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Calibration of Cellulose Nitrate ($C_6H_8O_8N_2$) Solid State Nuclear Track Detector CN-85 (LR-115, Type II) for the Measurements of Radon concentration

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Abstract: *A solid state nuclear track detector or SSNTD (also known as an etched track detector or a dielectric track detector, DTD) is a sample of a solid material (Photographic emulsion, crystal glass or plastic) exposed to nuclear radiation (Neutrons or charged particles, occasionally also gamma rays).Solid state nuclear track detectors (SSNTD) are widely used for radon measurements and CN-85 (LR-115, type II) is one of the most popular solid state nuclear track detector (SSNTD). Calibration is imported because it's the only way of evaluating the precession and accuracy of an instrument and making adjustments such that no errors occur in the readings. The main objective of this work is to calibrate the detector and also determine the calibration factor for the measurements of radon concentration through the passive method with CN-85 (LR-115) detectors.*

Keywords: *SSNTD, Calibration Factor, Environmental Radon, Alpha Tracks*

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I. Introduction

Radiations have always been a part of our natural environment. Human beings are always exposed to natural radioactive radiation present in the environment. The natural radioactivity is the main component to human exposure. Radon (^{222}Rn) and their short lived decay products are recognized as the most important contributors to committed effective dose received by population due to natural sources[1]. Radon and its short-lived decay products in the environment play the most important role to human exposure from natural sources of radiation. Radon is a naturally available radioactive gas, which is the decay product of radium. The possibility of cancer induction due to indoor radon has been attracting attention in the scientific community during the past decades. It is now wieldy recognized that indoor radon is a largest single source of exposure to ionizing radiation in the environment[2]. For the population as a whole, the average effective radiation dose from radon is estimated to the greater than the dose from all other natural sources of radiation combined, greater than the dose from industrial activities including nuclear power and the dose from medical treatments including x-ray. It is well known that inhalation of the short-lived decay products of radon and their subsequent deposition along the walls of various airways of the bronchial tree, provides the main pathway for radiation exposure to the lungs. Indoor radon and its decay products are assumed to be health hazardous for human.

The environmental radon concentration changes significantly and rapidly with time and also it is a function of weather conditions. SSNTDs are passive, low cast, long term method, most widely used for measuring radon concentration and can be used for site assessment both indoors and outdoors. These detectors are sensitive to alpha particles in the energy range of the particles emitted by radon. The emitted alpha particles damage the tracks in the detector surface. When a charged nuclear particle enters the plastic it creates a trail of radiation damage along its path, known as a latent track. The CN-85 solid state nuclear track detector has good ionization sensitivity, high degree of optical clarity and stability against various environmental conditions. Because of these characteristics, CN-85 has become the state-of-the-art track detector for the monitoring of environmental radon concentration[3, 4, 5, 6]. Public exposure to radon and its radioactive daughters present in the environment results in the largest contribution to the average effective dose received by human beings (Fleischer et. al, 1981)**.** The main objective of this work is to determine the calibration factor for the measurements of radon concentration through the passive method with CN-85 (LR-115) detectors[7, 8, 9, 10].

II. Experimental Technique

Although several active and quick methods are known for short term radon measurement, it is preferred to make long term time integrated measurements using passive alpha sensitivity plastic detectors[11]. This preference is due to the fact that the radon concentration inside dwellings and also in the open atmosphere are found to vary with several factors viz. the ventilation rate, presence and direction of wind, seasonal and weather conditions etc. The short term measurement does not give a value which may be taken as representative for calculating the average effective dose equivalent needed for the assessment of health hazards likely to be caused by constant inhalation of radon and its daughters. Long-term radon measurements with active devices are very tedious and expensive. The choice of the passive, relatively simple and less expensive. Plastic track detectors are evidently more advantageous. It is also facilitates data collection at several locations simultaneously.CN-85(LR-115, type II) plastic detector is considered more suitable for radon concentration measurement. The experimental setup for the calibration of CN-85 (LR-115, type II) solid state track detector is shown in the figure 1.The CN-85 detector was put in and adopted Luca cell and exposed to standard radon concentration through the Pylon Model RN-150 flow through gas source during approximately four to five days[12, 13, 14, 15]. The RN-150 contains a solid radium (^{226}Ra) source. It provides 100% emanation to radon gas source when the ambient temperature and pressure are respectively lies between -20ºC & 50ºC and between 0 & 3 atmospheres. When equilibrium is reached, the Pylon source dispenses a standard radon concentration of 15.2 kBqm^{-3} into the adapted Lucas cell with a CN-85 detector. The Rn-150 is operated with a vacuum hand pump. Under different atmospheric pressure, a precision manometer is provided for cross calibration with vacuum gauge.

After the completion of exposure time the detectors were, were etched for two hours in 2.5N NaOH solution maintained at 60 ^{0}C in constant temperature bath and scanned in the laboratory for the track density using spark counter. The measured track densities for indoor radon, is then converted into radon activity concentrations (Bqm^{-3}) by applying the calibration factor for LR-115 type II bare detector. For the calculation of radon concentration, it is necessary to know the track density (track per cm^2 in detector surface), the exposure time and the calibration factor that converts the track density to radon concentration.

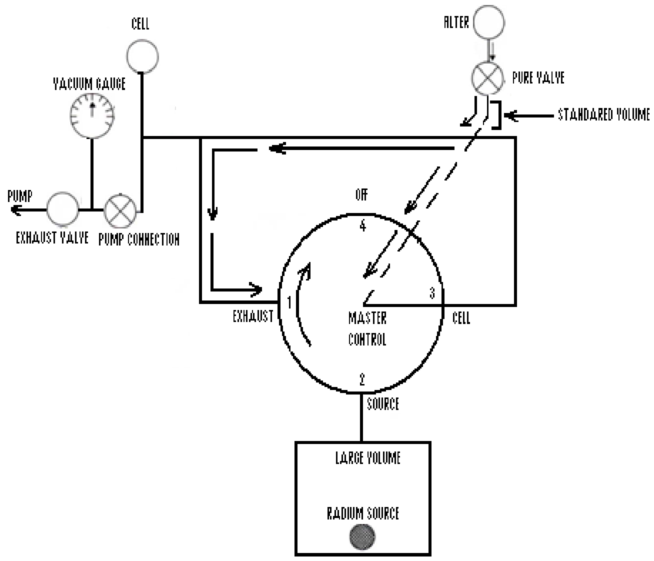

Figure 1: Experimental setup for the calibration of CN-85 SSNTD

The calibration factor was determined through the relation between standard radon concentration, track density and exposure time

$$K= \rho/(C_{Rn} .T)$$

Where K is known as sensitivity factor or calibration factor, C_{Rn} is the Standard radon concentration in Becquerel per cubic meter (Bqm^{-3}), ρ is the track density in track per square cm (tr.kcm^{-2}) and T is the time of exposure in days.

III. Result and Discussion

The calibration factor 'K' for CN-85(LR 115, Type-II) detector was calculated using equation (1). Four solid state nuclear track detectors (SSNTD) were exposed to the standard radon concentration. The average value of the calibration factor 'K' and its standard deviation are given in the table 1.The calibration factor was found $2.84\times10^{-2}\pm4.52\times10^{-3}$ tracks cm^{-2}Per Bqm^{-3}d, $2.78\times10^{-2}\pm4.49\times10^{-3}$ tracks cm^{-2}Per Bqm^{-3}d, $2.90\times10^{-2}\pm4.53\times10^{-3}$ tracks cm^{-2}Per Bqm^{-3}d and $2.87\times10^{-2}\pm4.53\times10^{-3}$ tracks cm^{-2}Per Bqm^{-3}d for sample 1 sample 2 sample 3 and sample 4 respectively with an average value of $2.847\times10^{-2} \pm 4.52\times10^{-3}$ tracks cm^{-2} Per Bqm^{-3}d. The result obtained shows a good agreement with other literature values for the same type detector[16, 17].

Table no. 1: CN-85 Average calibration factor

SSNTD(CN-85) (LR-115, Type II)	**Calibration factor (K) (tracks cm^{-2}Per Bqm^{-3}d)**
Sample1	$2.84\times10^{-2}\pm4.52\times10^{-3}$
Sample2	$2.78\times10^{-2}\pm4.49\times10^{-3}$
Sample3	$2.90\times10^{-2}\pm4.53\times10^{-3}$
Sample4	$2.87\times10^{-2}\pm4.53\times10^{-3}$
Average	**$2.847\times10^{-2}\pm4.52\times10^{-3}$**

IV. Conclusions

The calibration factor 'K' depends upon the geometry of the configuration, the type of track detector, the etching conditions used and the active volume of alpha monitoring devices. The result obtained shows a good agreement with other literature values for the same type detector[16, 17]. For the determination of calibration factor four exposures were made at the moment. Later more detectors will be exposed to the radon source in order to establish the calibration factor.

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