STUDY OF SOME RADIATION DOSIMETRIC METHODS AND THEIR APPLICATIONS IN RADIATION PROCESSING

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THESIS FOR Ph. D. IN PHYSICS
SUBMITTED BY

SALEH MAHMOUD ABDOU EL-SAYED

51657

Supervising Committee

Prof. Dr. A.Z.El-Bahey
Head of the National Center for Radiation Research & Technology

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Nuclear Materials Authority

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3. Prof. Dr. H. A. Ashry, National Center for Radiation Research & Technology.

4. Dr. F.A.S. Soliman, Nuclear Materials Authority.

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CHAPTER THREE

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Abstract
&
Summary

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ABSTRACT

One of the important aims of the present thesis is to design and construct different calorimetric systems as a primary standard dosimeters at the National Center for Radiation Research and Technology (NCRRT). The study contains three types of calorimeters (graphite, water and polystyrene -water). They consist basically from a thermistor embedded in the sensitive part (absorber), and a shield. The main features of the investigated calorimeters are the simplicity of the design, no need for vacuum system, and can be quickly put into operation. The measurements takes less than four hours, including the positioning of the calorimeter, getting it into operation and making multiple runs of measurements.

Temperature stability ($^{\circ}$C/min) and radiation sensitivity (Ω/Gy) tests for the constructed graphite, water and polystyrene - water calorimeters are found to be 0.003, 0.00283 and 0.0018 and 2.330, 1.80 $^{\circ}$C/min and 1.972 Ω/Gy respectively.

For the importance of the absorbed dose in water to radiation therapy, applications using the NBS graphite calorimeter has been performed to determine the absorbed dose at a point in water phantom, theoretically and experimentally.

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The absorbed dose measured by the investigated calorimeters are compared with that measured by the calibrated Fricke dosimeter at the same irradiation positions. The accuracy of absorbed dose determination are estimated to be ± 0.01, ± 0.003 and +4 using the graphite, polystyrene - water and water calorimeters respectively. In case of the water calorimeter, the difference found are discussed in terms of the heat defect of water.

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SUMMARY

The thesis concerns with the dosimetric measurements of absolute determination of absorbed dose using various dosimetric techniques (calorimetry, ionimetry and chemical dosimetry).

An "introduction" to calorimetry was described in the first chapter which contains the calorimetric phenomena in radiation dosimetry, stored energy in graphite, heat transfer, the technique used in temperature measurements, temperature induction and control. Also, calorimetric applications review and advantages and disadvantages of calorimetric dosimetry were mentioned.

In the second chapter, a description for the preparation and stability tests for ferrous sulfate (Fricke) are performed to be sure that it can be used as a transfer dosimeter. Also, description for the design, measurements procedure and technique, and temperature control of a copy of the NBS graphite calorimeter were used to calibrate the Fricke dosimeter. The resistance-temperature relationship and radiation sensitivity were studied for different types of temperature-dependent resistance (TDR) devices. Also, the design, measurements technique, temperature stability and radiation sensitivity tests for the graphite, water, and polystyrene-water calorimeters were described.

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Besides, the irradiation facilities used in the present work are reported. Finally, experimental procedure for ionization measurements are mentioned.

In the third chapter, the results obtained by the three investigated dosimetric techniques (calorimetry, ionimetry, and Fricke dosimetry), are reported. The advantages and disadvantages for each technique were discussed.

The obtained results for the seven different types of Temperature-Dependent Resistances (TDR) were reported. The temperature-resistance relationships for the used themistors were studied before, during and after their exposure to gamma ray with different dose levels. No permanent change in their resistance values is observed after gamma-exposure up to 2 MGy. On the other hand, their resistance decreased as the temperature increased due to gamma-exposure.

A simple type of four-body calorimeter was designed and constructed for measuring absorbed dose produced by ionizing radiation in graphite. A special design feature is that the core is enclosed by a jacket. Both are enclosed in the massive shield which acts as a thermal buffer between the medium and the graphite bodies (core and jacket). The four bodies are each thermally insulated by teflon sheets of 200 μm thickness. Absorbed dose measurements are made in the enclosed core, 20 mm X 20 mm and nearly 3 mm

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