Solid State Nuclear Track Detectors, SSNTDs, are becoming useful tools for measurements in many fields of science and technology /1/. In neutron dosimetry, few of their advantages are:

(i) they are insensitive to high background of gamma irradiation in reactors,

(ii) they offer permanence of recorded data which can be processed after any length of time at the convenience of the experimentalist,

(iii) they require simple and inexpensive equipment.

SSNTDs used in neutron dosimetry, are placed in close contact with converters such as U-235, Np-237, and Pu-239 fission foils which convert the incident neutron flux to fission fragments. These heavy charged particles cause damages or tracks in the detector. When the detector is chemically etched, the tracks become so large that they are clearly seen under an optical microscope. As stated by Price and Walker /2/ there is one-to-one correspondence between the fission fragments and the tracks they cause in the detector.

However, despite, this high efficiency of registration the overall accuracy of experiments in which SSNTDs are used is not very satisfactory. This shortcoming is attributed mainly to the converters whose mass and the profile of the distribution of fissile material are often not precisely known. Consequently, to improve the accuracy in such experiments, well calibrated fission foils must be used.

The aim of this work, therefore, is to develop the use of SSNTD in neutron dosimetry. For this purpose a well calibrated Np-237 fission foil in close contact with a piece of SSNTD and
In-115 threshold detectors were irradiated under identical conditions. Three runs of irradiations were performed. By measuring the activation rates, the Np-In integral cross section in uranium fission spectrum was determined.

EXPERIMENTAL PROCEDURE

Np-237 Fission Foil

To study the profile of fissile material on the Np-237 fission foil, an X-ray film was exposed to the alpha particles from the foil. The exposed film was later analyzed with the help of Jarell-Ash 21000 Non-Recording Microphotometer (see Figs. 1 and 2). A small area of the foil where the distribution was most uniform was chosen for relative counting. The ratio of fissile material on the whole active surface of the foil to that of the selected area was determined /3/. Therefore in counting an etched detector, only the surface which faced the selected area was counted. Then the number of tracks was multiplied by the ratio to obtain the absolute number of tracks on the whole detector. Thus the Np-237 fission foil has been calibrated for relative counting to improve the speed and the accuracy of using SSNTD in neutron dosimetry.

In-115 Threshold Detectors

The indium foils used in this work were of highest purity (99.99 %) with 95.6 % isotopic abundance of In-115. They were discs of 5 cm in diameter and 0.1 mm thick. These In-115 foils which have a well established cross-section are used here as reference detectors.

Makrofol KG Detector

A suitable SSNTD used in this work should be insensitive to recoil nuclei like C-12 and N-14 and to alpha particles emitted from the fission foil. Makrofol KG, which satisfies the above condition, is therefore an excellent detector for our purpose. Makro-
Fig 1 A profile of distribution of fissionable material on Np-237 fission foil drawn with average reading of each row (o) and column (●) respectively.

Fig 2 A more detailed profile of the distribution in the central part (along the horizontal (o) and the vertical (●) axes) of the foil.
fol is a light green tinted polycarbonate plastic, a product of Farbenfabriken Bayer AG, Leverkusen, West Germany.

A piece of Makrofol exposed to fission fragments and etched in 5.5 N KOH at 60 °C for about 45 min; reveals clearly fission tracks which are about 10 to 15 microns in length. But when a piece of this detector was exposed to alpha particles and etched as above for up to 150 mins, no alpha particle tracks were revealed. Fig. 3 shows a microphotograph of 40 micron thick Makrofol KG which was used to register fission fragments in fast neutron experiment. The etching conditions were as stated above.

**Irradiation**

The Np-237 fission foil was placed in close contact with a piece of 40 micron thick Makrofol KG detector. These were sandwiched between two In-115 threshold detectors and irradiated in about 1 mm thick cadmium case to minimize the activation of the materials by thermal neutrons. Three runs of irradiations were performed in positions 5, 11 and 3 cm respectively from a thermal-to-fast-neutron converter. The converter is a 20% enriched U-235 fission plate of 260 mm in diameter and 1.5 mm thick. It is clad in 0.8 mm thick aluminium to prevent the release of fission products. The fast neutron on the surface of the converter is $1.5 \times 10^7$ n/cm$^2$ sec. The converter is suspended in the middle of the exposure room of TRIGA Mark II Reactor, at Josef Stefan Institute of Ljubljana. Because of the size of the exposure room, the number of fast neutrons reflected from the walls of the room is negligibly low /5/. The irradiation time was one hour with reactor working at its full power of 250 KW.

**Counting**

After irradiation and an adequate period of waiting time for all the parasitic activities of the threshold detectors to decay away, the In-foils were cleaned with chloroformium, CH$_3$Cl$_4$, to remove any surface radioactive contamination produced during irradiation.
Fig 3 Microphotograph of Makrofol KG Detector used to register fission fragments in fast neutron experiments and etched in 5.5 N KOH at 60 °C for 45 min.
Fig 4 THE SCHEME OF THE COUNTING SYSTEM
The activities of the radioactive products were counted with the help of 7.6 × 7.6 cm NaI(Tl) spectrometer which was coupled to 512 channel pulse height analyzer and a CDC 1700 Computer (see Fig. 4). Counting time of 1000 sec was sufficient to accumulate well over 10000 counts in the peak area.

On the other hand, the Makrofol KG detector was etched in 5.5 N KOH at a constant temperature of 60 °C for a period of 45 mins. Only the preselected area of the detector, as stated above, was counted under an optical microscope. The number of the induced fission tracks was multiplied by the ratio factor (15.767) to obtain the absolute number of tracks on the whole detector.

EXPERIMENTAL RESULTS AND CONCLUSION

The results of the repeated measurements, in which irradiations were performed at positions 5, 11 and 3 cm respectively from the converter plate, are summarized in the Table:

<table>
<thead>
<tr>
<th>Runs</th>
<th>Positions</th>
<th>(A_{\text{Np}})</th>
<th>(A_{\text{In}})</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\text{st}</td>
<td>5 cm</td>
<td>4.898\times10^{-16}</td>
<td>1.393\times10^{-17}</td>
<td>7.279</td>
</tr>
<tr>
<td>2\text{nd}</td>
<td>11 cm</td>
<td>0.490\times10^{-16}</td>
<td>0.670\times10^{-17}</td>
<td>7.313</td>
</tr>
<tr>
<td>3\text{rd}</td>
<td>3 cm</td>
<td>14.616\times10^{-16}</td>
<td>1.938\times10^{-17}</td>
<td>7.542</td>
</tr>
</tbody>
</table>

The activation rates for the Np-237 fission foil and the In-115 threshold detectors are given in the third and fourth columns respectively. In the last column is the Np-In integral cross section ratio. The average of these ratios 7.378±0.143, compares favourably with the value 6.94 obtained from evaluated integral cross section data /6/.
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REFERENCES


