PHYSICAL CHEMISTRY 2012

11th International Conference
on Fundamental and Applied Aspects of
Physical Chemistry

Under the auspices of the
University of Belgrade

Proceedings

The Conference is dedicated to
Professor Ivan Draganić

September 24-28, 2012
Belgrade, Serbia

ISBN 978-86-82475-27-9 ***Volume*** **1**
ISBN 978-86-82475-28-6 ***Volume*** **II**

Title: PHYSICAL CHEMISTRY 2012 (Proceedings)
Editors: S. Anić and Ž. Čupić
Published by: Society of Physical Chemists of Serbia, Studenski trg 12-16, 11158, Belgrade, Serbia
Publisher: Society of Physical Chemists of Serbia
For Publisher: S. Anić, President of Society of Physical Chemists of Serbia
Printed by: "Jovan" Priting and Publishing Company; 200 Copies;
Number of pages: 6+ 497; **Format**: B5; Printing finished in September 2012.

Text and Layout: "Jovan"

200- *Coppy printing*

CONTENTS

F-24-P

CHARACTERIZATION OF DOSIMETERS USED IN RADIATION PROCESSING

B. Šećerov, I. Janković, M. Dramićanin

Vinča Institute of Nuclear Sciences, University of Belgrade, 11001 Belgrade, P.O.Box 522, Serbia

Abstract

Aérial L-alanine pellet dosimeter is characterized as the dispersion of dose measurement values in order to determine the level of uncertainty caused by dosimeter itself. The results of repeated measurements indicate that the uncertainty of 1.2% could be attributed to the homogeneity of alanine in dosimeter pellets. It was obtained by analyzing the results of measurements of the different dosimeters from the same batch that the uncertainty due to difference in dosimeter mass is 1%. The total uncertainty due to dosimeter itself is 1.5%.

Introduction

The quality of products treated in radiation processing depends on absorbed dose in product. During irradiation process all parts of product have to receive an absorbed dose within certain prescribed limits. The integral part of absorbed dose measurements in radiation processing is uncertainty (a parameter associated with the result of measurement that characterizes the dispersion of the values that could reasonably be attributed to the measured or derived quantity). In order to establish the accuracy of an absorbed dose measurement it is necessary to first identify and then quantify all possible sources of uncertainty. Hence, the uncertainty associated with an absorbed dose measurement can be estimated by considering the individual components together. There are some international guides for estimating the uncertainty of absorbed dose measurements [1, 2, 3], but there is no recommendation for exact measurement of uncertainty. In this article we have tried to determine the uncertainty due to dosimeter itself experimentally.

Experimental

L-alanine pellet dosimeters (diameter 3 mm, thickness 1.5 mm and mass between 37.5 – 37.6 mg) were purchased from Aérial (Illkirch, France). In the first experiment, the alanine dosimeters were put together with ethanol-chlorobenzene (ECB) dosimeters in the standard cardboard boxes filled with products for irradiation. Boxes were irradiated in common sterilization cycles in Radiation Plant of the Vinča Institute [4]. 40 pairs of alanine - ECB dosimeters were irradiated with nominal dose of 25 kGy and six pairs were irradiated with nominal dose of 12 kGy. In the second experiment, the alanine dosimeters were irradiated by ^{60}Co laboratory source [5] of about 10^{12} Bq activity. The dosimetry at the source was done by Fricke solution. Four alanine pellets were placed in polystyrene vial. Dosimeters in vials were irradiated with doses between 5 - 30 kGy and each dose was repeated three times.

The absorbed doses were measured by the oscillotitrator OK – 302/2 for ECB dosimeters, while the alanine dosimeters were measured by MiniScope MS300 ESR spectrometer using Aer'EDE Version 2.0.4. software for dose calculation. The measurements were repeated each day for five days after irradiation.

Results and Discussion

The results of absorbed doses measured by oscillotitrator and ESR spectrometer are compared for the pairs of alanine and ECB dosimeters. The differences in all examined pairs are less then 2% for 25 kGy nominal dose. For 12 kGy nominal dose the difference is slightly higher. This is expected since the calibration curve residuals for ECB dosimeter have the same trend [6], with the relative error being higher when the measured value decreases.

The results of measurements of alanine dosimeters that were repeated each day for five days after irradiation were analyzed. They can give us the information of homogeneity of alanine in dosimeter pellets. Aer'EDE Version 2.0.4. software calculates absorbed dose taking into account the correction factor of spectrometer variation during measurements using reference dosimeter. The standard deviation of reference value is 1.4% for all measurements. This value can be attributed to standard uncertainty due to instability of instrumentation. 70% of measured dosimeters showed the standard deviation of absorbed doses in this range. 91 % dosimeters have standard deviation of absorbed doses up to 2% and 9 % of measured dosimeters standard deviation between 2 % and 3 %. As the greater part of dosimeters has standard deviation near the midpoint, the standard uncertainty due to difference in homogeneity of alanine in dosimeter pellets is determined as type B [1] and the value is 1.2%.

The results of absorbed dose measurements of alanine dosimeters irradiated by laboratory source are presented in Fig.1. It is obvious that the standard deviation for all measurements is up to 3 % with no dose influence. In this case, the standard deviations of measured absorbed doses were calculated using 4 pellet dosimeters, so beside the homogeneity of alanine in pellets there is the difference in mass of dosimeters. The standard uncertainty is determined as type A [1]. The obtained value of 1.5% is the total uncertainty. As the total uncertainty is the square root of the sum of the squares of the individual components, it is obvious that 0.2% standard uncertainty in mass gives rise of up to 1% standard uncertainty due to the difference in mass of dosimeter pellets. The uncertainty due to the difference in mass of dosimeter pellets is in very close connection with the measurement parameters of ESR signal. When the measurement parameters are adjusted to give us high intensity of ESR signal (in this case modulation amplitude was 6 G and the noise was reduced by 5 passes), i.e. the highest measurement sensitivity, the value of uncertainty due to difference in mass of dosimeter pellets was also the highest. If the sensitivity of measurement is less it is more difficult to detect the difference in mass. However, the total uncertainty of measurement is not getting smaller by reducing the sensitivity of measurements, since the uncertainty due to instability of instrumentation increases.

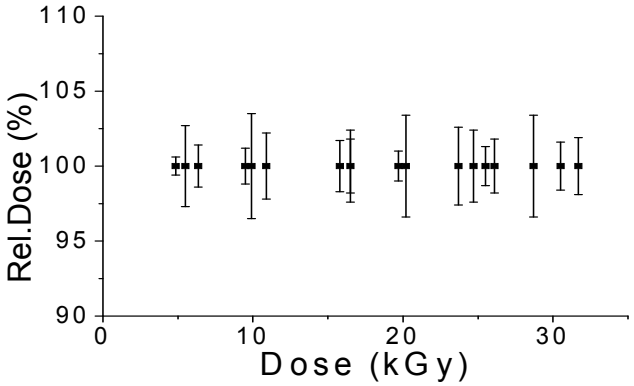

Figure 1. The relative dose response versus the absorbed dose. The error bars represent the standard deviation.

Conclusion

The uncertainty due to dosimeter itself can be determined by observing the absorbed dose measurements during the actual use of dosimeter in radiation processing. The total uncertainty of Aérial L-alanine pellet dosimeter is 1.5%. The components of this uncertainty are the uncertainty due to homogenity of alanine in dosimeter pallets (1.2%) and uncertainty due to difference in dosimeter mass from the same batch (1%).

References

[1] ISO/ASTM 51707 – 2002 (E) Standard guide for estimating uncertainties in dosimetry for radiation processing, 2002.
[2] P.Sharpe and A. Miller, Guidelines for the calibration of dosimeters for use in radiation processing, NPL Report CIRM 29, 1999, available at http://www.chemdos.npl.co.uk/dosc/NPLReportsCIRM29.pdf
[3] IOS, Guide to expression of uncertainty in measurement, International Organization for Standardization, Geneva, Switzerland, 1993.
[4] V. Marković, R. Eymrey, H. C. Yuanradiat, Phys. Chem., 1977, 9, 625-631
[5] B. Radak, I. Draganič, Bull. Of the B. Kidrič Institute of Nucl. Sci., 1962, 13, 77-88.
[6] B.Šećerov and G. Bačić, Nuclear Technology & Radiation Protection, 2011, 26, 271-274.

CIP Volume I

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

544(082)
621.35(082)
66.017/.018(082)

MEĐUNARODNA konferencija iz fundamentalne i primenjene fizičke hemije (11 ; 2012 ; Beograd)
Physical Chemistry 2012 : proceedings. #Vol. #1 / 11th International Conference on Fundamental and Applied Aspects of Physical Chemistry, September 24-28, 2012, Belgrade ; [editors S.[Slobodan] Anić and Ž.[Željko] Čupić ; organized by Society of Physical Chemists of Serbia ... et al.]. - Belgrade : Society of Physical Chemists of Serbia, 2012 (Belgrade : Jovan). - VI, 498 str. : ilustr. ; 24 cm

"The Conference is dedicated to Professor Ivan Draganić" --> nasl. str. - Tiraž 200. - Bibliografija uz svaki rad.

ISBN 978-86-82475-27-9
1. Društvo fizikohemičara Srbije (Beograd)
a) Физичка хемија - Зборници b) Електрохемијско инжењерство - Зборници c) Наука о материјалима - Зборници
COBISS.SR-ID 193432332