Radon Adsorbed in Activated Charcoal as a Tool for Teaching Radioactivity

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INTRODUCTION

The knowledge about radioactivity and radiation is best imparted while in school, which radioactivity and other concepts of introductory nuclear physics form an important part of schools' science curriculum [1] and science based undergraduate syllabi. However, many schools do not have the necessary equipments and materials for teaching nuclear physics. There are also a couple of legislations guiding the use and storage of radioactive materials that must be complied with. In addition, many students are apprehensive about handling radioactive substances. These problems can be circumvented, e.g. by creating opportunities for students and their teachers to visit and use facilities available in designated centers like relevant research institutes and university departments [2].

APPARATUS AND MATERIALS REQUIRED FOR THE EXPERIMENTS

Radiation (Gamma-ray) source

The experimental procedures presented here do not employ artificial radiation sources. Instead, the procedure exploits the adsorptive property of activated charcoal (70 g contained in a canister, Figure 1) to adsorb radon from indoor air, and subsequent radioactivity of ^{222}Rn and its decay products; ^{214}Pb and ^{214}Bi.

Gamma-ray spectrometer

A typical NaI detector with MCA is used inside lead shield (to reduce background and allow the detection of low level radioactivity).

EXPERIMENTAL PROCEDURE

Buildup of ^{222}Rn radioactivity in exposed charcoal canister

The charcoal canister was opened and placed on top of the NaI(Tl) detector inside the lead shield (Figure 1 Left). As the charcoal continued to adsorb radon gas, the buildup of radon in the charcoal was monitored by recording the gamma-ray spectra hourly (or every few hours) over the entire exposure period (up to 9 days). The net counts (after subtracting the background counts) in the energy regions from 242 to 609 keV are plotted as a function of time (Figure 2). Number of detected gamma-rays (count) increases rapidly within the first 50 hours of the exposure, indicating that radon production through adsorption exceeded losses through radioactive decay.

Decay of ^{222}Rn radioactivity in exposed charcoal canister

To demonstrate the radioactivity decay law, the canister was sealed and replaced on top of the same detector (Figure 1 Right). Successive measurements of gamma-ray counts were carried out at different times as the decay continued. A plot of the counts versus time shows an exponential decay (Figure 3). This plot can be manipulated to determine the half-life of radon: $N(t) = N(t = 0) \times Exp\ -(0.692\ t/T_{½})$

Figure 1 Photographs showing (left) open charcoal canister on top of the NaI detector (right) closed charcoal canister on the detector.

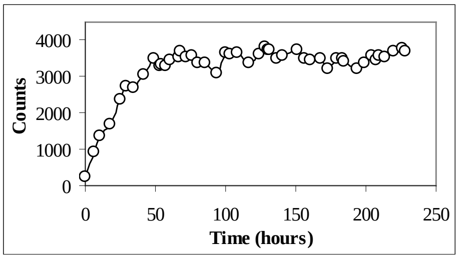

Figure 2 Counts of gamma-rays as a measure of radon buildup in the canister versus exposure time.

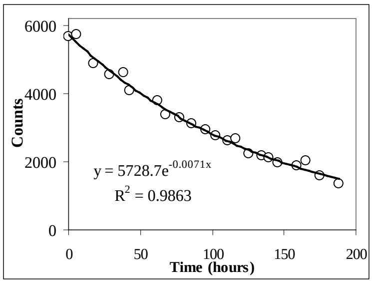

Figure 3 Variation of gamma-ray counts with time due to the decay of radon in the sealed canister.

REFERENCES

[1] CLEAPSS 2008 Managing ionizing radiations and radioactive substances in schools, etc L93, CLEAPSS (2008).

[2] Johansson K. E., Nilsson Ch., and Wachtmeister S. 2007. Measuring radon in air, soil and water—an introduction to nuclear physics for schools. Physics Education **42 (3)**, 281-288.

SUMMARY

The experiments presented in this paper could be easily adopted in the curriculum of physics laboratory teaching for schools and undergraduate students. These experiments would help the students to visualize and familiarize themselves with natural sources of environmental radioactivity, in general, and radon in particular. In addition, the students will learn practical radioactivity buildup and decay, which are the basic aspects of introductory nuclear physics. The availability of the radon gas everywhere and the simple way to collect it through the adsorption in activated charcoal presents a safer and simpler alternative radiation source that can be used in teaching and demonstration. This natural radioactive source does not require regulatory control, and the students are not apprehensive of their safety while working with it.