First Latin-American Congress
on Solid State Dosimetry and Radiation Measurements
13-17 September, 2021

PRELIMINARY RESULTS OF ELECTRON BEAM DOSIMETRY USING BLUE BERYL PELLETS

CARMO, L.S. do[1], WATANABE, S.[2], BITENCOURT, J.F.S.[2]

[1]Instituto de Pesquisas Energéticas e Nucleares, 05508-000 São Paulo - SP, Brazil – lucassatirocarmo@gmail.com
[2]Departamento de Física Nuclear, Instituto de Física da USP, 05508-090 São Paulo, SP, Brazil

Introduction: Nowadays, activities involving high doses of ionizing radiation are very common. The measurement of the absorbed dose involved in these activities became an important task. Since long back, the thermoluminescence technique has been used in radiation dosimetry and different materials have been developed to measure from low doses to high doses of ionizing radiation. Watanabe et al. (2015) studied the thermoluminescent dose response curve (DRC) for several powdered ionic crystals including silicates. In this work, a radiation dosimeter made of aquamarine (blue beryl) was used to measure high-doses of electron beams produced at the IPEN's Radiation Technology Center electron beam accelerator. Here we refer as "high-dose" any absorbed dose in the kGy range.

Material and method: Beryl is a silicate mineral of chemical formula $Be_3Al_2Si_6O_{18}$, this mineral has a few variations due to some impurities in the crystal lattice. The variety used in this work is known as Aquamarine (blue beryl). A raw Aquamarine stone was bought at LEGEP Mineração, Sao Paulo, Brazil. The stone was crushed into minor pieces and then put inside a sealed plastic pot with three silica balls of approximately 10 mm diameter. The set was placed in a rotating cylinder for 5 hours to produce fine beryl powder (< 0.75 μm). The powder was hydraulic pressed at 102 MPa for 15 seconds in a stainless-steel mold to form small pellets of 5 mm diameter and 1 mm thickness and 35 mg of mass, approximately. The dosimeters were sintered at 850 ºC for 5 hours to acquire mechanical resistance, then the furnace is switched off and dosimeters are removed when temperature reached 50 ºC (which lasted almost 3 h). Six aquamarine pellets (AMP) were prepared and irradiated at IPEN using a 1.5 MeV Radiation Dynamics Electron Accelerator from the Radiation Technology Center with doses of 10, 30, 50 and 70 kGy. The TL measurements were performed using a model 4500 Harshaw TL reader in N_2 atmosphere. The reader is controlled by WinREMS Software and the heating rate used in the TL measurements was 4 °C/s. A test dose of 10 kGy was given to the twelve dosimeters to analyze the TL glow curve. A mean intensity, given in Arb. Uni., of $13.63 \times 10^3 \pm 1.25 \times 10^3$ for the dosimetric peak at 310 ºC was obtained. The standard deviation represents 9.2 % of the mean.

Results: With increasing radiation, the dosimetric peak at 310 ºC starts shifting towards to high temperatures around 340 ºC. The low temperature peak, around 235 ºC, decreases in intensity with increasing radiation dose. The dose response curve was built using the maximum intensity from the dosimetric peak. The dose response curve shows linear growth ($r^2 = 0{,}99$) between 10 kGy and 70 kGy (Figure 1). When sintered with 1000 ºC, the beryl pellets are sensitized and shows an intensity increase of 52 % in the 310 ºC peak when irradiated with 10 kGy.

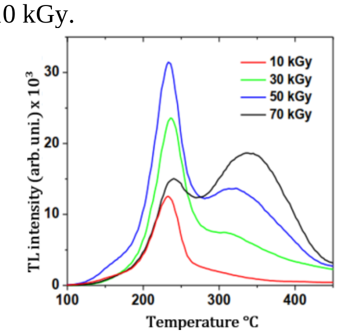

Figure 1 – Glow curves of blue beryl pellets irradiated with electron beams

Conclusions: This preliminary study of electron beam radiation dosimetry using blue beryl pellets is promising and presented the great potential of this particular beryl variety in high dose dosimetry. The high temperature peak showed linear growth ($r^2 = 0{,}99$) in the range of 10 kGy and 70 kGy. The dosimeter can be sensitized increasing the sintering temperature, which can be useful for low dose dosimetry.

Keywords: dosimetry, high-dose, beryl, thermoluminescnce, electron beam

References: WATANABE, S.; CANO, N. F.; CARMO, L.S.; BARBOSA, R.F.; CHUBACI, J.F.D.; High- and very-high-dose dosimetry using silicate minerals, **Radiation Measurements**, v. 72, p. 66-69, 2015.