INFLUENCE OF IRRADIATION AND STORAGE TEMPERATURES AND POST-IRRADIATION TIME IN THE AMBER PERSPEX DOSIMETERS.

Enrique Fco. Prieto Miranda*, Armando Chavéz Ardanza*, Gabriel Cuesta Fuente**

*Centro de Estudios Aplicados al Desarrollo Nuclear.
Calle 30, #502, Esq. 5^{ta} ave., Playa, Ciudad de La Habana.
**Instituto de Investigaciones para la Industria Alimenticia.
Carretera Guatao, km 3 1/2, La Lisa, Ciudad de La Habana.
Corresponding author:
E-mail: **efprieto@ceaden.edu.cu**
Fax:(53-7)241188

RESUMEN

Uno de los sistemas dosimétricos más empleados en la dosimetría de altas dosis como dosímetros de rutina para el control del proceso de irradiación de alimentos y material médico-farmaceútico son los dosímetros Perspex, por su rapidez en la obtención de la información, su fácil manipulación y la precisión que estos presentan. A este grupo de dosímetros pertenecen al igual que los Red y Clear los Perspex Ambar, los cuales son adecuados para la medición de la dosis de radiación en el rango de altas dosis.
En el presente trabajo se obtuvieron las curvas de calibración de los dosímetros Perspex Ambar 3042, Batch L, en nuestras condiciones de trabajo, como son las temperaturas de irradiación y de almacenamiento, así como para diferentes longitudes de onda de medición, factores estos que influyen en la determinación del valor de la dosis absorbida por estos dosímetros y además conocer la influencia del tiempo postirradiación en el valor de la absorción específica inducida en función de la dosis absorbida.

ABSTRACT.

The Perspex dosimeters are employed in the high dose dosimetry as a routine dosimeter for to control the radiation processing of food and medical products, due to the following properties: quick evaluation, appropiate accuracy and ease handling. The Amber Perspex the same as Red and Clear belong to this dosimeter king, which are used to measure the absorbed dose in the high dose range.
In the present paper were obtained the calibration curves of the Amber Perspex 3042 dosimeters,Batch L, in our condition of work, as the irradiation and storage temperatures, as well as, different measurement wavelengths, these factors influence in the absorbed dose value determination, and it to know the relation between the post-irradiation time and the induced specific absorbance value in function of the absorbed dose.

INTRODUCTION.

The Perspex dosimeters are one of the dosimetric systems recognized in the dosimetry of high dose that are meetly employed to study the dose distribution and in the routine control of the absorbed dose in such industrial applications as the sterilization of medical, biological materials and nutritious products, because it is a system reproducible, of easy manipulation and with characteristic of equivalent absorption to the biological tissue (1-3) .En precedent investigations has been pointed out that of a lot to another of dosimeter of oneself type the sensibility of the induced specific absorbance (K *) changes and different calibration curves have been obtained for different temperatures, which are found frequently in facilities of commercial irradiation, of calibration and in the laboratories of tropical countries. It means that it is not alone necessary to recalibrate each dosimeter lot but rather it is necessary to research the effects of the environmental changes with the objective of assuring that new lots present a satisfactory behavior under specific conditions of application (2) .En the present time a growing interest exists in the employment of the Amber Perspex 3042 dosimeters, due to the industrial use of the radiosterilización of medical products and to certain advantages that they present on the Red and Clear Perspex (6,7).

In the present work were obtained the curves of calibration of the dosimeters Amber Perspex 3042, Batch L, in our work conditions, as the irradiation and storage temperatures, as well as, for different measurement wavelengths, these factors influence in the determination of the value of the absorbed dose by these dosimeters and also it to know the influence of the time postirradiación in the value of K * in function of the absorbed dose.

MATERIALS AND METHODS.

The Perspex Amber Perspex 3042 dosimeters, Batch L, were calibrated in an laboratory irradiador , type PX-γ-30, with sources of cobalt-60, where the dose rate in the calibration position was determined with the Fricke dosimeter, recommended internationally as a reference dosimeter (8) and it was preparated according to Prieto (9). The calibration position was located in the center of the inferior area of the irradiation chamber and the dosimeters were placed in a polyethylene foam cylinder, which provided electron equilibrium conditions (10).

They were carried out two experiences, one without keeping in mind the initial absorbance (Ao) of the dosimeters and another keeping in mind this parameter. The dosimeter thickness, Xi (mm), was determined with a micrometer of a precision of ±0.01 mm and the absorbance value in an Pye-Unicam 8600 spectrophotometer, for wavelengths values of 603 and 651 nm.

This dosimeter type, according to the producer (11), it presents different dose ranges in dependence of the measurement wavelengths. The measurement dose range for the wavelength of 603 nm is from 1.0 to 15.0 kGy, where they were carried out 5 replicas for each dose value, the values are of 1, 5, 10, 13 and 15 kGy and for the wavelength of 651 nm the range is from 1.0 to 30.0 kGy and the values of dose of 1, 5, 10, 13, 15, 20 and 30 kGy.

The irradiations were carried out to temperature of 27 ± 1 ^{o}C, because it is the temperature value of the irradiation chamber of the Foods Irradiation Facility. The irradiated dosimeters were stored and carried out their absorbance readings at 25 ^{o}C. The absorbance values were determined at the 24 hours, 7, 14, 21 and 30 days.

The methodology of the calibration process was made according to the norm E1276 of the American Society for Testing and Materials (ASTM) (12). The K * value of each dosimeter it was calculated by the following expression:

$$K^* = \frac{A_i - A_o}{X_i} \quad (mm^{-1})$$

Where Ai is the absorbance value of each irradiated dosimeter.

RESULTS AND DISCUSSION.

The obtained dose rate value in the calibration position of the irradiation chamber of the irradiador type PX-γ-30 was of 3.74 $kGy.h^{-1}$, which agrees with the determined value during its process of calibration , it taken into account the decline factor of the cobalt-60 source for the moment in that this experience carried out (10).

The figures 1 and 2 show the calibration curves of the Amber Perspex 3042 dosimeter, Batch L, obtained without having and keeping in mind the value of Ao, being its similar behavior responding to a polynomial of second order, but however it should be kept in mind that they should not be used indistinctly since for this studied range of absorbed dose, where relative errors of K^* value are obtained superiors to 4% for oneself dose value among both curves, being this superior value to the precision of this dosimetric system, which would cause errors in the estimated dose value, besides the inherent errors in the operation of the irradiation facility. However it is more precise the value of absorbed dose when they are taken into account Ao values, since this eliminates the existent variation in the thickness of the dosimeter lot. Although , at present, the producer recommends the employment of the calibration curves without keeping in mind Ao (11) to avoid the manipulation of the dosimeter before the irradiation and to use it as routine dosimeter and not with ends of process calibration.

On the other hand in the figures 3 and 4 the calibration curves are observed for the same conditions that the previous ones but for different measurement wavelength, where similar behavior is appreciated among both curves, being obtained the same relative errors of K * that those analyzed previously, that makes valid also for this case the analysis before exposed, although the range of absorbed dose is bigger for this measurement wavelength. These results belong together with those obtained by other authors that point out the necessity to carry out their own work procedures and of making a careful calibration with these routine dosimeters to obtain exact and precise absorbed dose value (3,6).

Lastly in the figures 5 and 6 is shown the behavior during the postirradiation time of the K * value for different absorbed dose values, for the measurement wavelength of 651 nm, where it is observed that it stops dose values starting from the 10 kGy a falling significant variation of the K * value exists as it lapses the time between the end of the irradiation and the moment of the measurement of the dosimeter, what indicates that this dosimeter is not appropriated to maintain the information for postirradiation long time, what belongs together with other results obtained with the Red and Clear Perspex dosimeters (4,5,13).

CONCLUSIONS.

The calibration curves of the Amber Perspex 3042 dosimeters , Batch L, was obtained for the irradiation temperature of 27 ± 1 ^{0}C and of storage of 25 ^{0}C, also keeping in mind or not the Ao value, what allows us to obtain exact values of the estimated absorbed dose during the control of the irradiation process in our facility.
On the other hand it was studied the behavior of the K * value with relationship at the postirradiation time for different absorbed dose values, what demonstrated that this dosimeter is not appropriate to maintain the information once irradiated by lingering periods of time.
We have another dosimetric system for the control of the irradiation process in the range of high dose, being this appropriate system whenever they are kept in mind the factors that affect the estimated dose value.

REFERENCES

1 - Chadwick, K.. A standar procedure for the use the Clear Perspex HX dosimeters in the dose range 1-10 Mrad. Tech. Rep. Series, IAEA, Vienna, No.159. (1974).

2 - Ten Broeke, W.R. y col.. The effect of storage temperature on the calibration of the Clear Perspex dosimeters. Int. J. Appl. Rad. Isot. No.28, 1977,429-434.

3 - Amin, M. R. y col.. Evaluation of locally available white Perspex as a dosimeter in radiation processing, STI/PUB/846,IAEA, Vienna, 1991, 57.

4 - Prieto, E., Chávez, A.. Effect of the temperature during the calibration and the storage of the Perspex dosimeters (Red and Clear). Symposium Nurt-97, Oct., C. Habana.1997.

5 -Prieto, E. y col.. Perspex Dosimeters. Calibration process. Formless Stage. IIIA. C. Havana. 1997.

6 - Watts, M. F.. The influence of dose rate, irradiation temperature and post irradiation storage conditions on the radiation response of Harwell Amber 3042 PMMA dosimeters. Inter. Symp. On Techniques for High-Dose Dosimetry in Ind. Agric. And Med.. IAEA-SM-356.Vienna,Nov. 1998 .

7- Whittaker, B.. Recent developments in Poly (Methacrylate)/Dye Systems for megarad dosimetry. Radiation dose and dose rate measurements, Symposium Nat. Phy. Lab. (U.K.), 1970.

8 - IAEA, Manual of Food Irradiation Dosimetry. Tech. Rep. Series Not. 178, IAEA, Vienna, 1977.

9 -Prieto,E.. NRIAL. Determination of the absorbed dose using the Fricke dosimeter. 1991.

10- Prieto, E., Chávez, A., Cuesta, G..Commissioning dosimetry of the irradiador PX-γ-30. CEA-R 10/97. 1997.

11- Harwell Perspex (PMMA) Dosimeters. Didcot, Oxfordshire OX11 PRAYS, United Kingdom. 1997.

12- ASTM standards. Subcommittee AND 10.01. Dosimetry for Radiation Processing. E 1276-93. 1993.

13- Chadwick, K. y col.. The accuracy of the calibration curve of the Clear Perspex dosimeter. IAEA. SM-221/43, IAEA,Vienna,1978, 327.

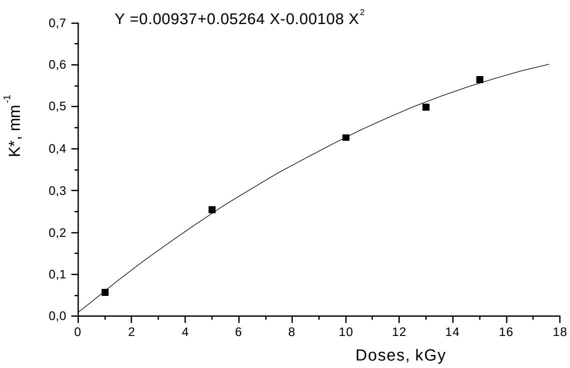

FIG. 1-Curve of calibration of the Amber Perspex 3042 dosimeter, Batch L,λ = 603 nm. Without keeping in mind Ao.

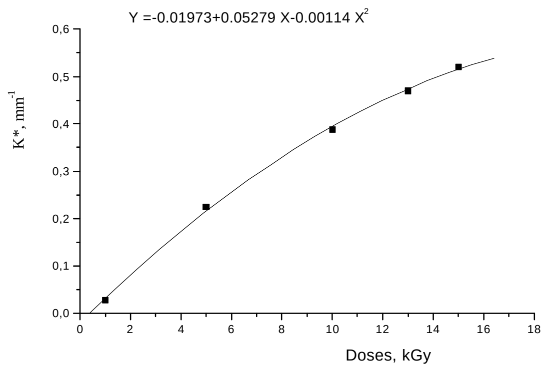

FIG. 2-Curve of calibration of the Amber Perspex 3042 dosimeter, Batch L, λ = 603 nm. Keeping in mind Ao.

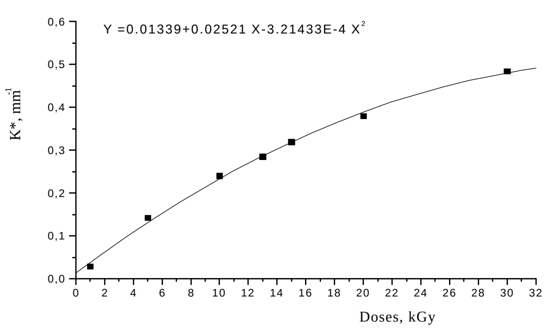

FIG.3-Curve of calibration of the Amber Perspex 3042 dosimeter, Batch L, λ= 651 nm. Without keeping in mind Ao.

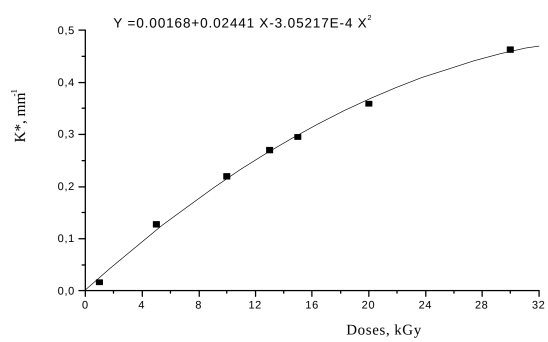

FIG.4-Curve of calibration of the Amber Perspex 3042 dosimeter, Batch L, λ = 651 nm. Keeping in mind Ao.

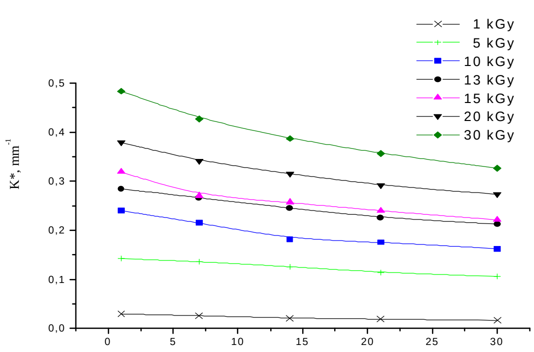

FIG.5-Variation of K * value during the post-irradiation time to different absorbed dose values for the Amber Perspex 3042 dosimeter, Batch L, λ= 651 nm. Without keeping in mind Ao.

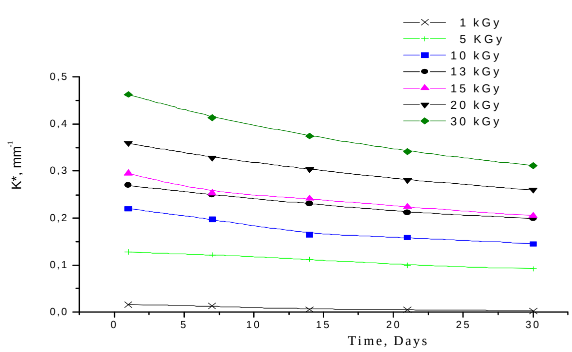

FIG.6-Variation of K * value during the post-irradiation time to different absorbed dose values for the Amber Perspex 3042 dosimeter, Batch L, λ= 651 nm. Keeping in mind Ao.