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Radioactivity Measurement on Dental Resin Composites

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Radioactivity is mainly due to natural ones from earth and also from outside of the atmosphere so-called cosmic radiation. Although radiation sources and their dose effect on humans are known, there is still some conflict on their health effect especially on dental restoration. The limited data for radioactive dental materials and their potential risks for patient makes those materials interesting to be investigated. For this purposes, uranium, thorium and potassium activity have been measured in some dental restorative materials, such as resin composites containing silica and zirconia particles as filler loading, using gamma spectrometer system with NaI(Tl) detector.

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1. Introduction

Natural radiation has occurred since Big Bang due to the long-lived radioisotopes especially in the earth sourced materials and also the cosmic rays from space can contribute to the natural radiation. Background radiation is defined by adding man making radiation due to development of technology to those natural radiation. Thus uranium and thorium concentration can be seen in the earth sourced matter and those can be varied with the location.

Natural teeth show some fluorescence characteristic, especially because of the dentin layer containing organic material [1]. In order to mimic the optical properties of living natural teeth, natural radioactive elements such as uranium and natural or depleted uranium salts were added into porcelain powder, used in the construction of artificial porcelain dental crowns-bridges prosthesis [2–4]. Used in dentistry the concentration of uranium in porcelain teeth and porcelain powder and the dose rate absorbed by the oral mucosa has been investigated in several studies [5–9]. In a study conducted in Sweden prosthesis porcelain teeth in different brands available on the market in amounts ranging from 15 to 186 ppm uranium content was determined [10] and stopping the use of dental ceramics containing over 100 ppm uranium were requested [2]. Then fluorescence inside the porcelain powder radioactive elements are replaced by alternative materials [11, 12].

While the radiation can be used from medicine to agriculture, higher dose can be detrimental for tissues. The natural radiation sources and average annual dose from these natural sources are well known. However, there is very little data about irradiation from dental restorations containing natural radioactive materials. Since the irritation level depends on natural radionuclide concentrations present in the dental materials, the activity concentration in such dental restorative materials is extremely important for documentation of radiation exposure levels from dental restorations.

The lack of data on the relationship radioactive dental materials and potential risks for the patient is a major uncertainty constraining conclusions about biocompatibility of such materials. Another open question about this issue is a possible trend towards modern radioactive dental materials, particularly with regard to the problems which might occur for dental technician and dentist.

It is aimed to investigate different types of materials used for dental prosthetics restoration, including feldspathic ceramics, glass ceramics, zirconia-based ceramics, and materials used for coronal fillings of the tooth, including resin composite, post-core materials and materials used for tooth replacement, including dental implants with regard to content of natural radionuclides by means of gamma spectrometry.

Thus, it is aimed to measure natural radiation and to determine dose rate due to those radiation for some dental materials used in dental restorations. For this purposes, different type of materials will be obtained, grained and dried to determine uranium, thorium and potassium activity from gamma rays in gamma spectrometer. From those activities dose rate and effective dose rate will be determined in order to determine hazardous to health and those values will be compared with the international limits.

2. Experimental details

The dental materials have been prepared in SDU Faculty of Dentistry and Endodontics Treatment Department Clinic for measurements and radioactivity measurements have been performed in Department of Gamma Spectroscopy Laboratory located in SDU Sciences Faculty. The radioactivity ^{226}Ra, ^{232}Th and ^{40}K in the peanut samples was determined using a gamma ray spectrometry [13] consisting of a $3'' \times 3''$ NaI(Tl) detector connected to a 16384 channel multi channel analyser (MCA).

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Before measurement the system should be calibrated. This is done using ^{137}Cs and ^{60}Co radioactive sources, which produce γ-ray energy of 662, 1173, and 1332 keV, respectively. The γ-ray spectrum obtained from the mentioned source and related fit has been displayed in Fig. 1.

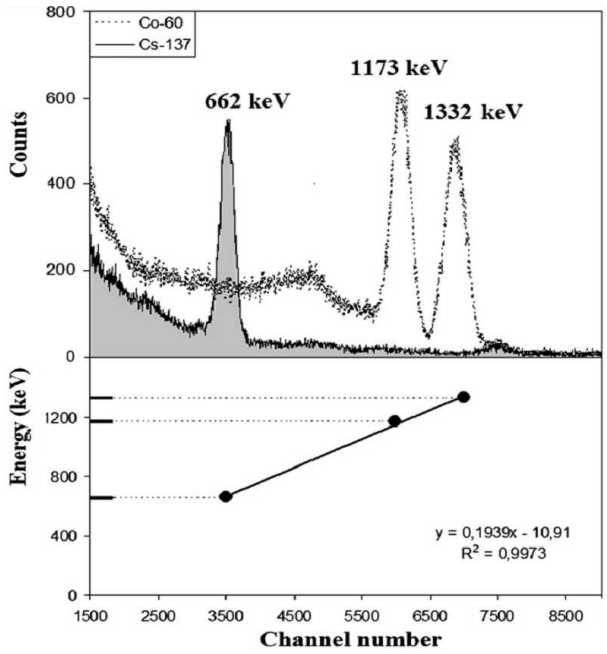

Fig. 1. Calibration spectrum obtained for ^{137}Cs, ^{60}Co source (upper) and related fit (lower).

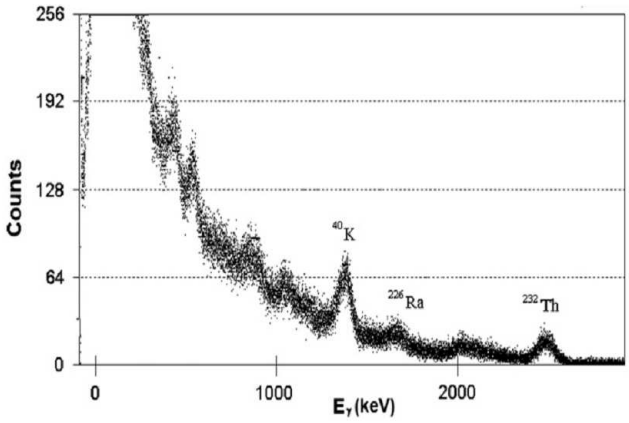

Fig. 2. A typical gamma spectrum for dental material.

The spectrum is analyzed using the MAESTRO obtained from Ortec. The measurement was based on recording natural radioactivity quantities of three natural long-lived elements: ^{226}Ra, ^{232}Th and ^{40}K which are considered the photopeaks at 1760, 2610, 1461 keV, respectively, in the natural γ-ray spectrum [14]. The samples were counted for a period of 40000 s and the spectra are analyzed for the photopeaks of ^{226}Ra, ^{232}Th and ^{40}K. A typical spectrum obtained for this kind of measurement has been shown in Fig. 2, where ^{226}Ra, ^{232}Th and ^{40}K peaks can be clearly seen.

The activities for the natural radionuclides were calculated using the following relation [15]:

$$A = \frac{NPA}{\varepsilon\gamma tm}, \tag{1}$$

where A is the activity of the radionuclide in Bq/kg, N is the net peak area under the most prominent photo peaks calculated by subtracting the respective count rate from the background spectrum obtained for the same counting time. The net count rate in the measurement is calculated from the background subtracted area of prominent gamma ray peaks. ε is the detector efficiency of the specific gamma ray, γ — the absolute transition probability of gamma decay, t — the counting time (s) and m — the mass of the sample (kg).

3. Results and discussion

The activity concentrations of ^{226}Ra, ^{232}Th and ^{40}K in dental resin composites have been measured. The obtained results have been displayed in Fig. 3. It can be seen from this figure that the activity concentration for potassium is higher than the others.

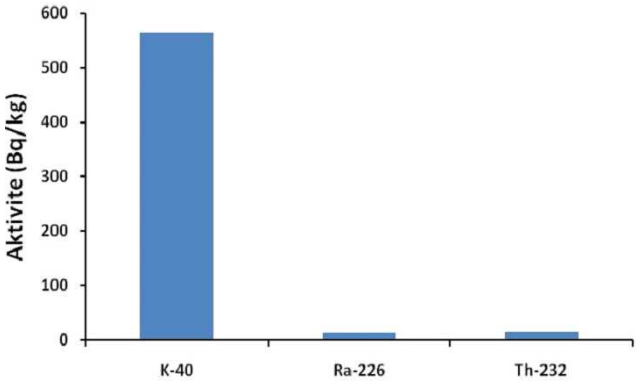

Fig. 3. Natural radioactivity concentration of dental sample.

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