm height of the nozzle from the electret surface and using an insulator while charging. Under these conditions, charging of E-perm carried out for 15 s attained required voltage and retained the charge for long durations. The response of recharged E-perm for radon activity measurements in a radon calibration chamber and in an open environment was compared with that of CR-39 detectors. Results showed close proximity in radon values.

1. Introduction

Radon gas is the second cause of lung cancer to the general population, after smoking (Zeeb and Shannoun, 2009). Epidemiological studies have provided convincing evidence of an association between indoor radon exposure and lung cancer, even at the relatively low radon levels commonly found in residential buildings. World Health Organization WHO has established the International Radon Project in 2005 to identify effective strategies for reducing the health impact of radon and to raise public and political awareness about the consequences of long-term exposure to radon (Zeeb and Shannoun, 2009; International Atomic Energy Agency (IAEA) and International Labor Office (ILO), 2003).

Several methods for measuring radon decay products were developed to measure radon gas in underground, outdoor and indoor environments. Today, emphasis is on direct radon gas measurements rather than radon decay products (George, 2008). Direct radon measurements are simple, convenient and practical for good estimate of radiation exposure of the general public in timely fashion (International Atomic Energy Agency (IAEA) and International Labor Office (ILO), 2003); George, 2008).

Many techniques are available for radon measurement in dwellings and workplaces:

1. Passive solid state nuclear track detectors (SSTD) (Zeeb and Shannoun, 2009; International Atomic Energy Agency (IAEA) and International Labor Office (ILO), 2003); United States Environmental Protection Agency 2007; Gorge, 1996; Doi et al., 1992).
2. Activated charcoal (Zeeb and Shannoun, 2009; International Atomic Energy Agency (IAEA) and International Labor Office (ILO), 2003); United States Environmental Protection Agency 2007; Urban and Piesch, 1981; George, 1984; US Environmental Protection Agency 1990).
3. Electret ion chamber (E-Perm) (Zeeb and Shannoun, 2009; International Atomic Energy Agency (IAEA) and International Labor Office (ILO), 2003; United States Environmental Protection Agency 2007; Gorge, 1996; Doi et al., 1992; Urban and Piesch, 1981; George, 1984; US Environmental Protection Agency 1990; US Environmental Protection Agency, 1992).

It is reported that 30% of all measurements in USA were performed using the electret ion chamber method (Kotrappa et al.,

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1988). Unlike in other methods, this method is found to have no adverse effect on the measurement due to humidity, temperature or air draft (Kotrappa et al., 1988, 1990).

Two different types of electret (identified by different colored labels) can be used for radon measurement (Rad Elec Inc and Frederick., 1991):

- Short-term measurement electret has a high sensitivity and it is identified by a green or blue label and has a white disk (used in this work).
- The less sensitive electret used for long term measurements has a red label and a black or silver disk (not used in this work).

The electrical charge of the electret decreases when charged ions created by radiation are collected on the electret surface. A measure of the difference in voltage of electret surface before and after exposure to a sampling environment is correlated with the concentration of radon in the sampling atmosphere. Charge depletion of the electrets warrants for periodic charging of the electrets for repeated use. Thus it becomes important to find a viable method for easy and fast charging of the electrets for repeated measurements of radon in sampling sites. The present work is aimed at finding a suitable method for charging the electrets more effectively and efficiently. The charged electrets by the present method is used in field experiments and compared with conventional methods for radon measurements.

2. Charging methodology

Poling technique was used for charging the electrets (blue and green labels). In this technique, one surface of the electret is held firmly to an earthed metal plate acting as one electrode and the other free surface (the sensitive part of the electret) is faced a chrome rod of 20 cm length and 3 mm diameter with sharpened end point acting as the second electrode.

Electrets were charged by exposing them to an electrical field (DC high voltage) situated directly above the electret surface Fig. 1. The electrical field will polarize the electric dipoles in the electret material to form bound induced charges. Technically, when a dielectric is placed in an electric field, electric charges do not flow through the material as they do in a conductor, but only slightly shift from their average equilibrium positions causing dielectric polarization. Because of dielectric polarization, positive charges are displaced toward the field and negative charges are shifted to the opposite direction to form bound inducted charges.

Two methods were used for the charging process. *The first method* was carried out by applying electrical fields (1–7 kV) slowly and gradually for the charging time at a fixed nozzle height (7 mm) from the electret surface as shown in Fig. 1a. *In the second method*, an insulator plate (15 cm × 30 cm Plexiglas plate of 3 mm thickness) was inserted in the gap between the nozzle and the electret surface. The voltage was raised from zero to a predefined value (say 5 kV). The plate was then removed for a short time (charging period) and then re-inserted in the gap before the high voltage has been decreased to zero as shown in Fig. 1b.

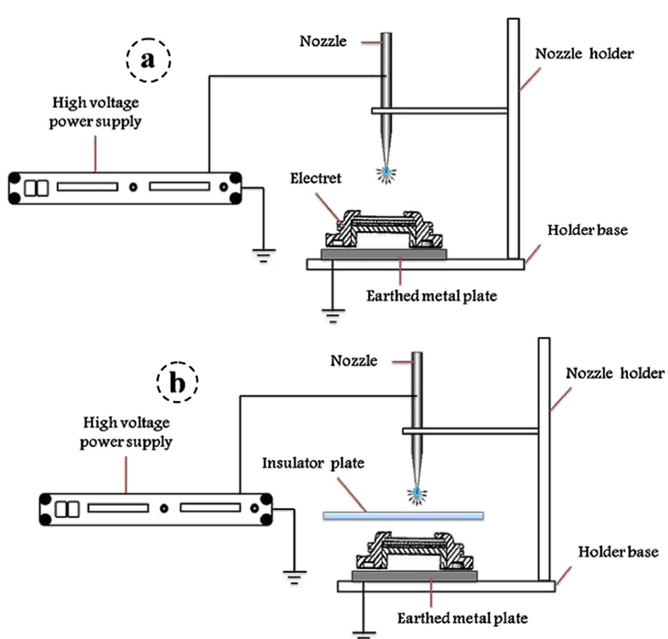

Fig. 1. Experiment set-up.

3. Results and discussions

3.1. Stability test

The stability of the charge on the recharged electrets was studied by measuring the charge using electrets voltage reader, at different times after completion of the charging process by the two charging methods (with and without insulator).

The results showed that the electrets were not getting charged when the applied voltage was below 3 kV and charging carried out with or without the insulator plate. But, when charging with higher applied voltage (up to 7 kV) without using insulator, the stability of the charge was found to be very poor. This could be explained by the phenomenon that the charging process is divided into three phases: **1**- the applied voltage increases gradually up to the desired voltage, **2**- the applied voltage is stable for the charging period, **3**- the applied voltage decreases also gradually to zero at the end of charging period. This process seems to have a negative effect on the stability of the charge as shown in Fig. 2. It can be noticed that the charged electret held less than 50% of its initial voltage after about 8 days.

Further experiments were carried out for studying the charge stability under a different charging set up. Charging voltage was limited to 5 kV and an insulator was inserted while charging the electrets. Electrets were charged for different charging durations (15 s, 1, 2, 3, 4 and 5 min). Fig. 3 shows the results obtained. This

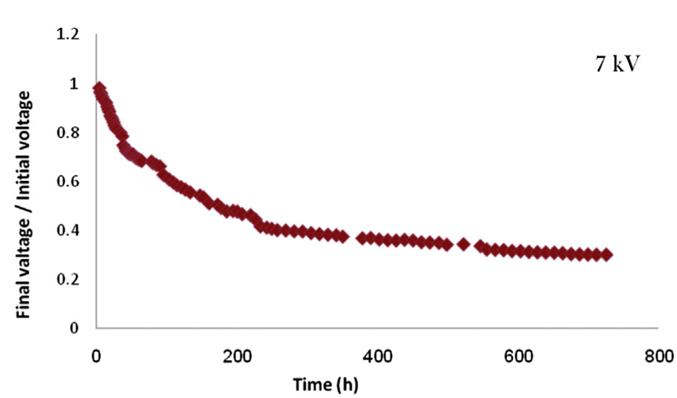

Fig. 2. Stability study without insulator plate.