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Investigation of Neutron Diffusion Length in Wax Medium

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Abstract

The investigation of the damage tracks of Pu (Be) neutron source by using solid state nuclear track detector in the wax medium was performed. Using the neutron tracks and neutron diffusion equation, neutron diffusion length in wax medium was calculated.

Introduction

The passage of heavily ionizing, nuclear particles through most insulating solids created narrow paths of intense damage on an atomic scale. These damage tracks may be revealed and made visible in an ordinary optical microscope by treatment with a properly chosen chemical reagent that rapidly and preferentially attacks the damaged material. It less rapidly removes the surrounding undamaged matrix in such a manner as to enlarge the etched holes that marks and characterizes the sites of the original, individual, damaged regions. Solid state tracks detectors using this principle have found widespread application in archaeology and geology, in meteorite and lunar research, in medicine and in all industries where the dosimetry of nuclear particles is important.

The apparatus involved is simple and inexpensive, avoiding costly electronics, and the very high efficiency of detectors in particular, makes the ideally suited for work with very weak radioactive sources. According to the track formation technique, the present research work was performed to study the nuclear fission tracks on the solid state nuclear track detector (biological glass slide) due to striking of the neutrons which emitted from Pu (Be) source in the wax medium. The research works were performed at Yangon University.

Neutron Detection

Neutron plays an important role in many nuclear reactions. Neutrons' lack of total electric charge prevents engineers or experimentalists from being able to steer or accelerate them. Charged particles can be accelerated, decelerated, or deflected by electric or magnetic fields.

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However, these methods have no effect on neutrons except for a small effect of a magnetic field because of the neutron's magnetic moment.

Exposure to neutrons can be hazardous, since the interaction of neutrons with molecules in the body can cause disruption to molecules and atoms, and can also cause reactions which give rise to other forms of radiation. The normal expectations of radiation protection apply: avoid exposure, stay as far from the source as possible, and keep exposure time to the minimum.

Some thought must however be given to how to protect oneself from such exposure. For other types of radiation, e.g. alpha particles, beta particles, or gamma rays, material of a high atomic number and with high density makes for good shielding; frequently lead is used. However, this approach will not work with neutrons, since the absorption of neutrons does not increase straight forwardly with atomic number as it does with alpha, beta, and gamma radiation. Hydrogen rich materials are often used since ordinary hydrogen scatters neutrons, so this often means simple concrete blocks, or wax loaded plastic blocks may be the best protection.

Experimental Procedure

A wax moderating assembly was made of eight wax blocks. The blocks were stacked one on top of the other to form a paraffin block 40 x 40 x 40 cm^3. This wax blocks were made holes of proper size (2.5 cm diameter for glass slides and 3.0 cm diameter for the neutron source) as shown in Figure 1. The holes should be smooth to accommodate the slides easily. The holes are at 7cm and 10cm distances from the source and also from each other linearly. The diagram of 40 cm x 40 cm x 40 cm wax block for experimental purpose was shown in Figure 1.

The neutrons from the source slow down in the wax and it gets 'thermalized'. Typically the energy of a thermal neutron is 0.025 eV. The wax is composed of hydrocarbon with a large amount of hydrogen. As the mass of the proton or hydrogen ion approximately equal to the mass of neutron and elastic scattering takes place resulting in a substantial loss of energy from neutron. The Pu(Be) neutron source was placed in the central hole. The glass detectors were tied with the thread and hanged it in the hole with a support on one side. The support is tied with thread on the one end to take the slides out.

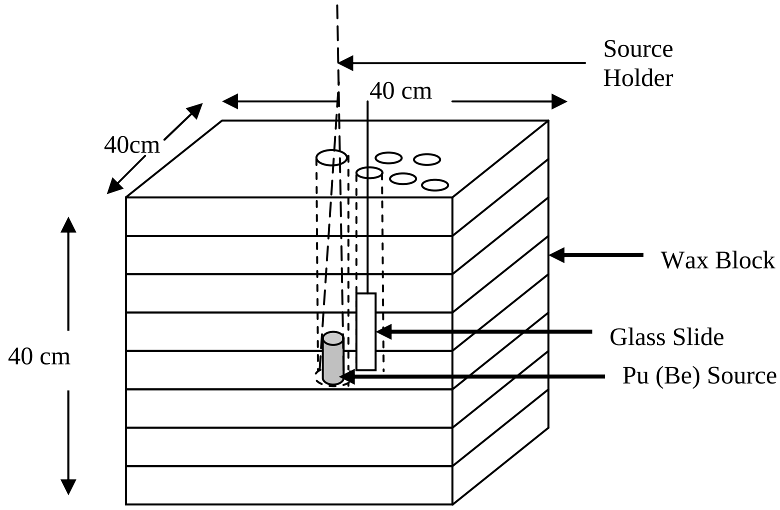

Figure 1 The diagram of 40 cm x 40 cm x 40 cm wax block for experimental purpose

The glass slides were placed in front of the Pu(Be) neutron source and they were irradiated for a time intervals 30 minutes. The glass slides were placed in such a manner so that it faces the neutron flux perpendicularly. Then the irradiated glass slides were taken out from the water and dipped in the hydrofluoric acid contained in plastic container by using plastic clips. The etch-time was 3 seconds. The glass slide was rinsed well with tap water to remove any traces of acid. We dry the slides with a clean cloth. The slides are now ready for observation. NOVEX Microscope was used to observe the tracks. These are easily observed. These tracks are formed due to thermal neutron fission of ^{235}U contained in the glass. The glass contains a trace amount of uranium with 99.3% ^{238}U and 0.7% ^{235}U. However, ^{238}U is not fissionable by thermal neutron. Therefore, the fission tracks must be due to fission of ^{235}U only. The same process for all the glasses were repeated for different exposure and different distances. The microphotographs of the fission tracks on glass detector were mentioned in Figure 2. The measurements of the fission track counting using DP 12 Olympus Microscope were shown in Table 1.

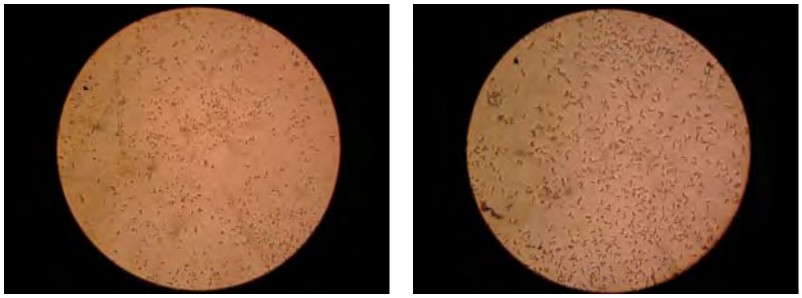

Figure 2 The microphotographs of the fission tracks on the glass detector

Table 1 The average fission track counts of ten views for different conditions

Sr No	Exposure Time (min)	Distance from Source (cm)	Average Fission Track Count
1	30	7	20.88 ± 0.24
2	30	10	24.12 ± 0.21

Precautions and Sources of Error

The holes of the wax should be smooth and cleaned. The glass slide should be kept in such a position so that large number of neutrons coming out of the source should irradiate it, perpendicularly. This may be the main source of error in our experiment Hydrofluoric acid (HF) is a strong acid because of strong hydrogen bonding. So, it is very reactive. Care must be taken while handling it. It does not react with the plastic. The radiation monitoring badges should be used while handling neutron source.

Neutron Diffusion Length in Wax Medium

The neutron diffusion length equation is

$$L = (r_2 - r_1) \ln [(N_2 / N_1) \times (r_2/r_1)]$$

where r_1 = distance between source and detector for condition 1

r_2 = distance between source and detector for condition 2

N_1= Number of fission counts for condition 1

N_2= Number of fission counts for condition 2

According to the diffusion length of the Pu (Be) source in wax medium were carried out using Table (1). The diffusion length in the wax medium using Pu(Be) neutron source was 1.50 ± 0 .03 cm.

Conclusion

Solid state nuclear track detectors (SSNTDs) provided a simple means to carrying out certain types of experiments in nuclear physics, radiation monitoring, geology, archaeology etc. They are particularly useful for measuring low levels of nuclear radiation. The fact that SSNTDs may be used and analysed without the need for any electronic circuitry brings the capability for the detection of small number of nuclear particles to even the most simply equipped laboratory. They also possess features which make them useful in a number of more advanced experiments.

Acknowledgements

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