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OSL response bleaching of BeO samples, using fluorescent light and blue LEDs

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Abstract. The optically stimulated luminescence (OSL) is widely used as a dosimetric technique for many applications. In this work, the OSL response bleaching of BeO samples was studied. The samples were irradiated using a beta radiation source (^{90}Sr+^{90}Y); the bleaching treatments (fluorescent light and blue LEDs) were performed, and the results were compared. Various optical treatment time intervals were tested until reaching the complete bleaching of the OSL response. The best combination of the time interval and bleaching type was analyzed.

1. Introduction
The optically stimulated luminescence (OSL) technique is widely used for personal dosimetry, geological and archeological dating, and in radiation diagnostic imaging [1]. Beryllium oxide (BeO) has been used as an OSL dosimeter presenting advantages as high sensitivity to ionization radiation, linear dose response and effective atomic number (Zeff = 7.2) similar to human soft tissue (Zeff ~ 7.6) [2].

The blue stimulation light for the OSL technique from BeO was reported in some papers emphasizing its use in personal dosimetry [3-5].

Most of the OSL dosimeters present a variation in readout due to light exposure; therefore, the dosimeters have to be stored in the dark before the dosimetry evaluation.

In this work fluorescent light was used in bleaching treatments. Different optical treatment time intervals were tested until reaching the complete bleaching of the BeO samples response. A study with a bleaching system with blue LEDs was also performed, and the results were compared.

2. Materials and methods

2.1. BeO samples
The BeO samples (figure 1) were in form of discs (diameter: 4.0 mm, thickness: 0.8 mm and weight: 27.9 mg ± 0.45 mg). The samples are pressed pellets with Si, K, Al, Fe and Mn impurities as reported by Groppo and Caldas [6].

2.2. Irradiations

The irradiations of BeO samples were carried out using beta radiation. It was a $^{90}Sr+^{90}Y$ source available in the Risø TL/OSL-DA-20 reader (figure 2), which was also used to perform the OSL readings. The absorbed dose rate was 0.1 Gy/s, according to the manufacturer's manual. The nominal activity was 1.48 GBq (calibration certificate, 10/06/2010). The appropriate corrections were applied for the measurement date. All samples were irradiated with 1 Gy of absorbed dose.

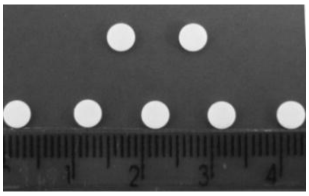

Figure 1. BeO disc samples.

2.3. OSL measurements

The OSL measurements were taken using a Risø TL/OSL-DA-20 reader (figure 2). The OSL measurements were carried out using the continuous wave mode (CW-OSL); the stimulation light type was composed by blue LEDs; an UV transmitting broad-band glass filter Hoya U-340 was used in front of the photomultiplier tube. Due to the high sensibility of the BeO samples, a collimator with 2 mm diameter was used. Each OSL measurement was carried out during 100 s of LED stimulation with 90% of power, and for each sample a calibration factor was obtained.

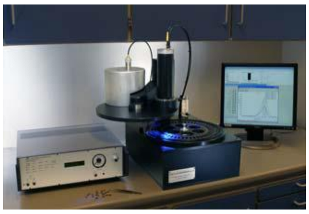

Figure 2. RISÖ TL/OSL (TL/OSL-DA-20) reader system.

2.4. Bleaching treatment

The established and conventional bleaching treatment of BeO samples was thermal. The samples were heated at 750 ºC during 15 minutes in a muffle furnace with microwave heating (MFLO1000 by Provecto Analítica). This procedure was enough to empty their traps. Moreover, after the OSL measurements it was possible to bleach the response in a homemade light box with blue LEDs (figure 3) (420-500 nm; 2.5 W; 7000 lux) [7].

Figure 3. Homemade light box with blue LEDs.

Another treatment was also tested. It consisted of the use of a fluorescent lamp system (figure 4): a white wood box (66x21x17) cm^3 containing two fluorescent lamps (Sylvânia, model F16W/78) with 20 W [8]. The lamp-sample distance was 9 cm and the illuminance was 26000 lux.

Figure 4. Homemade light box with fluorescent lamps [8].

3. Results

To determine an appropriate optical treatment for reutilization of the BeO samples, initially the samples were thermally treated at 750 ºC during 15 minutes in a MFLO1000 furnace, and irradiated with 1 Gy of absorbed dose (beta radiation source). The OSL measurements were taken and then the samples were optically treated during different time periods. In the fluorescent lamp treatment case, the time variation was between 15 min and 10 days. In the bleaching treatment with blue LEDs, the time interval varied between 5 min and 2 h. After each set of irradiation, optical bleaching treatment and OSL measurement, the samples were thermally bleached, as before. The OSL response was normalized for the reading obtained of samples without any treatment.

A typical OSL decay curve obtained by irradiating the sample at a dose of 1 Gy (^{90}Sr+^{90}Y) is presented in figure 5.

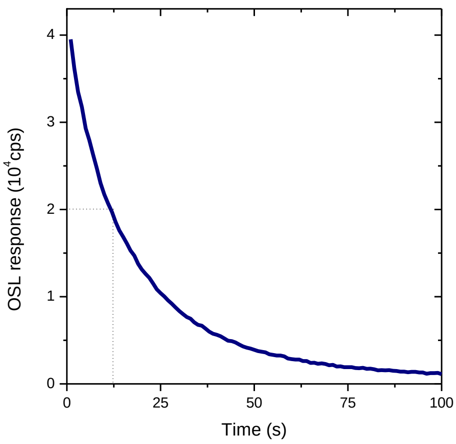

Figure 5. OSL decay curve of BeO samples irradiated with 1 Gy of absorbed dose (^{90}Sr+^{90}Y source).

The fluorescent light treated samples at different interval times were evaluated using the OSL technique, and some of the curves obtained are presented in figure 6.

Figure 7 presents the OSL relative response for each fluorescent treatment performed. It can be noted that until 168 h (7 days) of fluorescent light exposure, the OSL response was bleached and then the OSL response showed constancy with the same value as the OSL response of non-irradiated samples (0R).

The results obtained by optical treatment with the blue LEDs are shown in figure 8, and this procedure was already adopted in previous studies [6,7], with good results.

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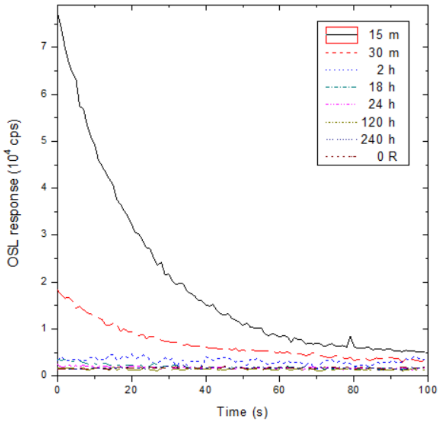

Figure 6. OSL decay curves of BeO samples irradiated with 1 Gy of absorbed dose (^{90}Sr+^{90}Y source), exposed to different time interval of the fluorescent system. 0R represents OSL response of non-irradiated samples.

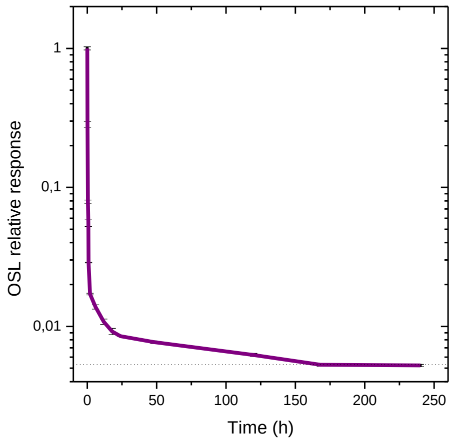

Figure 7. OSL relative response of BeO samples irradiated with 1 Gy of absorbed dose (^{90}Sr+^{90}Y source), exposed to different time intervals of the fluorescent system. The dashed line represents the OSL response of non- irradiated samples (0R).

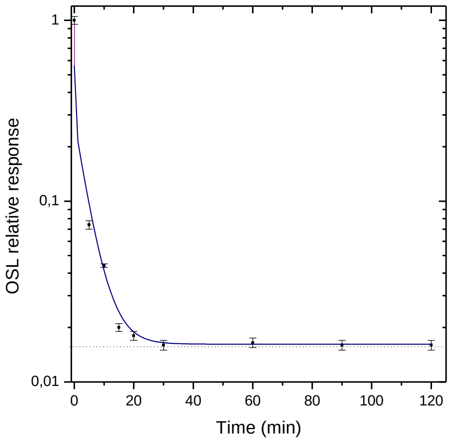

Figure 8. OSL relative response of BeO samples optically treated by blue LEDs.

In figure 8 it is possible to observe that from 30 min of exposure to blue LEDs the OSL response remained constant. It means that the traps involved in the OSL phenomenon were emptied, therefore the treatment with 30 min of blue LEDs exposure can be adopted.

4. Conclusion

For the purpose of response bleaching of BeO samples using the OSL technique, the system with blue LEDs was proved to be more effective in relation to the fluorescent light treatment. In 30 min of blue LED treatment it is possible to bleach the OSL response, much faster than the 7 days required by the fluorescent light. This work shows also the influence of fluorescent light in emptying traps, above all the rapid decrease in the first minutes of exposure; this fact contributed to the adoption of a careful storage of dosimeters after irradiation, mainly under fluorescent light used in most of the laboratories.

Acknowledgments

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References

[1] Akselrod M S, Bøtter-Jensen L and Mckeever S W S 2007 *Radiat. Meas.* **41** S78
[2] Bøtter-Jensen L, McKeever S W S and Wintle A G 2003 *Optically Stimulated Luminescence Dosimetry*.Amsterdam: Elsevier
[3] Sommer M and Henniger J 2006 Radiat. *Prot. Dosim.* **119** 394
[4] Sommer M, Freudenberg R and Henniger J 2007 *Radiat. Meas.* **42** 617
[5] Sommer M, Jahn A and Henniger J 2008 *Radiat. Meas.* **43** 353
[6] Groppo D P and Caldas L V E 2014 *Radiat. Meas.* **71** 81
[7] Groppo D P 2013 *MSc Dissertation* Instituto de Pesquisas Energéticas e Nucleares, University of São Paulo (In Portuguese)
[8] Gronchi C C 2009 *PhD Thesis* Instituto de Pesquisas Energéticas e Nucleares, University of São Paulo (In Portuguese)