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≪Original≫ Natural Beryl as a Thermoluminescent Dosimeter

P. S. Moon

Korea Atomic Energy Research Insititute, Seoul, Korea

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Abstract

The possibility of using natural beryl thermoluminesence for gamma-ray dose measurement was investigated through the analysis of glow curves obtained with Co-*60* gamma-ray irrediation. The natural beryl powder of 80-200 mesh has a good gamma-ray thermoluminescent response and stability at room temperature. The thermoluminescent response is linear from 10mR to 10^3R and can be measured up to 10^6R.

요 약

녹주석의 열형광현상을 이용하여 감마선 측정가능성을 glow 곡선분석방법으로 연구하였다. 80~200mesh의 녹주석분말은 감마선에 대해 좋은 열형광반응을 보였고 상온에서 안정됨을 알았다. 감마선에 대한 녹주석의 열형광반응은 10mR 에서 10^3R까지는 선형적관계를 갖고 있었으며, 10^3R 에서 10^6R 까지는 비선형적관계를 갖고있다. 녹주석에 의한 감마선측정이 가능하다.

1. INTRODUCTION

There has been a rapid growth in thermoluminescent radiation dosimetry during the past decade[1,6]. Many different kinds of phosphors were used for thermoluminescent dosimetry by many investigators[1,2,3,7,8] but the natural beryl has not been used for this purpose. The natural beryl has shown very interesting dosimetric properties for Co-60 gamma-ray. This paper reports the dosimetric properties of natural beryl obtained from Chungbug, Korea[5].

The natural beryl dosimeter used was in powder form of 80-200 mesh size and it was annealed in an oven for one hour at 1450°C.[5]

The natural beryl powder sample was put into a bakelite capsule before Co-60 gamma-ray irradiation. The samples were irradiated with different degrees of gamma-ray dosage in an ambient temperature of 22°C.

The linearity and supralinearity relationships between exposure and thermoluminescent response were investigated in order to see the feasibility for radiation dosimetry[4]. For the elimination of the first glow peak at 65°C, the preheat technique was used and the stable second glow peak at 200°C was utilized for thermoluminescent gamma-ray dosimetry.

2. EXPERIMENTAL

The thermoluminescent material used in this experiment is a natural beryl (aluminum beryllium silicate) and its chemical composition is $3BeO \cdot Al_2O_3 \cdot 6SiO_2$. The natural beryl contains 82.5% of SiO_2, 2.19% of Fe_2O_3, 2.48% of Al_2O_3, 9.46% of BeO and 2.4% of 17 other impurity elements[5]. The natural beryl of 80-200 mesh powder was annealed in an oven for one hour at 1450°C in order to eliminate all effects of previous irradiations. After the annealing, the powder sample was cooled rapidly. The sample was put into polyethylene capsule and then placed it for Co-60 gamma-ray irradiation with dosages ranging from 10mR to 10^6 R at a similar condition.

Co-60 gamma-ray irradiation was done to the natural beryl powder with dose rate of 173R/min at 100cm from 10,000Ci Co-60 source. For lower dose irradiation, 16.2 Ci Co-60 source was used and the dose rate at 10cm from the source was 345 mR/min. 50mg of the irradiated powder sample was placed on a high-resistivity nichrome heating discs with the aid of powder sample dispenser and then the discs are inserted into the screen type heating element between the screen and the nichrome strip. The thermoluminescence of sample was measured and the thermoluminescent glow curve was recorded with TLD 7100 and its associated dual-channel recorder of Teledyne Isotope Co.

The preheat technique was investigated in order to utilize the stable second peak at 200°C for thermoluminescent dosimetry of natural beryl.

The linearity and supralinearity of the thermoluminescent response versus Co-60 gamma-ray exposure dose was studied.

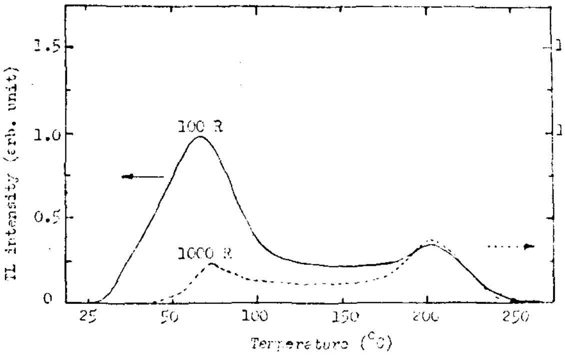

Fig. 1. TL glow curves of beryl 10 min. after irradiation. Heating rate: 10°C/sec

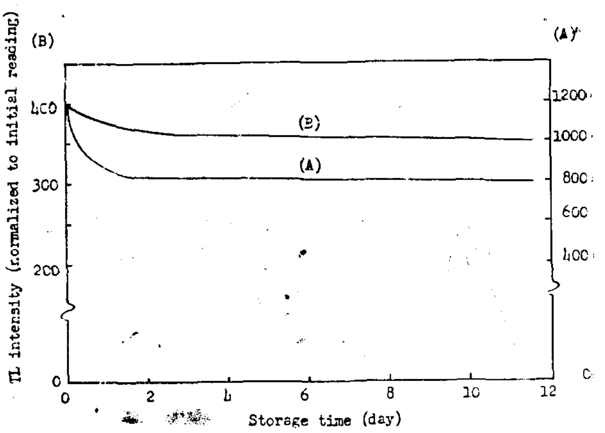

Fig. 2. Fading of beryl TL light sum on storage at room temperature (18°C) in the dark. Dose: 100R (A) Total light sum, (B) Light sum of second peak.

3. RESULT and DISCUSSION

Figure 1 shows the typical natural beryl glow curves after Co-60 gamma-ray irradiation. The glow curve was plotted 10 min. after irradiation and the heating rate of readout system was 10°C/sec. The glow curve, a plot of light output versus time, consisted of two distinct glow peaks at temperatures of about 65°C and 200°C The first one at 65°C was not stable, but the second one at 200°C was quite stable at room temperature[5]. From the figure, it was apparent that the first glow peak height did

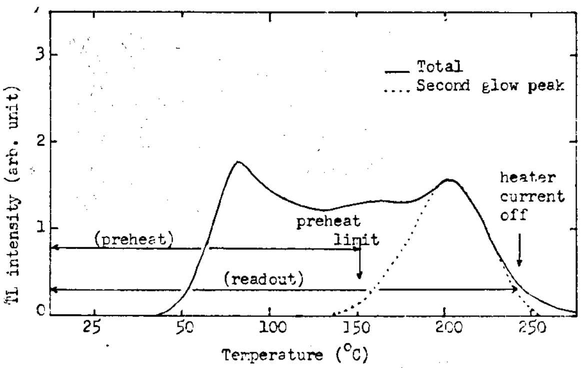

Fig. 3. TL glow curves of beryl: total glow curve and second glow peak obtained by preheating, 4hour after 100R irradiation.

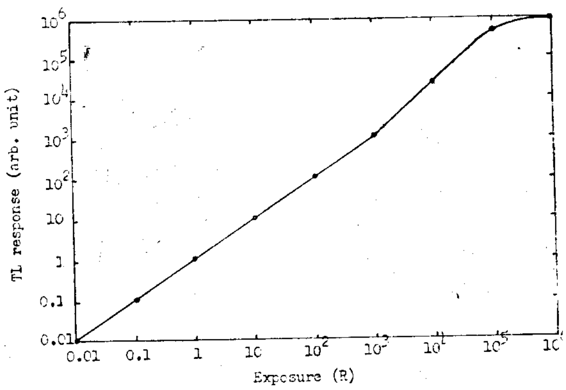

Fig. 4. TL response of beryl versus Co-60 gamma-ray exposure

not change by exposure dose. For 100R exposure, the second peak becomes more prominant than the first one. Therefore, the second glow peak at 200°C was used for thermoluminescent dosimetry study of natural beryl.

Figure 2 shows the thermoluminescence change due to different storage time after irradiation. That is, total light sum of thermoluminescence from 100R gamma-ray irradiated natural beryl sample was fading faster than the light sum of second glow peak thermoluminescence.

Figure 3 shows the preheating effect on the shape of thermoluminescent glow curve. In order to eliminate the first glow peak at 65°C, the irradiated sample was initially heated up to 150°C by readout heating system. The resulting glow curve was shown by dotted line and with this glow peak, the thermoluminescent dosimetry of Co-60 gamma-ray was carried out. For the symmetrical glow curve, the heater current of readout system was cut off at 240°C.

Figure 4 shows the thermoluminescent response of natural beryl for Co-60 gamma-ray exposure. Up to 10^3R exposure the response shows a linearity. 10^3R to 10^5R range also shows a supralinearity, but around 10^6R the response curve becomes saturated. With a little correction, the natural beryl powder can be used as a reliable thermoluminescent dosimeter from minimum detectable dose of 10mR to maximum dose of10^6 R.

The standard deviation of all measured light sums of thermoluminescence is within 4% of mean value.

The thermoluminescent measurements were made with a Teledyne Isotopes' readout system. A linear thermoluminescent response is observed for Co-60 gamma-ray exposure ranging from exposure of 10mR to about 10^3 R. The glow curve consists of two distinguished glow peaks at temperatures of 65°C and 200°C. For higher exposures a second peak at a temperature of 200°C becomes evident and repidly overtakes the initial peak as can be seen in Fig. 1.

A supralinear thermoluminescent response is observed for Co-60 gamma-ray exposure ranging from 10^3R to 10^6 R and the thermoluminescent response becomes saturation over 10^6 R exposure.

All the exposure readings were read out with nitrogen gas flowing through the heater chamber in order to avoid any spurious peak appearances on glow curve.

4. CONCLUSION

The natural beryl powder of 80-200 mesh annealed at 1450°C for one hour is good for thermoluminescent dosimetry of gamma-ray exposure, and it has a measureble range for gamma-ray exposure extending from 10mR to 10^6 R, with a linear response to 10^3 R and a supralinear response from 10^3 R to 10^6 R. The supralinear region can be used for thermoluminescent dosimetry of gamma-ray exposure. A preheat technique is utilized for the elimination of the first peak of thermolnminescent glow curve in order to use the second glow peak for thermoluminescent dosimetry. There was a little fading of the 200°C glow peak when stored in the dark.

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