CHAPTER - I

INTRODUCTION

Man's requirement of energy (heat) has increased continuously from the early ages. The caveman used about 2,000 kilocalories in a day. The early hunting man needed 5,000 kilocalories per day, some of it in the form of firewood for cooking. Energy management experts have conducted extensive studies on the pattern of energy consumption in many countries. According to them, the per capita daily consumption of the modern American in 1970 was 230,000 kilocalories and today more than this. If the trend in energy consumption is like this, all the presently known resources of fossil fuel in the world will be exhausted by 2010 A.D. Even if one assumes that the energy consumption would remain stagnant as 1970 level, the period can be stretched only to 2070. It has been realized that energy sources which are orders of magnitude higher are necessary for the existence of modern civilization. Scientists have found out different means to get energies, like the energy from the sun, geothermal sources, tidal and wave motions, ocean winds, coal, gases and nuclear reactions. Among these, energy from nuclear reactions could be found usefully exploited for the long term solution of man's energy problems.

Enormous quantities of energy are released in the fission process which can be used for different purposes, e.g. electrical power production, to run automobile, submarine, train, plane etc. Besides this, the nuclear reactions also produce different invisible high energy ionizing radiations like; alpha-, beta-, and gamma rays. These high energy radiations have been found very useful in Industries, Defence, Agriculture, Medicine, Engineering and Research. Even though, the nuclear reactions and radiations are found very useful in the growth of day-to-day life of the modern civilization, they have been investigated to cause potential hazards to the personnel and public. Careless use of them can lead to harmful effects which may include some of the genetic defects also, for those who are exposed to these radiations. Sometimes the radiation exposure to human body leads to cancer and other diseases. In view of this, the basic need of these professional workers, is to detect and estimate the absorbed radiation dose precisely for the better use and ascertaining requisite precautionary measures. Many young scientists directed their attempts to this important field of research. Variety of methods have been suggested by different persons for the detection and estimation of radiation and radiation doses[1-3]. Since the different developed techniques have one or other limitations, people always looked for a new better method for this purpose. Now-a-days thermoluminescence (TL) technique has been found to be the best suitable method for detection of radiation and its dose measurement. The same one is discussed in detail in the present thesis.

The visible emission from the pre-irradiated material during warm-up with uniform rate is known as thermoluminescence (TL). During last two and half centuries, an extensive experimental and theoretical work has been done on TL by the large number of scientists in the different laboratories all over the world. It is believed that all crystalline solids contain variety of structural imperfections. Some of them constitute regions of localized positive or negative charges which are able to attract and bind the charges of opposite signs. Such defects are therefore called "traps". The strength of binding called the "trap depth" depends upon the nature of the imperfection.

A luminescent solid material when exposed to ionizing radiation generates large number of electrons and holes in it. Most of these electrons and holes recombine immediately afterwards emitting light. However, some of the electrons and holes are trapped at the defect sites, where they remain trapped until sufficient energy is supplied for liberating them. One of the ways in which the escape energy is provided by increasing the temperature of the solid. It has been shown by Daniels in 1953 [4-6] that the energy stored in the phosphor can be released as per one desire at any time by supplying heat. The magnitude of the TL emission from the solid was found to be proportional to the incident ionizing radiation dose. From the calibration curve of the incident excitation dose versus the TL output for certain phosphor, it is possible to determine the unknown excitation dose the material could have received. Such an estimation is done by measuring the TL intensity which the material displays after exposing it to the exciting radiation.

In TL dosimetry, the important basic point to be taken care of is the TL solid state dosimeter. The dosimeter contains dosimetry grade TL material in the form of single crystal or polycrystalline powder form or in tablet form. The accuracy of radiation dose measurement and the sensitivity of the dosimeter depend on the quality and state of the TL material used to fabricate solid state dosimeter. The alkali halides have been selected as ideal host materials for experimental and theoretical TL-dosimetry studies, on account of the following features:

(i) Simple cubic structure.

(ii) Ionic nature of binding.

(iii) Large binding energy [$\sim$200K cal/mole].

(iv) High melting point [$\sim$1000°C] which provides vast range of temperature over which the phenomenon can be studied, and

(v) Large electronic band gap [$\sim$10 ev] which offers a wide range of optical transparency to study the effects of impurity vacancies and other crystalline defects.

Almost all alkali halides in pure as well as impurity activated forms exhibit emission of visible light (TL) on warming them with constant heating rate after excitation with ionizing radiation. Amongst them, only LiF [LiF-TLD-100] is selected as an efficient TLD-material to fabricate solid state dosimeter in radiation dosimetry. Inspite of the commercially available standard efficient LiF-TLD-100 dosimeter material, the use of sodium and potassium chlorides in pure as well as mono-, or di-valent impurity doped forms, in radiation dosimetry has recently been gaining an importance. The survey of literature indicated that none or very few have reported the use of the other alkali halide, namely, NaF in radiation dosimetry. In view of this, the main aim of the present work is to investigate the usefulness of the pure and potassium doped NaF in TL radiation dosimetry.

In this context, the TL characteristics of pure and monovalent potassium doped sodium fluoride material in different physical conditions on beta irradiation, their explanations on the basis of the current state of understanding of the subjects, and the study of dosimetric properties of a well defined isolated prominent glow peak (165°C), are presented in the thesis. The presentation is divided in the following two parts.

[A] Basic TL characteristics of pure and K^+ doped NaF.

[B] Application of TL of NaF and NaF:K to radiation dosimetry.

The experimental work in the present thesis clearly indicates that the NaF and NaF:K phosphors exhibit respectively 120, 150 and 360°C, and 165, 190, 230, 300 and 360°C glow peaks. The 400°C air-quenched NaF and NaF:K (1000 ppm) designated in this thesis as NaF(T) and NaF:K(T) respectively, display dominant isolated glow peaks at 150 and 165°C. These glow peaks have been found to satisfy most of the basic requirements that should be fulfilled by the TL peak of an efficient dosimeter material. Therefore, it is inferred that sodium fluoride material is of use in the estimation of beta dose in radiation applications.