DOSIMETRIC CHARACTERIZATION OF MgB_4O_7:Dy FOR NEUTRON DETECTION

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Abstract.

This work develops the dosimetric characterization of MgB_4O_7:Dy. Some parameters related to the production of Magnesium Borate doped with Dysprosium (MgB_4O_7:Dy) were studied, in order to increase the phosphor thermoluminescent (TL) sensitivity and verify its characteristics for thermal neutron detection. This phosphor was choosen due to the presence of boron (B). The isotope ^{10}B (isotopic abundance of 19.8%) has a thermal neutron cross section of 3837 barns for the $^{10}B(n,\alpha)^7Li$ reaction.

1. Introduction.

The advance of nuclear instalations and the great utilization of neutron radiation in radioterapy treatment has increased the interest for neutron personal dosimetry throughout the world. The great difficulty in this area is to develop a sufficiently small detector that can be used on the body of the worker.

There are several types of dosemeters in use based in different techniques of neutron detection such as: photographic films, nuclear emulsions, electrets, nuclear track detectors, overheated buble chamber, thermoluminescent dosemeters and others[1,2,3].

In the last years, many researchers are working in the development of thermoluminescent dosemeters (TLD) due to the following advantages[4]:

- small size;
- simple and fast reader system;
- relatively simple and inexpensive production;
- reusability possibility.

2. Materials and Methods.

MgB_4O_7:Dy is produced mixing magnesium oxide (MgO) with boric acid (H_3BO_3). The reaction occurs in acid solution (diluted nitric acid)[5]. The material is dried up, sintered, ground and sieved, washed and cold pressed as pellet discs. In order to obtain a resistant pellet, the powder is mixed with teflon.

The irradiation set up consists of an ^{241}Am-Be neutron source surronded by a lead filter for shielding against the low energy gamma rays, and a paraffin block for neutron moderation. ^{60}Co (15 TBq) and ^{137}Cs (3.7 GBq) sources were used for gamma rays irradiation.

The measures of TL emission were done just after irradiations (except for fading analysis) using a Harshaw reader Model 2000 A-B.

3. Results.

Energy Dependence

The TL response of MgB_4O_7:Dy pellets was measured for X and gamma radiation between 20 and 1250 keV, and normalised to ^{60}Co radiation.

A low energy dependence for gamma and X-rays (maximum dependence factor 2 in comparison with ^{60}Co energy) was observed and is showed in figure 1.

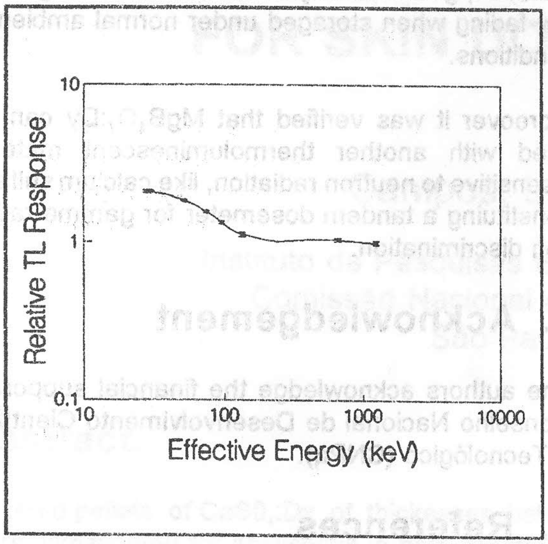

Figure 1. Energy Response of MgB_4O_7:Dy pellets relative to ^{60}Co gamma radiation.

Linearity

The linearity of the TL response for gamma and neutron radiation was confirmed by gamma exposure measurements of a ^{60}Co source at exposures values between 10^{-6} and 10^{-3} C/kg and by neutron fluence measurements of an Am-Be source at fluence values between 10^7 and 10^9 $n_t.cm^{-2}$. The results are showed in Figures 2 and 3.

Fading

The MgB_4O_7:Dy pellets were subjected to the annealing process of 300 ⊕C during 15 min and then were irradiated and stored. The low TL response fading under normal storaged conditions was 9 % and 9.7 % for neutron and gamma radiation respectively during a storage period of 30 days. The results are showed in Figures 4 and 5.

Example of Application

In order to verify the dosimetric application it was developed a test to determine the thermal neutron fluence of an ^{241}Am-Be source neutron source. The gamma exposure was determined using $CaSO_4$:Dy teflon pellets early calibrated with gamma radiation of ^{60}Co.

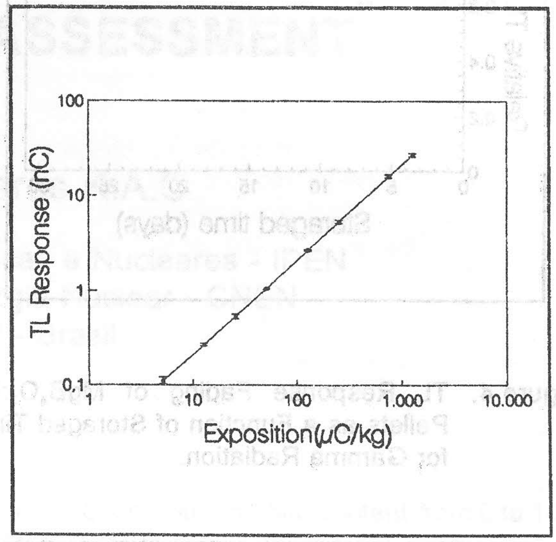

Figure 2. TL Response of MgB_4B_7:Dy Teflon Pellets as a Function of Gamma Ray Exposure to a ^{60}Co Source.

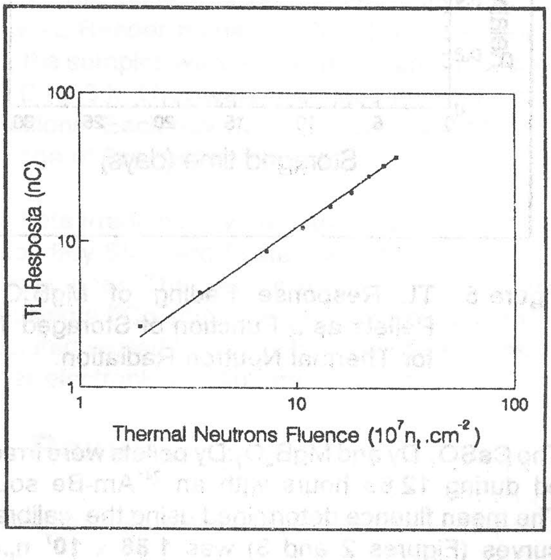

Figure 3. TL Response of MgB_4O_7:Dy Teflon Pellets as Function of Thermal Neutrons Fluence of an Am-Be Source.

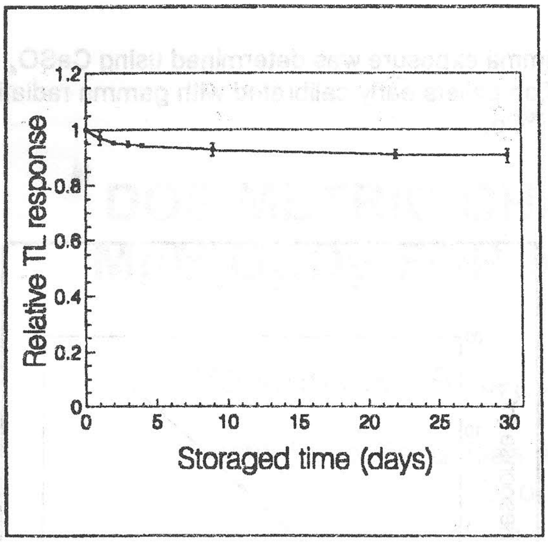

Figure 4. TL Response Fading of MgB_4O_7:Dy Pellets as a Function of Storaged Time for Gamma Radiation.

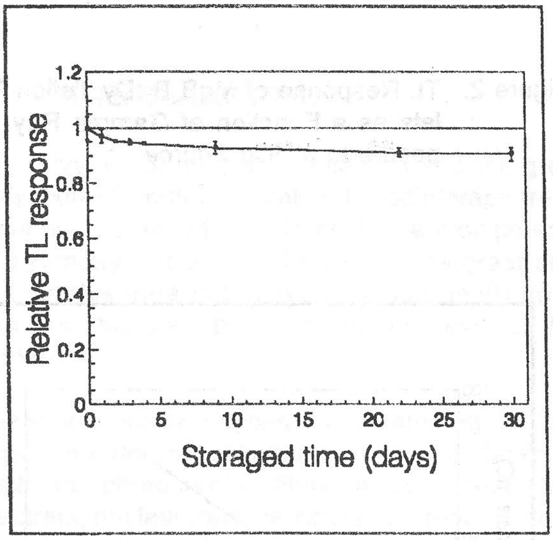

Figure 5. TL Response Fading of MgB_4O_7:Dy Pellets as a Function of Storaged Time for Thermal Neutron Radiation.

The $CaSO_4$:Dy and MgB_4O_7:Dy pellets were irradiated during 12.63 hours with an ^{241}Am-Be source. The mean fluence determined using the calibration curves (Figures 2 and 3) was **1.86 x 10^7 n$_t$.cm^{-2}** (corresponding to 12.3 hours). This result differs only 2.6 % from the real value. It shows the viability of this method.

4. Conclusion.

The results obtained show the utilization feasibility of this material in neutron personal monitoring, showing adequate sensitivity (1.8x10^6 nC(Ckg^{-1})$^{-1}$g^{-1}), low energy dependence for X and gamma radiation, good linearity in studied dose range and low fading when storaged under normal ambiental conditions.

Moreover it was verified that MgB_4O_7:Dy can be used with another thermoluminescent material insensitive to neutron radiation, like calcium sulfate, constituing a tandem dosemeter for gamma radiation discrimination.

5. Acknowledgement

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6. References.

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