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Optically stimulated luminescence of common plastic materials for accident dose reconstruction

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1. Introduction

Optically stimulated luminescence dosimeters (OSLD) are well known in personal dosimetry. Optically stimulate luminescence (OSL) arises from mineral which have been exposed to radiation. The OSL intensity is related to the absorbed radiation dose. The OSL technique itself has been used for the estimation of the environmental dose using naturally occurring minerals [1]. OSL has many applications in a variety of radiation dosimetry fields, including personal dosimetry, environmental radiation level monitor, retrospective dosimetry for dating, and reconstruction of radiation doses from radiation accident. In the reconstruction of radiation doses from radiation accident, OSL technique has been used to estimate the doses exposed to public area through analysis of housewares or house construing materials. Recently, many efforts have been carried out for dose reconstruction using personal electronic devices such as mobile phones and USB memory chips. [2]

Some of natural minerals such as quartz and feldspar have OSL properties. [3] Quartz is the second most abundant mineral in continental crust of the Earth. In some of common plastics, inorganic fillers (quartz, alumina etc.) are added to make strengthen of their properties depends on applications areas. [4]

The aim of this research is to explore a possibility of use of the common plastic materials for dose reconstruction in radiation accident case. In this research the OSL dose response-curve and fading characteristics of the common plastics were tested and evaluated. Finally, we expect this work contribute to elevate the possibility of the dose reconstruction.

2. Methods and Results

2.1 Materials

In this work, samples were selected from common plastic products easily found at a house and office such as a ballpoint pen, compact disk case and plastic eraser etc. The tested samples are listed in Table 1. All the samples were cut to fit the sample holder size of 5 mm diameter.

2.2 OSL measurement system

All measurements were carried out by a Risoe TL-OSL DA-20 OSL reader. It has inbuilt ^{90}Sr/^{90}Y irradiator for reference dose irradiation which gives the dose of 8.7 mGy/s. For the OSL measurement, the inbuilt blue LED light source was used as stimulation light.

2.3 Measurement method

The measurement protocol used for dose response was as followings:

Step 1: Illumination (bleaching) using blue LED for 200 s 80 % of total power

Step 2: Irradiation with 87 mGy of beta

Step 3: OSL measurement for 40 s at 80 % of the LED power

Step 4: Repeat the step 1-3 for each dose of 174 mGy, 435 mGy, 870 mGy, 1.74 Gy, 4.35 Gy, and 8.7 Gy

In Fig. 1, the OSL glow curves of ballpoint pen sample are shown as one of test results over the range from 87 mGy to 8.7 Gy. The sensitivity was estimated around 0.46 counts/mGy.

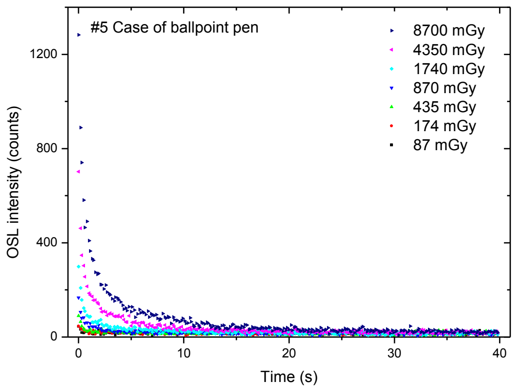

Fig. 1. OSL glow curve of the sample of ballpoint pen irradiated from 87 mGy to 8.7 Gy with ^{90}Sr/^{90}Y beta irradiator.

2.4 Dose response curve

Fig.2 shows that the result dose response curves of the tested samples listed in Table 1. It appears that the responses exhibit linear over the range from 87 mGy to

8.7 Gy. Especially, the vial cap sample gives a significant OSL signal around 16 counts/mGy.

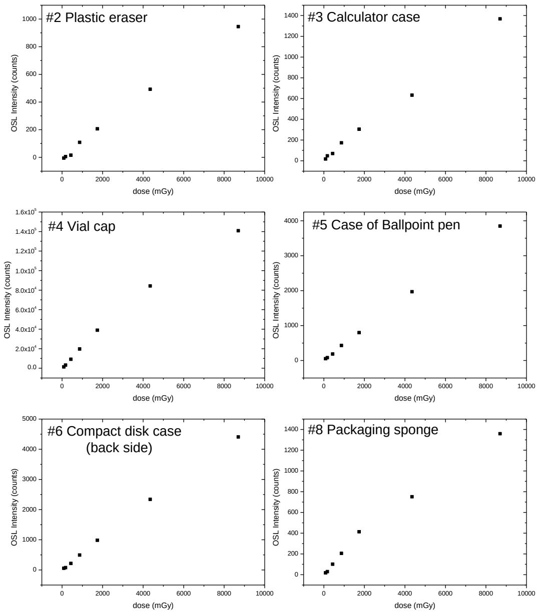

Fig. 2. Dose response curve for common plastic materials from 87 mGy to 8.7 Gy.

Table 1: Summary of OSL sensitivity

Sample No.	Sample name	OSL sensitivity (at 8.7 Gy, Counts/mGy)
#1	Plastic tube	-
#2	Plastic eraser	0.11
#3	Calculator case	0.15
#4	Vial cap	16.18
#5	Case of ballpoint pen	0.44
#6	Compact disk case	0.51
#7	Memory stick cover	-
#8	Packaging sponge	0.16
#9	Polyethylene vinyl	-
#10	Vinyl of film packing	-

2.4 Fading

The success of the OSL as dosimetric tools is based on the existence of energy level with long life time on materials. Unfortunately, in some inorganic materials a rapid fading of the luminescence signals is observed. Rapid fading is one of the most serious problems in OSL dose reconstruction with natural materials. Several possible ways have been suggested for choosing a non-fading signal, including high temperature thermal treat of the samples. But most of plastic materials are weak for high temperature. Therefore, in the case of use of plastics, fading characteristics is important for dose reconstruction. Fig.3 shows that OSL relative signal loss of the tested plastic samples. Fading test was carried out from 0 h to 48 h after irradiation. The compact disk cover sample exhibit much lower fading rate than other tested samples (approximately 80% signal remains after 48 h).

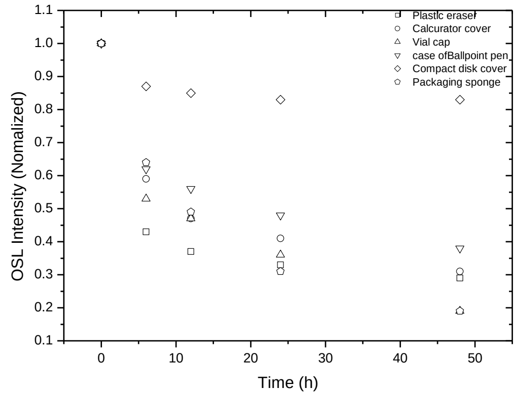

Fig. 3. Relative OSL signal loss of plastic samples at the room temperature. All the samples were irradiated with 8.7 Gy of the $^{90}Sr/^{90}Y$ beta irradiator.

3. Conclusions

The general conclusion of this work is that the possibility of dose reconstruction using common plastic materials is showed using the OSL characteristics of the materials. However, the tested common plastic materials have relatively low sensitivities. This means that the minimum detectable level (MDL) of the materials is not good as like the chip resistor extracted from a mobile phone.

Plastic materials have unique characteristics depend on ingredients of basic binder and filler materials. Further work is required to establish a database of OSL properties of common plastic materials for emergency dose reconstruction by using housewares.

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