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# APPLICATION OF PLASTIC TRACK DETECTORS IN THERMAL NEUTRON DOSIMETRY AND BORON ESTIMATION IN PLANTS

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Abstract - Alpha sensitive plastic track detectors viz. CR-39 (Pershore), CR-39 (Homalite) and LR-115 (Kodak) are employed to measure neutron fluences in the range $10^5$ to $10^9$ (nvt) using the converter technique. The cellulose nitrate plastic coated with $Li_2B_4O_7$ layer and a pellet of $H_3BO_3$ are used as converter materials. The fluence sensitivity (tracks/neutron) is determined for three different types of plastic detectors. Boron content in plants is determined using $(n,\alpha)$ reaction.

## 1. INTRODUCTION

Solid state nuclear track detectors because of their simplicity, versatility and low cost are being extensively used in diverse fields[1] for more than a decade. In dosimetry, these are generally used for the measurement of radiation dose. A particle can be detected either directly in the material itself in the form of etchable damage known as a track or the product particles emitted can be detected in the overlay detector pressed against the material during irradiation. In case of neutrons which cannot cause direct ionization of the media, the detection is possible only through the indirect means. A converter material which through nuclear reactions can produce charged particles is placed in contact with the detector and the system is exposed to neutrons. The detection of these charged particles as tracks gives an indirect measure of neutron dose. The converter materials are generally the materials doped with traces of uranium or Boron. The glass standards (with known value of U.content) have been calibrated for neutron fluence determination by some workers[2-4]. The neutron fluence F is related with the track density, pd, by the equation F = K pd where K is the calibration constant. The value of K depends on the U.content of the dosimeter. Thus in order to measure the low neutron fluences (Below $10^8$ n/cm$^2$ s) a high content of U. will have to be doped in the dosimeter. However, the measurement of low neutron fluence is possible by using the Boron converter and an alpha sensitive plastic track detector[6,7]. In the present work we have used this technique to measure neutron fluence in the range $10^5$ to $10^9$ (nvt). The fluence sensitivity is determined for three different types of plastic detectors viz. CR-39 (Pershore), CR-39 (Homalite) and LR-115 (Kodak).

Boron is present in almost all the plant species. Because of its high cross-section for $B^{10}$ $(n,\alpha)$ $Li^7$ reaction with thermal neutrons, it is easy to map and a number of papers[8-11] have appeared on the subject. In the present investigations Boron content was determined in some plant samples collected from G.N.D. University Campus, Amritsar.

## 2. EXPERIMENTAL

Lithium tetraborate ($Li_2B_4O_7$) and Boric acid ($H_3BO_3$) were used as converter materials. Cellulose nitrate plastic coated with $Li_2B_4O_7$ layer of 15 µm thickness was cut into circular disc of 1.3 cm diameter. A mixture of 50 mgs of Boric acid and 100 mgs methyl cellulose powder was pressed into a pellet 1.3 cm in diameter and 1 mm in thickness. These converter materials were then pressed against the plastic detectors. These were then irradiated with thermal neutrons from a Amercium-Beryllium (Am-Be) neutron source. The detector samples were then etched and scanned for track density measurements. The results for fluence sensitivity (track per neutrons) corresponding to each neutron dose for $Li_2B_4O_7$ and $H_3BO_3$

converters are given in Tables 1 and 2. The graphs are plotted between track density and fluence sensitivity vs neutron fluence (Fig.1-4).

Table 1. The results for fluence sensitivity at different neutron fluences using $Li_2B_4O_7$ as converter material.

| Neutron Fluence (F) | Fluence sensitivity $K'(x10^{-5})$ for | | |
|---|---|---|---|
| | CR-39 (Homalite) | CR-39 (Pershore) | LR-115 (Kodak) |
| $1.13x10^5$ | 6.00 | 7.00 | 3.00 |
| $1.13x10^6$ | 6.90 | 9.80 | 4.90 |
| $1.13x10^7$ | 6.17 | 7.53 | 3.79 |
| $1.13x10^8$ | 6.39 | 7.64 | 3.66 |
| $1.13x10^9$ | 6.04 | 7.74 | 3.77 |

Table 2. The results for fluence sensitivity at different neutron fluences using $H_3BO_3$ as converter material.

| Neutron Fluence (F) | Fluence sensitivity $K'(x10^{-5})$ for | | |
|---|---|---|---|
| | CR-39 (Homalite) | CR-39 (Pershore) | LR-115 (Kodak) |
| $1.13x10^5$ | 5.00 | 8.00 | 2.00 |
| $1.13x10^6$ | 7.00 | 9.90 | 3.70 |
| $1.13x10^7$ | 5.95 | 8.74 | 2.75 |
| $1.13x10^8$ | 5.27 | 8.27 | 2.89 |
| $1.13x10^9$ | 5.74 | 9.60 | 2.66 |

Plant samples were dried powdered and converted into pellets using methyl cellulose as binding material. These were then coverd with CR-39 (Pershores) plastic detectors. A similar pellet was made of SRM-613 NBS glass having 32 ppm Boron used as a standard material. These were then irradiated with thermal neutron dose of $1.52x10^9$ (nvt) from Am/Be source of PAU, Ludhiana. After irradiation the detectors were etched and scanned for track density measurements. The Boron content in the unknown specimen is given by:

$$\frac{B_u}{B_s} = \frac{P_u}{P_s}$$

where $B_u$ and $B_s$ are Boron content in the unknown and standard respectively and $P_u$ and $P_s$ are the alpha track densities recorded in the plastic detector covering the unknown and the standard respectively.

## 3. RESULTS AND DISCUSSION

The linear relationships (Figs 1 and 3) between track density and neutron fluence can be used as calibration curves for neutron fluence from $10^5$ to $10^9$ neutron/cm$^2$ for CR-39 and LR-115 plastic detectors. The fluence sensitivity (Figs 2 and 4) varies at low neutron fluences but remains

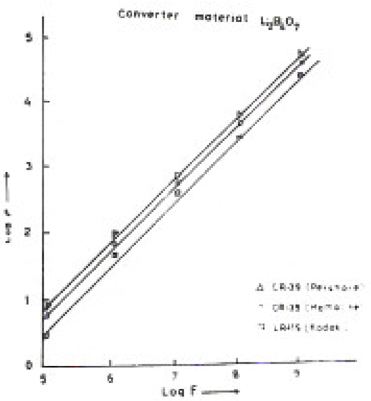


Fig.1 Plot of log of neutron fluence (F) vs log of track density (p).

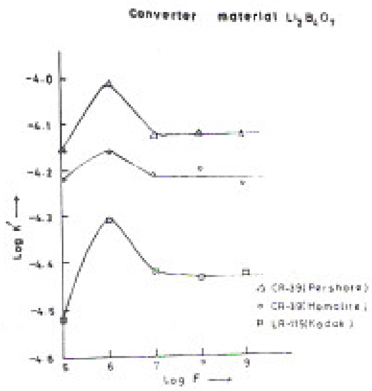


Fig.2 Plot of log of neutron fluence (F) vs log of fluence sensitivity (K').

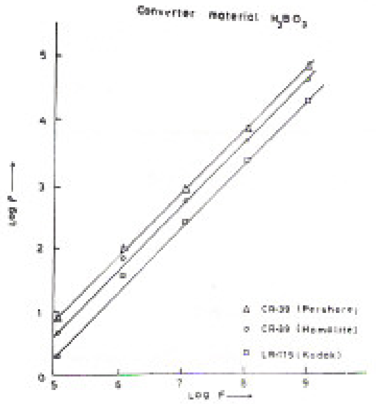


Fig.3 Plot of log of neutron fluence (F) vs log of track density (p).

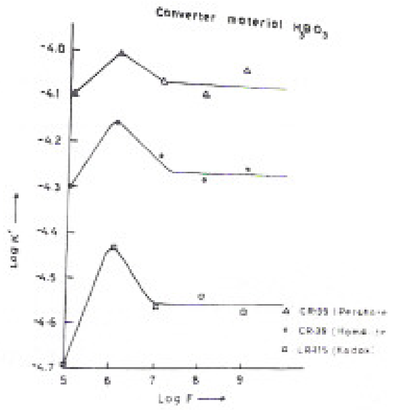


Fig.4 Plot of log of neutron fluence (F) vs log of fluence sensitivity (K').

approximately constant after the neutron fluences of $10^7$ n/cm$^2$. The present study shows that the fluence sensitivity is $6.19\times10^{-5}$, $7.60\times10^{-5}$ and $3.74\times10^{-5}$ track/neutron for CR-39 (Homalite), CR-39 (Pershore) and LR-115 plastic detector respectively with $Li_2B_4O_7$ foil as converter material. Our results corroborate the findings of other authors[6,7]. The typical sensitivity for thermal neutron dosimetry reported by these author is $10^{-5}$ tracks/neutron.

The results indicate that the fluence sensitivity of CR-39 (Pershore) is higher than that of the other two detectors. This makes CR-39 (Pershore) together with $Li_2B_4O_7$ as external radiator an excellent candidate for thermal neutron dosimetry having high sensitivity. The fluence sensitivity is $5.65\times10^{-5}$, $8.87\times10^{-5}$ and $2.76\times10^{-5}$ tracks/neutron for CR-39 (Homalite), CR-39 (Pershore) and LR-115 plastic detector respectively with $H_3BO_3$ as the external radiator. In this case too the fluence sensitivity is higher for CR-39 (Pershore). The present investigations indicate that $H_3BO_3$ if available in the pure form can be used as a converter material for the determination of thermal neutron dose.

The Boron content in plant species (Table 3) is found to vary from 46.04 to 96.77 ppm. Cassia fistula is found to have minimum content of Boron (46.04 ppm) whereas Hibiscus rosa-sinensis lava shows maximum value of 96.77 ppm. Since all these plants belong to the same area the variation of Boron content can be due to the nature and type of the plant. So the uptake of Boron by plants from soil is different for different species.

Table 3. Boron content in plants.
Boron content in the standard = 32 ppm
Track density in the standard = 3068 tracks/$cm^2$.

| S.No. | Name of the plant | Track density (Track/$cm^2$) | Boron content (ppm) |
|---|---|---|---|
| 1. | Nerium indicum | 4877 | 50.86±3.2* |
| 2. | Casuarina equistifolia | 6305 | 65.76±4.9 |
| 3. | Cassia fistula | 4415 | 46.04±4.1 |
| 4. | Thevetia peruviana | 7193 | 75.02±4.8 |
| 5. | Cassia glauca | 5943 | 61.98±5.1 |
| 6. | Bryo-phyllum sp. | 5398 | 56.30±4.1 |
| 7. | Hibiscus rosa-sinensis | 9278 | 96.77±6.1 |
| 8. | Bougainvillea glabra | 6734 | 70.23±4.5 |

$^{*}1\sigma = \frac{100}{\sqrt{N}}$ , N = No. of tracks counted

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