PERSONNEL DOSIMETRY USING PELLETS OF $CaSO_4$:Dy BOUND IN ALKALY HALIDES

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Thermoluminescent dosemeters (TLD) are widely used for routine dose measurements in personnel monitoring due to their advantages over film dosemeters (1,2). Among TL materials used in this field the most accepted has been LiF:Mg,Ti which is obtained commercially. However, Teflon embedded $CaSO_4$:Dy is being increasingly utilized in many countries for this purpose (3-6).

In our laboratory, to replace LiF commercial TLD's in personnel monitoring pellets of $CaSO_4$:Dy bound in alkaly halides were developed.

Before deciding on the suitability of introducing $CaSO_4$:Dy bound in alkaly halides pellets in routine personnel dose measurements, dosimetric characteristics of $CaSO_4$:Dy+KBr, $CaSO_4$:Dy+KCl and $CaSO_4$:Dy+NaCl pellets were determined and tests of comparative effectiveness of $CaSO_4$:Dy+KBr pellets in the field were carried out for a period of one year.

Our test design was done encasing $CaSO_4$:Dy+KBr pellets together with TLD-100* ribbons in black plastic cassettes provided with appropriate compensating filters. The cassettes were then distributed to selected groups of occupationally exposed personnel in the Nuclear Center of Mexico.

Results obtained during this test period showed good agreement between the dosimetric effectiveness of $CaSO_4$:Dy+KBr pellets and the Harshaw TLD-100 ribbons.

EXPERIMENTAL

$CaSO_4$:Dy phosphor powder was prepared using the acid evaporation method proposed by Yamashita (7) and improved by us (8,9) doping $CaSO_4.2H_2O$ with 0.1 mol% of Dy_2O_3 at 285°C and drying in an oven at 600°C during one hour in a platinum crucible. The dried material was powdered and sieved and crystalline powder of grain size between 80 and 200 μm was selected to be used as TL phosphor.

To make pellets of $CaSO_4$:Dy+KBr, $CaSO_4$:Dy+KCl and $CaSO_4$:Dy+NaCl the phosphor powder was mixed with the respective alkaly halide which was used as binder in a ratio of 1:3 applying a pressure of 980 Pa for each 100 ± 3 mg of mixture. This technique yielded pellets of 0,95 ± 0.05 mm thickness.

Before determining their dosimetric characteristics the pellets were treated by standard thermal annealing procedure consisting in heating them at 400°C during one hour.

To select homogeneous batches all the pellets were irradiated at a dose of 5 mGy of ^{60}Co gammas and those pellets which TL response deviated ± 5% from the average were considered within an homogeneous batch.

The dosimetric characteristics of the pellets were determined irradiating them with ^{60}Co gammas from an encapsulated source of 18 GBq. All irradiations were efectuated under electronic equilibrium conditions.

Readings were made in a Harshaw 2000 A/B TL system connected to an x-y recorder to obtain glow curves. TL signal was integrated between room temperature

* Trade name of Harshaw Chemical Co. Solon, Ohio USA.

(∿20°C) and 300°C during 60 seconds using a linear heating rate of 6°C/s.

TL response in function of dose was determined irradiating the pellets with ^{60}Co gammas at different known doses and plotting TL intensity against dose.

Fading of TL response was investigated irradiating 20 pellets of each kind at 5 mGy of ^{60}Co gammas and storing them, protected from the light, along with 5 other unirradiated pellets of each kind. Readings were made immediately after irradiation and at different post-irradiation times ranging from 1 to 30 days.

Reusability was determined irradiating 10 pellets of each kind at 5 mGy and recording the glow curves and the TL response for each pellet. After readings, pellets were annealed and again submitted to the same absorbed dose under the same conditions and their TL response and glow curves were recorded. This process was repeated 10 times and the average TL response for each pellet of the three groups was determined.

For personnel monitoring, in the field, we decided to use pellets of $CaSO_4$:Dy +KBr. For this purpose we selected, from a large number of pellets, a batch of 500 pellets to be distributed to 30 occupationally exposed individuals working at the Department of Radioactive Materials in the Nuclear Center of Mexico.

Each dosemeter distributed consisted of two $CaSO_4$:Dy+KBr pellets and two TLD-100 ribbons placed into black plastic cassettes consisting of two plates of dimensions 4x5x0.5 cm hinged toghether at the center by means of a screw, sealed with an O'ring rubber seal and provided with a clip for wearing. As shown in figure 1 both two plates have four circular depressions: two of 1.0 mm and two of 2.0 mm depth of diameter 6 mm. At the locations 3 and 4 and 3' and 4' lead filters of 0.8 mm thick are placed with silicon glue. When the cassette is closed pairs of filters face each with other.

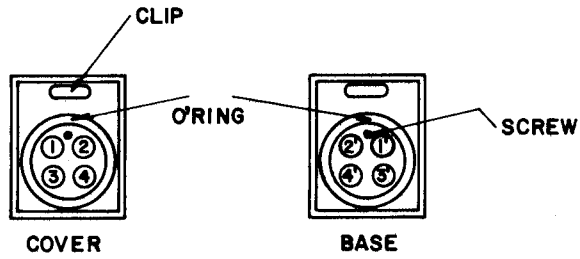

Figure 1.- Black plastic cassettes in which $CaSO_4$:Dy+KBr pellets and TLD-100 ribbons were placed for personnel monitoring.

Two CaSO4:Dy+KBr pellets were placed in locations 1 and 3 and two TLD-100 ribbons in locations 2 and 4 respectively.

Two personnel dosemeters, constituted by two pellets and two ribbons, were asigned to each individual. Three of such dosemeters were supplied to the users to be kept as control dosimeters.

During the processes of thermal annealing, placing in plastic cassettes and

read out, the pellets and the ribbons were handled in safe light conditions.

After one month of use in field the dosemeters were sent back to the laboratory and substituted by other set assigned.

Immediately arriving the dosemeters to laboratory readings were taken. To determine the unknown doses a calibration curve was constructed using 100 pellets having TL characteristics very similar to those of the pellets used in the field.

Pellets were reused by the same individual before thermal annealing. This annealing consisted in reading each pellet twice.

During the 12 months of this study a record of date of thermal annealing, date of dispatch, period of use, name of users, date of receipt and date of TL reading were maintained.

RESULTS AND CONCLUSIONS

Pellets of $CaSO_4$:Dy+KBr, $CaSO_4$:Dy+KCl and $CaSO_4$:Dy+NaCl presented similar glow curves as shown in figure 2. For the three kinds of pellets, TL response in function of dose fitted to a straight line in log-log scale from 1 mGy to 1 Gy (see figure 3). Also they exhibited a fading rate of about 5% per year. Both characteristics are desirable for personnel monitoring.

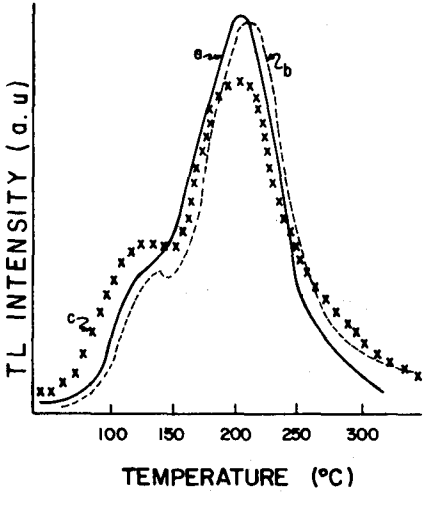

Fig. 2. TL glow curves of $CaSO_4$:Dy bound in alkaly halides obtained irradiating with 5 mGy of ^{60}Co gammas a) $CaSO_4$:Dy+KBr, b) $CaSO_4$:Dy+KCl, c) $CaSO_4$:Dy+NaCl

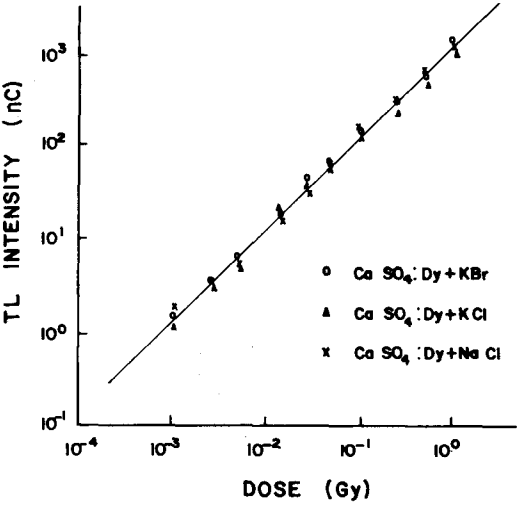

Fig. 3. TL response in function of dose for $CaSO_4$:Dy bound in alkaly halides.

Taking the average TL response of 10 pellets, submitted to repeated irradiation and reading cycles by 10 times, the standard error found was 1.2% for $CaSO_4$:Dy+KBr, 1.5% for $CaSO_4$:Dy+KCl and 1.4% for $CaSO_4$:Dy+NaCl. Therefore, all pellets can be used repeatedily without any recalibration.

The standard error we obtained for $CaSO_4$:Dy+KBr pellets (the smallest of the three) decided us to use them to test in the field.

Results of using $CaSO_4$:Dy+KBr pellets in the field during 12 months were quite satisfactory. Absorbed doses measured with these pellets deviated from those measured with TLD-100 placed in the same cassette by ± 3% which we considered as a good grade of agreement.

Based on these results we concluded that pellets of $CaSO_4$:Dy+KBr provided with appropriate filtration to make their TL response energy independent and placed in plastic cassettes furnish a practical, sensitive and reliable dosemeter for personnel monitoring.

Therefore, this dosemeter can be produced locally on mass scale and commercialized at low cost.

Acknowledgements.

The authors acknowledge the cooperation of Luis E. Guzmán R. in the experiments and express their sincere appreciation to the staff of the Radiactive Materials Department who participated in this study wearing the dosemeters at the same time of their routine personnel dosemeters.

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