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Radioactivity Measurements for Some Ophthalmic Glasses

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ABSTRACT

The main aim of the present work is to implant the latest ICRP/IAEA recommendations related to exemption and clearance to the Ophthalmic Glass. As consumer product, glass lenses may contain trace quantities of uranium, thorium and potassium. Glass lenses under investigation were monitored for the detection of gamma rays and beta particles using radiation measuring devices.

Using high purity germanium detector radioactivity concentration was estimated in Bq/kg. Activity concentration of Ra-226, Th-232 and K-40 were determined using the energy gamma lines of ^{214}Pb (352 keV), ^{212}Pb (238 keV) and 1460 keV gamma line for ^{40}K respectively.

Keywords: *Radioactivity, consumer products, ophthalmic glass, HPGe detectors.*

INTRODUCTION

Ophthalmic glass manufacturing process includes mixtures of rare earths and zirconium oxides, which contain low level of radioactivity concentrations from natural uranium and thorium. (1)

Because uranium and thorium are distributed widely in the earths crust and are present at very low levels in practically all sands and other raw materials used in ophthalmic glass manufacture. So some background activity can be expected in all samples.

Gamma radiation from these radionuclides represents the main external source of irradiation of the human body and the eye is an organ in the human body. Evaluation of activity concentrations of the ^{238}U, ^{232}Th and ^{40}K released from the ophthalmic glass is our main goal in this work.(2)

The aim of this work is to measure the radioactivity concentrations of uranium, thorium and potassium in some ophthalmic glasses and to compare these results with those published and regulated according to exemption and clearance levels.

In the exemption criteria; practices and sources within practices may be exempted from the requirements of the Standards, including those for notification, registration or licensing. (3)

EXPERIMENETAL WORK

Detection System Setup

In this work, a digital nuclear radiation monitor (Radalert inspector) was used to count the sixty nine samples for all kind of radiations.

The energy and intensity of various gamma ray lines have been measured using an ORTEC coaxial (HPGe) detector of relative efficiency 50% coupled to a 4096 channel analyzer. The full width at half maximum(FWHM) was found to be 1.9 keV for ^{60}Co –1332 keV gamma ray line. For accurate

energy determination the spectrometer was calibrated using gamma ray lines of different standard sources.

The energies of the various gamma peaks were obtained by least square fit of the data. The area under the full energy peaks was calculated and corrected for absolute detector efficiency to give activities of the samples.

Sample Handling and Counting

Samples Counted Using Survey Meter

Beta –gamma radiations were counted using a digital survey meter, all 70 samples were exposed directly to be counted as it is without any change as it was used by consumers. Samples were counted 3 times and the background was taken into account in our calculations.

Samples Measured Using HPGe Detector

Four samples were measured using high purity germanium detector to measure the radioactivity concentrations in Bq/kg. Activity concentration of ^{226} Ra was determined using the energy gamma lines of ^{214}Pb (352 keV). While that of ^{232}Th was obtained from gamma lines of ^{212}Pb (238 keV). The ^{40}K activity concentration was finally determined using the 1460 keV gamma line. Assuming the equilibrium between uranium and thorium and respective daughters.

The obtained spectrum of the background gamma radiation was subtracted from the measured gamma ray spectra of each sample. Fig (1) shows the spectrum of one sample.

The spectra of all samples were perfectly analyzed using PC software program gamma-vision (GV32) to calculate the activity concentrations of the three radionuclides of interest. Furthermore; we used SPSS for statistics of frequency distribution for counts of glasses.

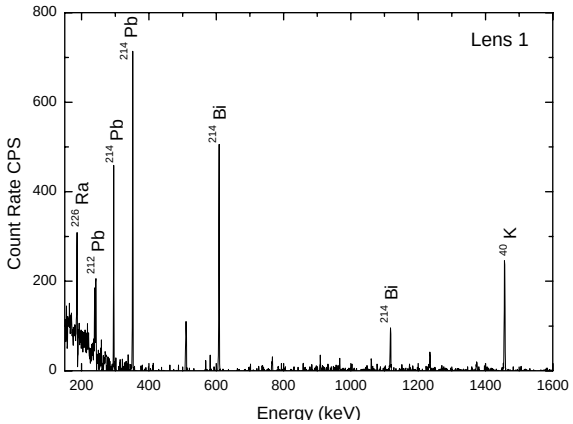

Fig 1: Typical gamma-ray spectrum measured for sample (lens 1). The important photopeaks are shown

The activity concentrations of the natural radionuclides in the measured samples were calculated using the following relation [(4)]:

$$A_s\left(Bq\ /\ kg\right) = C_a\ /\ \varepsilon \times P_r \times M_s \quad \textbf{(1)}$$

Where C_a is the net gamma counting rate (counts per second), ε the detector efficiency of the specific gamma-ray , P_r the absolute probability of gamma decay and M_s the mass of the sample (kg).

RESULTS AND DISCUSSION

Results Obtained Using Nuclear Radiation Monitor

Background radiation was measured to be 37.0 ± 1.0 cpm. The background radiation was subtracted from the count of each sample.

The revealed results showed that the maximum value was 69.7 cpm/unit while the minimum value was 1.3 cpm/unit. The average value is 29.2 cpm/unit. The frequency distribution of the cpm for glasses is shown below fig. 2.

From the obtained data, it is cleared that the results were fluctuated and there are values twice background radiation and other below it. It depends upon the chemical composition and the manufacturing process of the samples and this will be studied in the near future research using another advanced radiation measurement techniques.

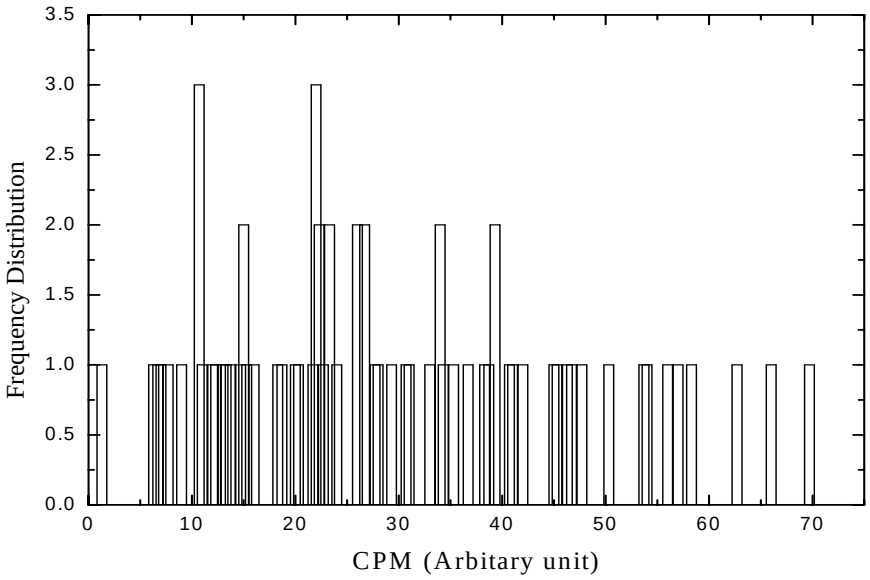

Fig 2: Frequency distribution of the counts of glasses

Results Obtained Using HPGe Detector

Activity concentrations in Bq/kg of thorium, uranium and potassium were calculated and the revealed data are shown in table 1. the results showed that the minimum activity concentration was recorded for L4 to be 0.0006 Bq/g and the maximum value for L1 to be 0.00861 Bq/g.

Table 1: Activity concentration (Bq/g) for thorium, uranium and potassium.

Sample	Activity concentration (Bq/g)		
	Thorium	**Uranium**	**Potassium**
L1	0.00283	0.00498	0.0008
L2	0.00118	0.00204	0.00113
L3	0.00029	0.00019	0.00021
L4	0.00018	0.00021	0.00016

Comparing the obtained results of radioactivity concentrations for the samples of the ophthalmic glasses with regulated by the Egyptian Regulations [5], ICRP-2005 draft [6] and IAEA safety series, 115 [3]; it is clear from table 2 that the revealed results are below the levels of exemption and clearance.

Table 2: Exemption levels of the three radionuclides of interest

Reference	Exemption levels of three radionuclides of interest (Bq/g)		
	Thorium	**Uranium**	**Potassium**
Egyptian Regulations	Less than 1	Less than 1	4
ICRP-2005 draft	1	1	10
IAEA Standard SS-115	1	1	100

CONCLUSION

It is obvious from the obtained data that some ophthalmic glass samples contain amounts of radioactive materials and they are less than regulated and recommended as shown in table 2.

Use of high purity germanium detector as a detection technique is convenient to measure the activity concentrations in such samples to detect the gamma photons for particular radionuclides with bigger weight.

Further studies should be made to detect the emissions of alpha and beta particles and classify the samples according to chemical composition and manufacturing companies.

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