BEHAVIOUR OF AN IRRADIATION INDICATOR FOR LOW DOSE IRRADIATIONS

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ABSTRACT

There are chemical pigments that are sensible to radiation and are very usefull as indicators in the field of industrial processing. Dyed plastics are fixed on labels and applied to indicate if a product was or not irradiated. This kind of material was tested for low dose dosimetric applications. ^{60}Co γ-rays were used to perform the experiments by means of uninterrupted and fractionated absorbed doses. It was observed that not only visual response can be achieved but it is possible to use the indicator as a dosimetric material in exceptional cases.

INTRODUCTION

Several solid state materials are used as irradiation indicators, specialy when large lots of products has to be irradiated in dynamic or static ways. These indicators are usually made of radiosensible chemicals fixed on paper labels in form of inks or as dyed plastics[1,2]. The labels are fixed on products or packages and give the possiblity to difference that irradiated from the not irradiated items.

Common solid state dosimeters as thin films have characteristic curves generated by means of different reading out techniques. The most common technique used in film dosimetry is spectrophotometry which lead to obtain the optical density change (ΔA), at selected wavelengths, as a function of absorbed dose (D). After the determination of the response curve (ΔA vs D), for a given batch, the dose value can be provided by this calibration when the same batch dosimeters are used in irradiation processes.

The aim of this study was to determine the variation of the material response by using the spectrophotometric technique, upon irradiation with different doses, verify the maintenance of the response within time after irradiation, at room temperature conditions, and to observe if there is some light influence when the material is manipulated at the laboratory and the irradiation installation. Another characteristics must be tested and are proposed.

EXPERIMENTAL CONDITIONS

Irradiation indicators were supplied* in label form and identified as 125 Gy INDICATOR and 300 Gy INDICATOR. Beginning on the mid point of the label there is the information "NOT IRRADIATED". A radiosensible transparent red plastic is sticked over the word NOT and this word disappears after the upper limit dose irradiation of 125 Gy or 300 Gy, depending on the label type that is used, since the pigment used becomes darker with the irradiation dose. Upon irradiation the sensible part changes its colour from red to dark brown and only the word IRRADIATED comes up for identification of irradiated products.

All tests were performed at room temperature and air umidity at about 60-85%.

The labels were irradiated in 21,501 GBq ^{60}Co gamma-rays cell with a dose rate of 7.2 Gy/min and at 114,229 GBq ^{60}Co gamma rays panoramic source with different dose rates ranging from 15 x 10^{-4} Gy/min to 8.5 Gy/min. The dose rates at each irradiation point were determined by means of a Fricke dosimeter solution. Uninterrupted (full dose in one irradiation) and fractionated irradiations(full dose in succeeded irradiations) were adopted to imitate common irradiation conditions at the panoramic source. Precision limits of dose interpretations, due to readings of $k=\Delta A/l$ (where l is the indicators thickness in milimiters), were determined as the mean standard deviation.

After the irradiation, the sensible plastic was unsticked from the label and was cleaned with ethil acetate mixed with mamona (brazilian tree) oil to remouve the adhesive glue.

The samples were mantained at room temperature conditions during manipulation at the laboratory, irradiation and storage after the irradiation.

The optical density changes were measured with a Pharmacia LKB Model Novaspec II spectrophotometer. Thickness measurement were made with a Peacock micrometer at the same position where optical absorption was measured.

Response curve was taken over dose range from 5 to 125 Gy and from 5 to 300 Gy for each type of labels at the choosed wavelength.

RESULTS

Suggested wavelength for spectrophotometry for 125 Gy INDICATOR and 300 Gy INDICATOR is 665 nm as can be seen in Figure 1. This value was choosen because of the sharper absorption in that wavelength region.

* ISP Technologies Inc.

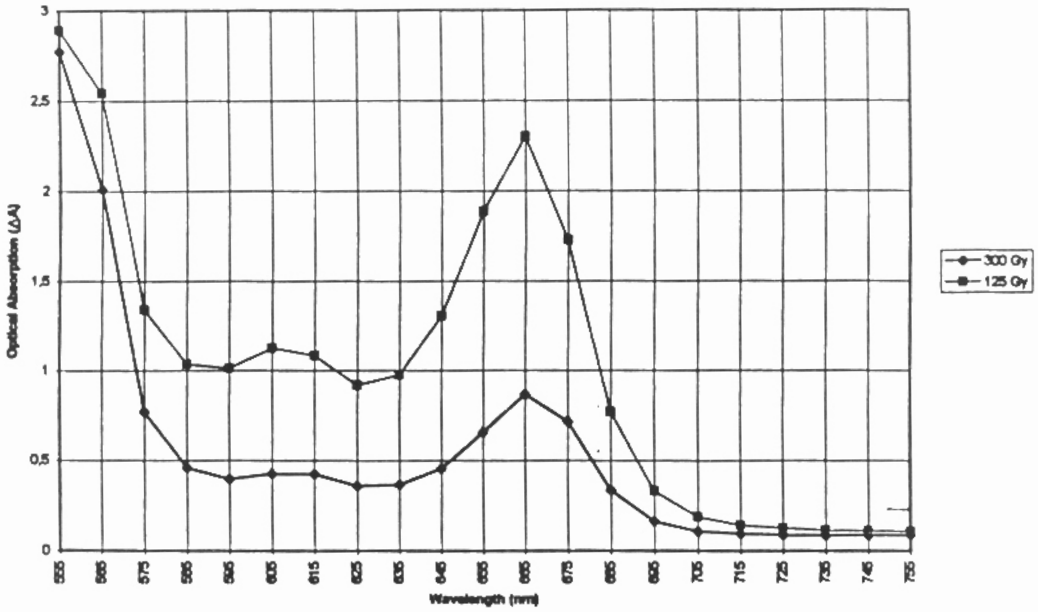

Figure 1 - Optical absorption curves for 125 Gy and 300 Gy INDICATORS, between 555 and 755 nm.

Figures 2 and 3 are the response curves for both types of labels. It can be noted that a sublinear effect is observed for doses near the maximum value.

Indicators measured thicknesses, l, were 0.573 ± 0.002 mm for 125 Gy - INDICATOR and 0.370 ± 0.002 mm for 300 Gy INDICATOR. Response curves are plotted with values of dose against $\Delta A/l$.

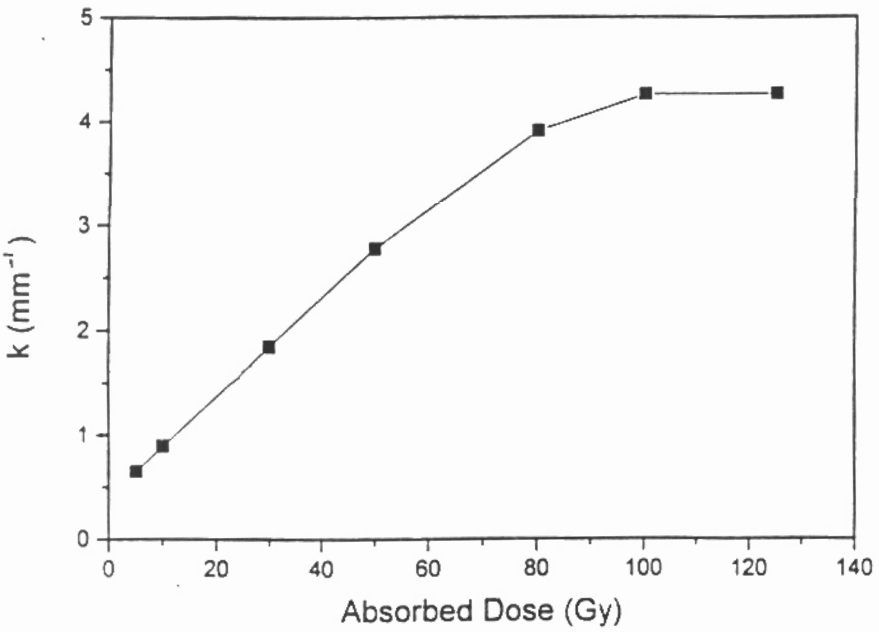

Figure 2 - Response curve at 665 nm for 125 Gy INDICATOR irradiated with ^{60}Co gamma-rays.

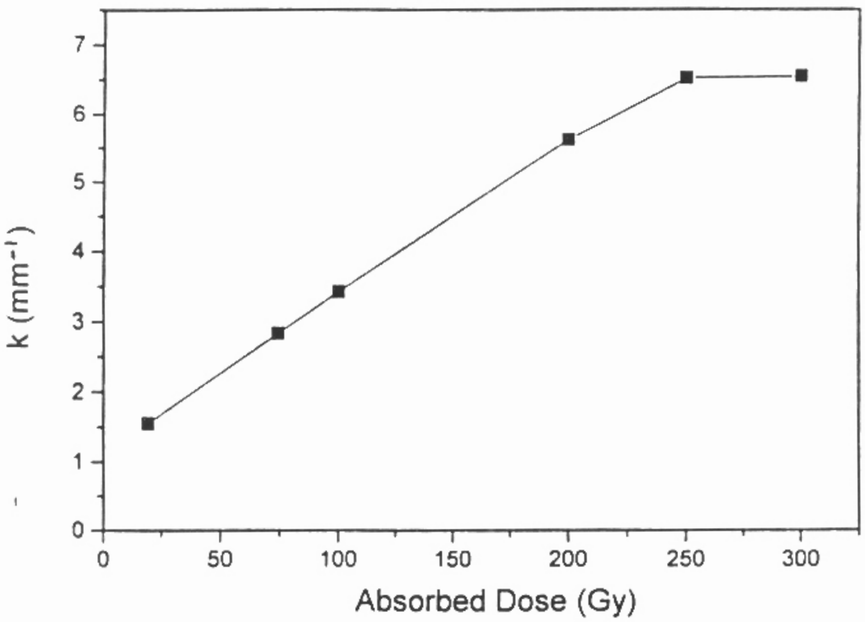

Figure 3 - Response curve at 665 nm for 300 Gy INDICATOR irradiated with ^{60}Co gamma-rays.

No significative differences were observed when the indicators were irradiated in uninterrupted manner from that fractionated. Fractionated time has no more than few minutes intervals (maximum 8 min) between one irradiation and the next, to reach the accumulated dose.

No influence was observed on indicators surface when the ambient has 85% air relative umidity. Ambient light, usually composed of fluorescent and day light, do not provoque the sensible pigment darkness for long exposure periods (about one month).

When the labels were irradiated with gamma rays at the panoramic source, where it is possible to have different dose rates due to distance effect, no differences were observed in the absorption value at 665 nm.

The fluorescent ligh as well as the day light do not influence the darkening effect of the dyed material and after two months storage at room temperature the absorption value becomes 7% higher.

CONCLUSIONS

It is seen that the radiosensible plastic has its response linear up to 80 Gy for 125 Gy INDICATOR and up to 250 Gy for 300 Gy INDICATOR. Room temperature or air umidity conditions ranging 85% do not affect the indicator response.

Although these characteristics seems to be promissing, the irradiation indicator must be tested for other properties before its application as dosimetric material when no other dosimeter is used due to some reason.

Experiments as reproducibility, systematic errors, angular dependence, long term storage in different room temperatures and higher umidity conditions are proposed.

ACKNOWLEDGEMENTS

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