Feasibility of online $^{222}Rn/^{220}Rn$ progeny monitor through alpha spectroscopy

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Introduction

The radioisotopes ^{222}Rn and ^{220}Rn which are the decay products of U and Th series contribute to a major fraction to natural background dose [1]. Being radioactive gases, they enter human body through inhalation, followed by deposition of the progeny particulates in the respiratory tract, thereby contributing to the inhalation dose due to the emission of energetic high LET alpha particles by the short lived progenies ranging from 5.5 to 8.78 MeV. Therefore, it is necessary to measure the progeny concentration accurately in-order to calculate the inhalation dose. Although passive Direct Radon and Thoron progeny sensors (DRPS and DTPS) [2] are being widely used for progeny measurements, yet development of an online progeny monitor will be very helpful in the situations like accidental exposure where immediate results are sought. In the present work, we have carried out the feasibility study to indigenously develop an online radon progeny monitor using Si surface barrier detector.

Design of the Progeny Monitor

The proposed $^{222}Rn/^{220}Rn$ progeny monitor consists of a progeny sampler, a Si detector and the detector electronics. The schematic diagram of the progeny monitor is shown in Fig 1. The Si detector used in this study is a surface barrier detector with thickness of 100 μm and energy resolution of 32 KeV. Since Si detector has good energy resolution and 100% detection efficiency, it can be used for alpha spectroscopy. A cylindrical progeny sampler was designed (dia. 45 mm, height 20 mm) in which a Filter Paper (FP) can be placed at one end and the detector can be placed at the other end facing the FP. Small holes of diameter 2 mm were made in the body of the sampler for passing of air in to the sampler. This sampler has to be connected to the pump for sampling of air so that the progeny particles will be deposited on the FP and the alphas emitted by these progenies will be counted by the Si detector with proper signal processing and data acquisition system.

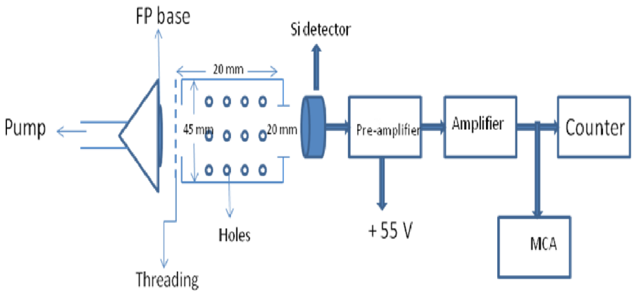

Fig1. Schematic diagram of the progeny monitor setup

Experimental Details

The response of the Si detector to alpha particles in air was first tested using Th-229 disc source. The source was placed at the FP position in the sampler while keeping the Si detector at the other end. A bias voltage of +55 V was given to the detector. The detector readout signal was connected to a preamplifier, amplifier and then to ADC. In each event, the pulse height information was recorded using a CAMAC data acquisition system. A typical alpha spectrum measured in air is shown in Fig 2 (a). Using this spectrum with known alpha energies of Th-229, the energy calibration of the system was carried out which is shown in Fig 2 (b). Then the Th-229 source was replaced with FP and the progeny monitor was tested in normal environment simulated in a 0.5 m^3 calibration chamber using 52 g of thorium nitrate powder as source of ^{220}Rn. The air mixed with ^{220}Rn source was sampled at a flow rate of 2 lpm for 30 minutes through this sampler and the FP was counted and the spectrum was recorded.

Results and Discussion

The spectrum obtained with Th-229 disc source is shown in Fig 2 (a) which shows four well resolved peaks corresponding to alpha energies of 5.8 MeV, 6.3 MeV, 7.1 MeV and 8.4 MeV emitted by the Th-229 source. In the 2nd case, in the spectrum obtained from the FP sampling in a calibration chamber with thoron source, two distinct peaks with long tail were observed at energies about 6.2 MeV and 8.8 MeV instead of three peaks as shown in Fig 2 (c). The peak due to 6.78 MeV energy may have merged with the 6.29 MeV energy peak since energy difference between them is very less and the sampling was carried out in air. The long decay tail of the peaks is due to the energy degrade of the alpha particles while passing through the air [3].

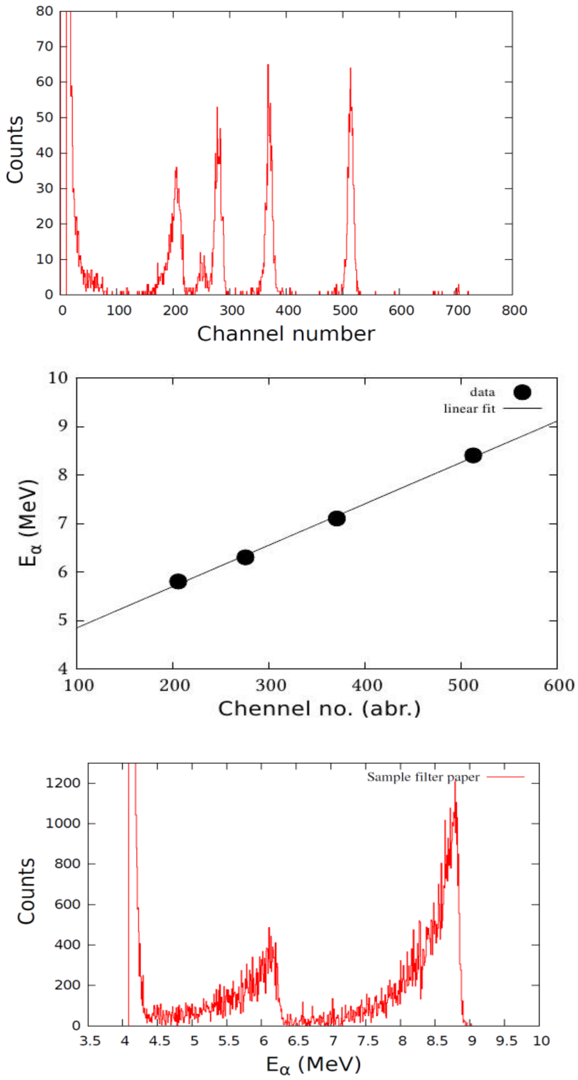

Fig 2. (a) Spectrum of Th-229 disc source (b) Energy Vs Channel no. calibration curve (c) Spectrum of FP sampling with ^{220}Rn source in a calibration chamber

The well resolved alpha peaks in air using the Si detector demonstrates its application for suitable $^{222}Rn/^{220}Rn$ progeny monitor.

In the present exposure condition, the integrated counts per second (CPS) under the 6.2 MeV and 8.8 MeV peaks were found to be 15.36 and 25.24 respectively after a delay time of 15 minutes. By repeating this experiment with varying known concentration of thoron progeny and analyzing the integrated counts under these 2 peaks a calibration factor could be established. This calibration factor will be used to calculate the unknown progeny concentration. The uncertainty in the measurement of progeny concentration will be less as the detector efficiency is very high. This monitor will be very useful where instantaneous measurement of progeny concentration is required.

Conclusion

Towards the development of an online $^{222}Rn/^{220}Rn$ progeny monitor, a prototype monitor was designed using alpha spectroscopy technique. The response of the monitor was tested using a standard source of known activity and then the monitor was tested in a normal environment simulated inside a calibration chamber. The spectrum showed well resolved peaks and by analyzing the integral counts under these peaks with varying known progeny concentrations a calibration factor could be established. This monitor will serve as a fast measurement technique of $^{222}Rn/^{220}Rn$ progeny concentration.

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