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Research Paper

Thermoluminescence of β-irradiated human teeth

Agustin de la Isla [2], Rodolfo Bernal [3], Catalina Cruz-Vázquez [4], Victor R. Orante-Barrón [4], Victor M. Castaño [1]*

[1] *Centro de Física Aplicada y Tecnología Avanzada, Universidad Nacional Autónoma de México, Apartado Postal 1-1010, Querétaro, Querétaro 76000 México*
[2] *Universidad Autónoma de Querétaro, Facultad de Ingeniería, Campus Aeropuerto, Santiago de Querétaro, Querétaro 76010 México*
[3] *Departamento de Investigación en Física, Universidad de Sonora, Apartado Postal 5-088, Hermosillo, Sonora, México*
[4] *Departamento de Investigación en Polímeros y Materiales, Universidad de Sonora, Apartado Postal 130, Hermosillo, Sonora 83000 México*
**Corresponding author E-mail: meneses@unam.mx*

Abstract

The thermoluminescence (TL) response of samples obtained from human teeth exposed to beta irradiation shows that the characteristic glow curves exhibit TL emission at high enough temperatures, which ensures thermal stability of the TL signal, and the TL increases as the dose increases from 0.25 up to 128 Gy, with linear behavior for doses below 32 Gy. The dose interval tested is of interest for clinical applications. Samples do not suffer damage due to heating if the TL readouts are performed from room temperature up to 300 °C. W This indicate that human teeth are promising phosphor materials for use in different TL and afterglow dosimetry applications.

Keywords: *Thermoluminescence; Human Teeth; Dosimetry; β - Irradiated Human Teeth; Hydroxyapatite.*

1. Introduction

Human tooth is formed by dental pulp, dentin, cement, and enamel. Dental enamel contains high concentration of hydroxyapatite, Ca10 (PO4) 6 (OH) 2, which exhibits thermoluminescence (TL) if exposed to ionizing radiation [1], [2].
Tooth enamel dosimetry using electron paramagnetic resonance (EPR) and electron spin resonance (ESR) has been useful measuring doses due to contamination by osteotropic radioisotopes in radiation-exposure contingencies, in the dose interval of 100 mGy to less than 50 Gy [3-5]., On the other hand, there are reports showing the feasibility of measuring optically stimulated luminescence (OSL) on tooth enamel, proposing this material as suitable in radiation dosimetry applications [6], [7].
Indirect methods for estimating radioisotope concentrations in dental tissues by carrying out TL dosimetry measurements of dental samples, using TL commercial dosimeters, have been performed [8], [9]. Nowadays, there are no reports showing further studies on the TL signal of human teeth, either proposing them to TL dosimetry applications. Motivated by the above, in this work we aimed to show that the thermoluminescence of human tooth can be useful in several fields of radiation dosimetry, as are in vivo dosimetry in odontology, retrospective dosimetry and anthropology dating.

2. Experimental

Freshly extracted teeth (central superior incisor) were selected, that had been extracted because of prosthetic reasons. It was brushed and disinfected, and then a little piece of tooth enamel obtained, that was cut as 3 x 5 x 0.5 mm samples, using a low-speed diamond disk.

A Risø TL/OSL model TL/OSL-DA-15 unit equipped with a 90Sr beta radiation source was used to perform beta particle irradiations and the TL measurements. All irradiations were accomplished using a 5 Gy/min dose rate at room temperature (22 °C). The TL readouts were carried out under N2 atmosphere using a heating rate of 5 °C/s.

3. Results and discussion

In order to establish the heating temperature range for the thermoluminescence (TL) measurements, some small pieces of human teeth, as the one shown in figure 1, were read from the room temperature up to 450 °C. The pieces were damaged when subjected to this heating temperature, so the ending temperature of the TL readouts was gradually decreased, to guarantee that no damage of samples occurs during the TL measurements. It was found that the TL measurements can be carried out without any sign of sample burnout, using a temperature interval from room temperature (ca. 22 °C up to 300 °C).

Figure 2 shows the TL glow curves from a piece of a human tooth exposed to different doses of beta particle irradiation, obtained using a 5 °C/s heating rate, from room temperature up to 300 °C. As can be seen, the TL intensity increases by increasing dose in the range from 0.25 to 128 Gy of beta particle irradiation, with no evidence of reaching the saturation dose values. The shape of the thermograms is wide with emission from doses lower than 50 °C onwards, which could give rise to an easy-to-detect isothermal luminescence useful for in vivo and in situ afterglow (AG) dosimetry for dental patients.

Since the TL emission is higher within the temperature interval between 175 - 250 °C, considered to be suitable for TL radiation dosimetry, human teeth pieces are also attractive to carry out retrospective dosimetry as well as dating of interesting specimens for anthropology fields.

As can be noted in figure 2, the glow curves reveal that the TL intensity at 300 °C, the higher temperature during the TL readouts, is still dose dependent, and from the whole curve shape it can be concluded that a single TL readout is not enough to completely erase any information of the irradiation. Hence, further research is in progress to investigate a pre-irradiation annealing protocol to assure a reset of the samples if these are to be re-used.

Figure 3 shows the integrated TL response as a function of dose, of a piece of human tooth after being exposed to beta particle irradiation, in the dose range from 0.25 up to 128 Gy. In the inner frame, the TL response as a function of dose is shown for the lower doses used (from 0.25 up to 16 Gy), exhibiting a linear dependence below 32 Gy, and then a sublinear behavior is observed for higher doses. In spite to the sublinear behavior for doses higher than 32 Gy, there is no saturation effects evidence.

4. Conclusions

In this work, we provide experimental evidence that human teeth could be used as radiation dosimeters in several novel applications, including in vivo afterglow-based and retrospective TL dosimetry, as well as anthropology dating. In order to use human teeth as dosimetric phosphors, TL readout must be performed heating samples from room temperature up to $\approx$ 300 °C to avoid samples damage.

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