SOLID STATE NUCLEAR TRACK DETECTORS AND ITS APPLICATIONS

BY

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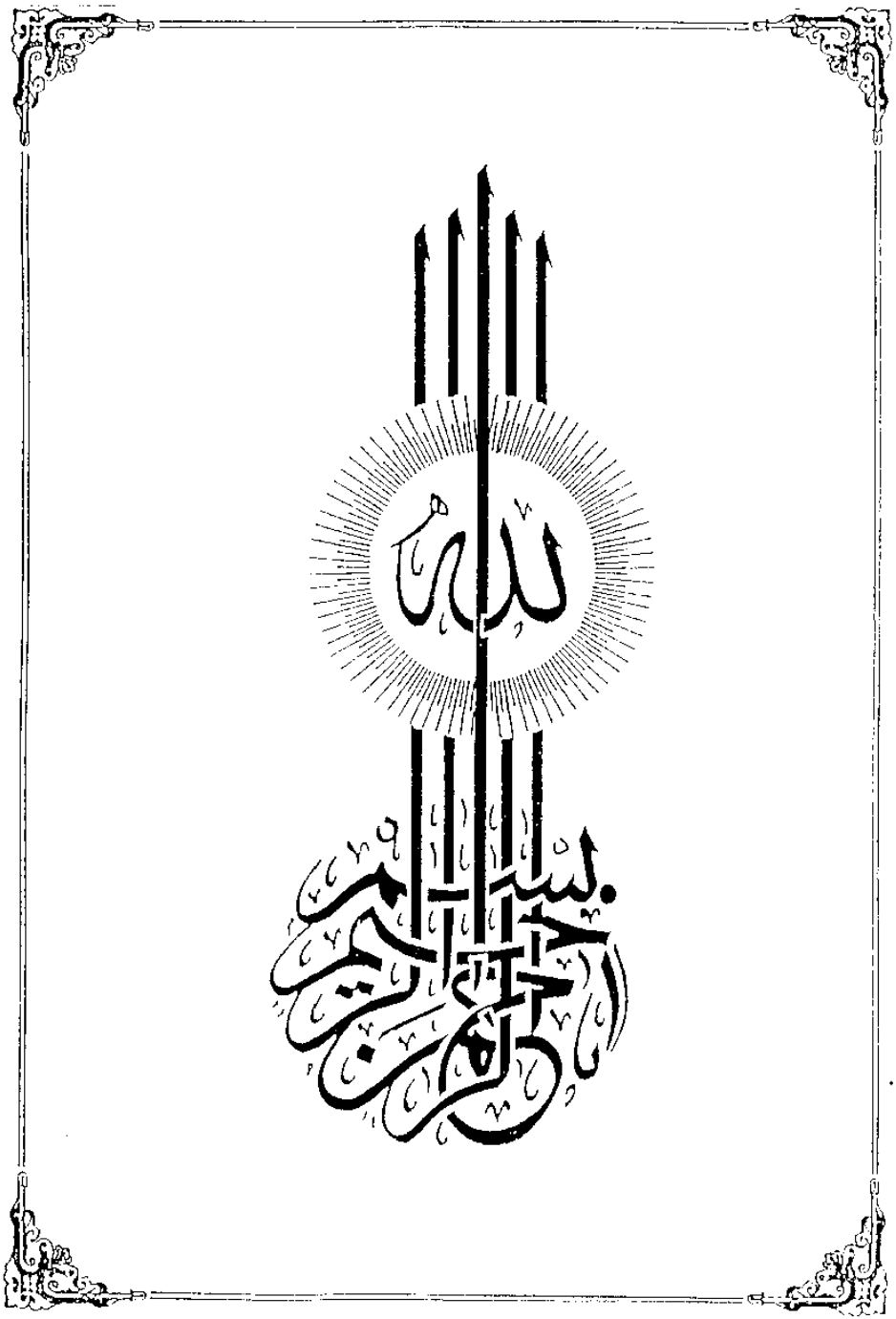

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S Y N O P S I S

This thesis attempts to contribute to the understanding of the properties of plastic detectors in order to apply them to the study of problems in nuclear physics and dosimetry.

The first chapter deals with hiatrical and basic informations concerning the interaction of charged particles with matter and polymers. The track formation models and the etchable track formation criteria were disscussed briefly.

In the second chapter the properties of the solid state nuclear track detectors (CR-39, LR-115 and CA 80-15) used in this work were reported. Several experiments were carried out to study the influence of the etchant temperature and concentration on the bulk etching rate V_B. It is found that the bulk etching rate of the CR-39 foils etched in NaOH or KOH solutions of concentrations ranging from 2N to 12N, our data for the variation of the bulk etching rate in different etchant concentration at different temperatures for both NaOH and KOH are in excellant agreement with the relation $V = A \exp E/KT$. It is observed that for the same molarity and etching temperature, V_B is higher in KOH than NaOH.

The camphor content in cellulose nitrate plastics and its low

solubility in the etchant leads to the formation of a colloid layer during the etching which produce significant alternations in the etching properties. A white precipitate is formed at the surface of the cellulose nitrate detector, this precipitate seems to increase at higher etchant concentrations. The measurements for LR-115 have not been extended above 6M because in stronge etchants the surface of LR-115 becomes heavily pitted and corroded and th outline of the tracks becomes very irregular. In general, the bulk etching rate increases slowly at low etchant concentrations, and then more rapidly with increasing the etchant concentration.

Since the bulk etching rate differ (for the same detector) from batch to batch due to many reasons, e.g. the adoption of different initiators, initiator concentration and curing cycle. However, the amount of surface removal have to be monitored each time samples were etched.

The critical angle and the track registration efficiency were studied. It is found that, in general the track registration efficiency is 100% at high angles of incidence but the registration efficiency drops sharply for obliquely incident tracks. The critical angle for the alpha tracks is approximately 24, and for the fission fragment tracks is arround 2. It is interesting to note that the number densities in plastic detectors do not fall suddenly to zero

at the critical angle rather, they show a smooth rounding-off near it. This feature may be explained as being due to the finiteness of the collimator aperture and to the energy spectrum of the fission fragments from the break-up of the Cf-252 nucli. The results predicts the existance of different critical angles of etching for different groups of fission fragments, since the track etching rate which depends on the damage produced, will be different for different energy groups of the fission fragments.

The third chapter deals with the equipment which designed to aid the experiments. The electrochemical etching apparatus, the electrochemical etching cells, microprocessor-based image measurement system, programming the microprocessor, the alpha particle irradiation chamber and the scintillator system.

The electrochemical etching (ECE) of CR-39 plastic is discussed in details. It is observed that there is a threshold electric field strength value below which no treeing intiation can occur. Generally the plot of ECE versus the electric field, frequency, etchant concentration, etching temperature and etching time shows a common features in the relation of the track-diameter to any mentioned above parameters. The track diameter increases rapidly, then decreases or/and reaches a plateau.

It is possible to express Mason's equation, as applicable to electrochemical etching of polymers, in terms of physically meaningful track-etching parameters. An important parameter, viz. the critical or breakdown electrical stress of the CR-39 plastic, has been obtained experimentally.

In chapter five the environmental effects on the characteristics of track registration in CR-39 were discussed in details. The influence of temperature (ranging from -197 °C to 200 °C) on the registration properties of CR-39. It is found that, complete annealing of ^{241}Am alpha particle tracks occurs after 2 h of annealing at 190 °C. Total fading of fission-fragment tracks from a ^{252}Cf sources takes place after 2h of heating at 250 °C. The latter treatment also produces many cracks in the surface of the plastic and brings about a change in its colour.

It is found that, the exposure of the CR-39 to Gamma-ray energy could sensitize the CR-39 plastic and thus improve the Z/B threshold for track registration. It is also found that, the exposure of CR-39 plastic to ultraviolet light increases the extent of damage in the latent damage trail, which in turn increases the track etching velocity, i.e. the ultraviolet decreases the critical angle θ_c and increases the CR-39 efficiency.

Chapter six deals with the concentration of radon and its decay products in the general environment and their hazard for the publics. The working level concept and the ICRP recommendations were discussed. A description of the radon and radon daughters measurement techniques also included, and some basic calculations of the radon daughters activity in WL units.

In chapter seven the advantages of using SSNTD's for radon and thoron measurements were revealed. The scintillator method for rapid assessment of track density was adopted for the radon dosimetry, the tracks were enlarged as a result of applying electrochemical and/or chemical etching. The ZnS:Ag was employed as sintillator material. The sample preparation and the readout methods were described. Several modification to improve the reproducibility of results as well as the efficiency of counting were introduced.

The ^{222}Rn and ^{220}Rn concentration profils inside long tubes under different conditions of source strength and temperature, and their transport in soil with different moisture content were studied.

Design and performance of a pssive system for radon and thoron measurements, using an electret made in our laboratory. The collection efficiency of the electret for the radon decay products was found to depend upon the relative humidity and radon concentration. This method provides an inexpensive, fast, and accurate means of making radon and thoron measurements

C O N T E N T S

CHAPTER 2 ETCHING PROPERTIES OF PLASTIC DETECTORS

CHAPTER 3 EXPERIMENTAL METHODS AND APPARATUS

CHAPTER 7 RADON AND RADON DAUGHTERS MEASUREMENTS USING SOLID STATE NUCLEAR TRACK DETECTORS