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# Indigenous Development of a Track Etch Detector

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**ABSTRACT**

Solid state nuclear track detectors (SSNTDs) have been recognised by IAEA as a standard method for estimation of radon, thoron and their daughter products in the environment. The detectors that are commonly used in environmental monitoring are generally made from cellulose nitrate (LR-115) and polycarbonates (CR-39). In view of the non-availability of these detectors in India, need was felt to develop them indigenously. Accordingly, an attempt has been made to develop cellulose nitrate films for their use in SSNTD. Cellulose nitrate with a particular nitrogen content was used for preparing these films by a cast method. The films were annealed, evaluated and then compared with imported films. The background track density and alpha track density after exposure to 150 nCi of $^{241}Am$ source at 2.5 cm distance were found to be comparable with those of imported films.

## NOMENCLATURE

$Bq$ bulk etch rate
$E$ film efficiency
$J$ expected track density
$M_1$ mass before chemical etching
$M_2$ mass after chemical etching
$T$ track density
$t$ film thickness

## 1. INTRODUCTION

For over three decades the photographic emulsions have been the only method for registering the tracks of ionising particles. However, nuclear emulsions were found to suffer from several drawbacks, such as limited shelf life, fogging by other types of radiations, fading at high temperature, humidity and need for dark room processing, etc. The research work done in finding alternative methods has been reviewed by various authors[1-4]. These detectors can be divided into two categories, namely inorganic and organic. Cellulose nitrate (CN) and polycarbonates are the most widely used organic materials. More recently, polysulfone copolymer has been reported by Stejny and Portwood[5] as a promising polymeric material for the preparation of these detectors, while Fujii and Yokota[6] have used thermosetting resin for nuclear track detections.

Owing to the non-availability of the indigenous detectors, efforts were made to develop CN films at Defence Laboratory, Jodhpur. These films are widely used in environmental monitoring of alpha radiation and are the only polymer out of the above mentioned which are indigenously produced and are available commercially.

Benton[7] has described a method for the preparation of CN films from CN containing 30 per cent ethyl alcohol. Bhagwat and Soman[8] have also prepared CN films using Benton technique[7]. The thickness of the films was controlled by changing the viscosity of the solution.

This paper presents a method of preparation of CN films using the indigenously available raw materials, modified formulations, and technique for thickness control. The performance of these films has been compared to the imported LR-115 films using $^{241}Am$ as the alpha source.

## 2. MATERIALS AND METHODS

All the chemicals used for the development of films were either of AR grade or chemically pure. The CN having particular nitrogen content and molecular weight range, was taken in the solvent and a co-solvent was added to it. The contents were thoroughly mixed, and a plasticizer and the dye were added to it and mixed again. The solution was kept for 24-72 hr to make it homogeneous. The film was then cast at a fixed temperature with the help of a sharp knife edge. The thickness of the film was controlled by the side runners.

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After gel formation, the film was cured at a fixed temperature for several hours and then evaluated. The results were compared with those of the imported ones.

## 3. EVALUATION DETAILS

The films were cut into standard size of $1.5 \times 1.5 cm^2$, washed with distilled water and dried in a dust-free chamber. These were then exposed to $^{241}Am$ source of strength 150 nCi for 15 min in a geometry indicated in Fig. 1 .

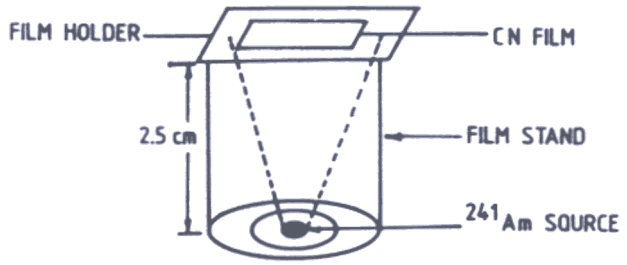


**Figure 1. Geometry for exposure of SSNTD films to $^{241}Am$ source.**

### 3.1 Optimum Etching Time

Exposed films were etched in 6N *NaOH* solution at 40-60 °C for time intervals varying from 5 min to 2 hr. These were then washed with distilled water and dried in a dust-free chamber. Alpha tracks formed on the film were counted under 900X magnification using Zenval microscope. For each set of observations, more than 1000 tracks were counted to minimise the statistical error. An increase in the track density with increase in time and temperature was observed. It was found to be maximum at 60 °C after 9 min of etching when it attains a constant value (Fig. 2). For all other experiments, the etching was carried out in 6N *NaOH* for 9 min at 60 °C.

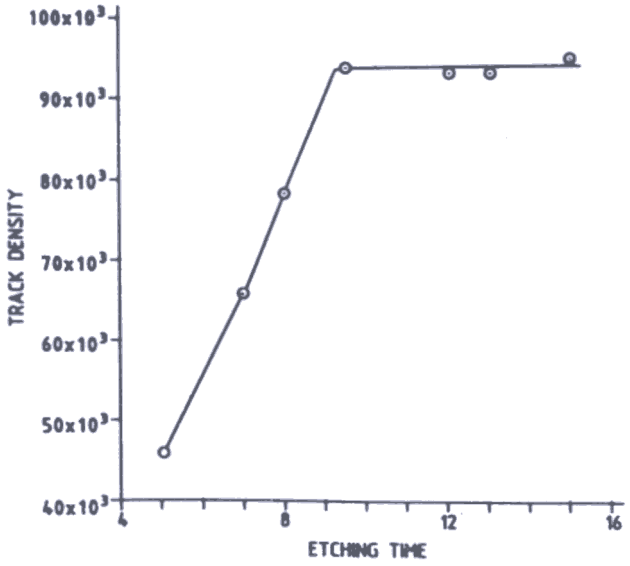


**Figure 2. Plot of alpha track density versus etching time.**

### 3.2 Background Track Density

The background track density was determined from the unexposed CN films by etching them under optimum conditions and then observing the ambiguous alpha tracks under 900X magnification. The background track density determined in these films varied from 16-48 tracks/$cm^2$ with an average of 22 tracks/$cm^2$.

### 3.3 Bulk Etch Rate

The bulk etch rate was determined by measuring the mass and thickness of unexposed film of standard size before and after the etching at 60 °C in 6N *NaOH* for 9 min. From the values so obtained, the bulk etch rate *Bq* was calculated by using the standard relation[9].

$$Bq = \frac{(M_1 - M_2).t}{2M_1}$$

The value of *Bq* was found to be 2.14 for 9 min

### 3.4 Track Density Measurements

The films of standard size were exposed to $^{241}Am$ of 150 nCi strength for time intervals varying from 5 to 30 min. These were then etched under optimum conditions and the tracks counted under 900X magnification. For each set of observation a minimum of 1000 tracks were counted. An increase in the alpha track density with the increase in exposure time was observed and found to be $6.10 \times 10^4$ tracks/$cm^2$ for a 15 min exposure time.

### 3.5 Efficiency

The efficiency ($E$) of the film was determined by exposing the films to alpha source ($^{241}Am$) of strength 150 nCi in a geometry indicated in Fig. 1 and using the relation

$$E = \frac{T \times 100}{J}$$

The value of $E$ in the case of CN films developed at DL, Jodhpur, is 48.1 per cent.

## 4. EVALUATION OF IMPORTED FILMS

Kodak LR-115 films were also evaluated in a similar fashion as mentioned above except for the etching

**Table 1 Comparative evaluation of indigenous and imported films**

| Parameters | Indigenous | LR-115 |
|---|---|---|
| Background track density (tracks/cm$^2$) | 16-48 | 48 |
| Thickness of film ($\mu$m) | 110-160 | 110 |
| Etching parameter at 60 °C | 9 min | 120 min |
| | 6N *NaOH* | 2.5N *NaOH* |
| $\alpha$-Track density after exposure to $^{241}Am$ source strength of 150 nCi at a distance of 2.5 cm (tracks/cm$^2$) | $6.1 \times 10^4$ | $6.2 \times 10^4$ |
| Efficiency | 48% | 49% |

conditions which are mentioned in Table 1. The results are computed and compared with the indigenously developed films.

## 5. DISCUSSION AND CONCLUSION

In the present investigations, all the chemicals used in the preparation of CN films were Indian. The evaluation results obtained for these films were comparable to the imported LR-115 SSNTD films. A perusal of Table 1 shows that background track density, alpha track density and efficiency of the two films are almost equal, which indicates that the films developed indigenously can be employed in the estimation of radon level in the environment and alpha radiation in other areas.

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