RADIATION DOSIMETRY IN HIGH RADIATION FIELDS

A Thesis Submitted

BY

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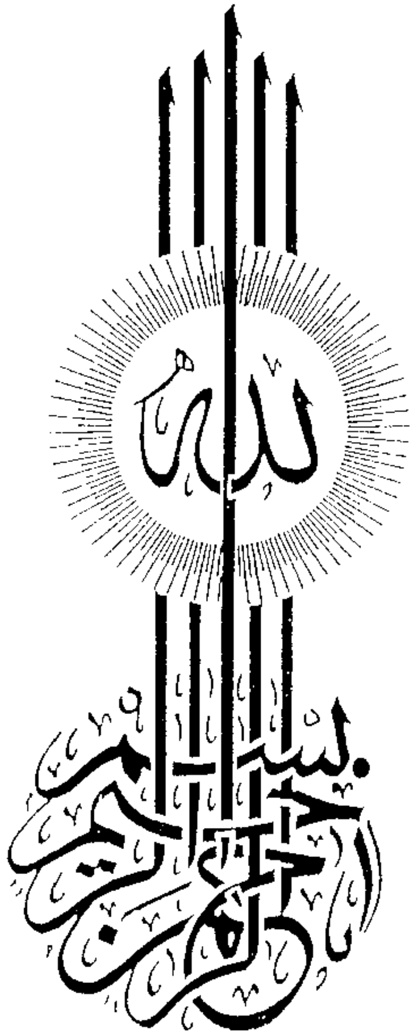
Contents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S U M M A R Y

The work presented in this thesis investigates the response of different types of solid state dosimeters to radiation. The aim is to examine and select certain dosimeters which could be used for megarad dosimetery, as in radiation sterilization and food preservation .

The investigation includes the dose range characterstics and the physical parameters affecting the dose estimation. The environmental parameters studied were relative humidity, temperature, daylight and ultraviolet light.

The different solid state dosimeters investigated were, red perspex, clear perspex, Makrofol, and silicate glass . The measurements include optical measurements for the four types of dosimeters as well as measurements based on thermoluminescent phenomena for silicate glass . The experimental results indicated that :

(1) The maximum response appears at wavelengths of 340 nm, 640 nm, 296 nm and 410 nm for clear perspex, red perspex, Makrofol and silicate glass respectively.

(2) The useful range extends to 4 Mrad, 3 Mrad, 9 Mrad and 10 Mrad for clear perspex, red perspex, Makrofol and silicate glass respectively.

(3) TL thermoluminescence measurements in silicate glass showed a main glow peak at 175°C and a dose range applicabilicy of 0.1-10 Mrad.

(4) No effect of temperature was obtained at 22°C, as the temperature increased to 55°C, fading was noticed and found to be dependent on relative humidity.

(5) An increase in optical density was observed for irradiated samples exposed to daylight. When exposed to ultraviolet light the rate of increase in optical density became higher .

CHAPTER ONE

INTRODUCTION

INTRODUCTION

1. General :

Egypt has recently established the National Center for Radiation Research and Technology aiming at utilization of high intensity radiation fields for the industrial and pilot irradiation processings, such as the sterilization of medical products and possible improvments in the properties of egyptian fabrics[1].

The center comprises a mega-curie capacity cobalt-60 irradiator and 1.5 MeV electron accelerator. The center is to be accomplished on a two five year plans. The first is confined to the establishment and application of Co^{60} facility.

Hence, there has been an actual processing need to evaluate the dosemeteric methodolgy carried out for mega-rad fields as applied to the egyptian environmental conditions as daylight, temperature and relative humidity.

The work undertaken in this thesis investigates the ability and limits of accuracy in the determination of exposure dose using some commercially available materials such as Makrofol, clear perspex, Red perspex, and silicate glass under the local environmental conditions.

1.1 Radiation Processing :-

Commercial radiation processing can be devided into two parts. The first, involves pure chemical processing involving radiation induced effects such as curing, polymerization, and changing dielectric properties, etc. The second part involves the radiation sterilization of medical and pharmaecutical products and food preservation by irradiation. The two parts are essentially different in that the second one involves ethics, if the sterilization or perservation process is not correct then the cost may be counted in human life or illness, in the other hand if the chemical process is not correct then a batch is spoilt.

1.1.1 Chemical Processing :-

In chemical processing there is no need for dosimetry after the research stage, and process control by the monitoring effect will ensure that the irradiation treatment is properly carried out. Of the two other processes, the sterilization of medical products is a well established radiation process which is becoming increasingly important. Food perservation by irradiation is still in the research and development stage but will undoubtedly develop into an industrial process in due time. The most common radiation source applied in sterilization, and probably for food irradiation in future is the ^{60}Co bulk irradiation plants[2,3].

1.1.2 Radiation Sterilization of Medical Products (4-8 :-

The use of ionizing radiation for sterilization of medical products is now a well established technology which is steadily replacing other sterilization techniques on grounds of convenience, economy and freedom from cross-contamination. Recently, large number of new types of medical devices, of which many may only be sterilized by radiation, has been introduced to medical practice. In the last 15 years, prestерilized medical disposables have stimulated a drastic change in hospital design and planning, with less need for complex sterilization facilities. Furthermore, radiation sterilization allows a much wider choice of materials to be used for packaging than any other sterilization method.

The radiation sterilization dose internationally accepted as adequate; namely 2.5 Megarads, has been described as more than sufficient to kill all contaminating bacteria. There are two types of ionizing radiation now in use for sterilization of medical products, gamma radiation and high-energy electrons. Gamma radiation is the more penetrating and may be used to process thick and dense articles. The penetrating power of electrons on the other hand, is dependent upon the energy to which they are accelerated and the density of the material itself.

Radiation sterilization of medical products has many advantages in the context of medical treatment, particularly in developing countries with denser population and less appropriate hygienic conditions. The product is sterilized within its sealed container and remains sterile as long as the latter is unbroken. The process offers the opportunity to sterilize medical products within plastic packages, which is not always possible with steam sterilization, and does not suffer from the disadvantages of sterilization by use of ethylene oxide gas. Since radiosterilized medical products are prepacked and hermatically sealed during manufacture, it is safe to introduce single-use disposable syringes, needles, infusion sets ... etc. in hospitals nationwide. The extension of radiosterilization technique to various hospital supplies, bone banks, pharmaceutical products, biological tissues and other items seems quiete feasible. Such practice is a positive measure to safeguard public health against cross infection of hepatitis and other epidemics. The subject has attracted great attention and the IAEA has organized a large number of international symposia and expert meetings within this particular field.

1.1.3 <u>Food Preservation by Radiation (6)</u> :-

In this case several different process are involved, each having a certain dose range for effect. Sprout inhibition in potatoes, onions, 7 to 15 Krads, disinfestation of grain, 20 to 50 Krad, shelf-life extension 50 to 500 Krad. Food sterilization; 1 to 2.5 megarad, specific pathogen-free 0.5 to 1 megarad. The only possibility for checking is dosimetry, and the only conclusions that we can draw now are :-

a) That dosimetry is required in the food preservation radiation process quite definitly;

b) That dosimetry, whilst not absolutely required in radiation sterilization of medical products, is most probably the most convenient and least expensive positive method applicable;

c) That dosimetry is not required in purely chemical radiation processing, where [illegible] testing is [illegible] best [illegible] control.

d) [illegible] been placed on dosimetry [illegible] the [illegible] are directly [illegible] ration [illegible].

1.4 [illegible] :-

[illegible] which can [illegible] very wide range of [illegible] radiation energies with [illegible] necessary [illegible] for [illegible] safety, [illegible] and routine measurements and for personnel dosimetery. Solid state dosimetry in its accepted sense is in a new development stage.

1.2.1 Solid State Dosimeters :-

Generally any solid material that exhibits at least one measurable parameter varying as a function of the absorbed dose "or dose rate" deposited in the material by some type of ionizing radiation can serve as the bases for a solid state dosimetry system(9). Solid state dosimeters are useful(10) for four main reasons :

1) For their high density " 800-4000 times more atoms/c.c. than air can lead to small dosimeter sizes.
2) Changes induced in solids by radiation may persist for long periods, enabling total dose to be estimated at a convenient time after irradiation.
3) Solid systems showing an obvious visible change are useful for measuring spatial distribution of dose.
4) Higher dose-rates can be measured than by ionization chambers.

1.2.2 Radiation Effect in Solids :-

The effects of radiation on solid materials include the following phenomena :- coloration or decoloration, radio-photoluminescence(11), radiothermoluminescence(12) luminescence