Optical density for CN-85 and CR-39 Plastic Detectors and α-Particle Radiography

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Abstract

Optical density has been measured for CN-85 and CR-39 plastic detectors that irradiated with high doses of α-particle. It was found that the rising of optical density to its maximum value happens for CN-85 detector in a shorter etching time than that required for CR-39 .And by increasing the α-particle dose, the optical density peak appeared at earlier etching time . It found in this work that plastic track detectors are good candidates for α-particle radiography.

Keyword: SSNTDS,CN-85,CR-39,Optical density, α-particle radiography ,Etching.

Introduction:

The polymer Solid State Nuclear Track Detectors (SSNTDs) such as CR-39 and CN-85 are very sensitive to the energetic alpha-particles since they cause intense damage trail as it passing through them . So, CR-39 and CN-85 as well as LR-115(II) are used widely for detecting and measuring the α-particle emitter isotopes such as radon gas [1,2] and Uranium [3].The concentration of the radioactive materials is correlated with the number of etched tracks per unit area of the detector surface(tracks density),which can be counted with the aid of an optical microscope. This visual counting method is replaced by the measurement of the optical density [4, 5],or the diminishing in the laser beam intensity as it transmit through the etched SSNTDs [6,7].Those two tracks counting techniques are preferable as the tracks density being too large.

As well as radiation detection ,SSNTDs have biological applications based on the production of nuclear tracks microfilters. These filters are used in the filtration of the cancer cells out of the blood, filtration of bacteria and particles, and many other scientific application (see [8] and reference therein).

In the present work, the track etch detectors CR-39 and CN-85 are irradiated with high doses of α- particles etched, and the optical density is measured. A wing of an insect, dragonfly in this work is sandwiched between the α-particle source and the track detector to register its structure.

Experimental:

Irradiation:

One piece of CR-39 (with thickness 250 µm supplied by pershore Moulding, England) and two pieces of CN-85 (with thickness 100 µm ,supplied by Kodak-pathe, France) with dimensions 1×1 cm were prepared.

One piece of each detector was irradiated with α-particle from ^{241}Am (in contact) for 7 days ,while the time of irradiation of the second piece of CN-85 was 12 days. The activity of the α-source was 555 Bq and supplied by Radio-chemical Ltd., Amersham,England.

Etching:

The etching process was achieved by using NaOH solutions of 6.25 N, 70 ^{o}C and 5N,50 ^{o}C for CR-39 and CN-85, respectively, and for different etching times.

Optical density measurement:

The optical density of each sample was measured by using digital transmission densitometer DT1505,. which supplied by Parry Instruments, Ltd, England. The minimum reading of this instrument was 0.001.The optical density readings have taken successively after every etching interval and for each sample.

Alpha particles radiography:

A third piece of CN-85 detector was cut into 2×2 cm and a portion of dragonfly wing is inserted between this detector piece and the α-particle source, ^{241}Am .The time of irradiation of this sample was 12 days, then it developed by the etching process described above.

Results and Discussion:

The transmission of a light beam through etched SSNTD will decrease its intensity due to scattering with the etched tracks.This scattering process depends on track density ,track sizes ,and track orientations[6].The optical density (D)is correlated with the fraction of light transmitted by the detector(T)through[4]:

$$D= - \log T \qquad (1)$$

This relation tells that as the transmission of light increase ,the optical density decreases and vice versa.

Fig(1) shows the optical density as a function of etching time for irradiated CR-39 and CN-85 track detectors with alpha particles in same dose (time of irradiation is 7 days).Both curves of this figure have the same behavior, i.e. they have a peak followed by a decrease in the optical density as etching time increases .This behavior can be easily ascribed to the overlapping in the etched tracks as etching time increases[7].The overlapping makes the etched tracks more shallow, which increases the transmission of light ,and thus decreases the optical density according to eq(1).By comparison of the two curves of this figure, one can observe that the optical density curve of CN-85 detector reaches its peak in a shorter etching time (1 hr). than that required for CR39 detector(4.5 hr.) .

On the other hand, the irradiation of CN-85 detector with a higher dose of α-particles (12 days of irradiation)peaked its optical density curve at a shorter etching time (40 min as compared with the corresponding curve belonging to a lower dose of irradiation (7 days), as shown in figure (2).This movement of the optical density peak to appear at shorter etching time as the α-particles dose increase is clearly due to the increasing of the track density which makes the overlaping of etched tracks happen faster.

The appearance of the optical density peak in CN-85 track detector at early etching time than CR-39 track detector, as shown in fig.(1),gives it the preference for the second part of this work as α-particle radiographer.

Fig.(3)shows a photograph of a portion of dragonfly wing as registered on CN-85 track-etch detector. The treeings in the wing are appear in this photograph by virtue of the difference of their density as compared with the transparent parts of the wing . Thus, tracks that registered on CN-85 detector corresponding to the transparent parts of this wing are more dense (greater in number) than that corresponding to the dark parts (treeings).This difference in the track density leads to the development of the picture in fig(3).

Conclusions:

One can concluded the following items from this work:-

1-The optical density is a firm function of the etching time, plastic detector type ,and the α-particles dose.

2-The shift in the peak position of the optical density as α-particles dose varied can be used as dose-meter.

3-The result displayed in fig(3)represents a prototype work which needs further investigation to be useful.

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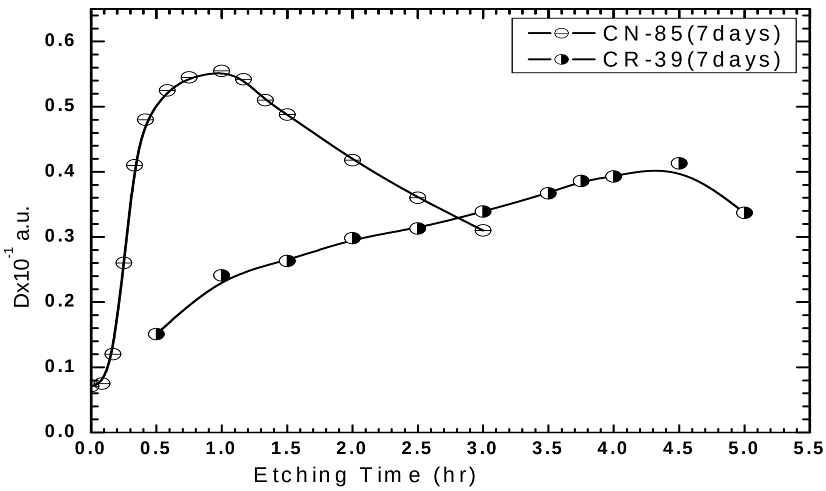

Fig.(1):-optical density of irradiated CN-85 and CR-39 track detectors as a function of etching time.

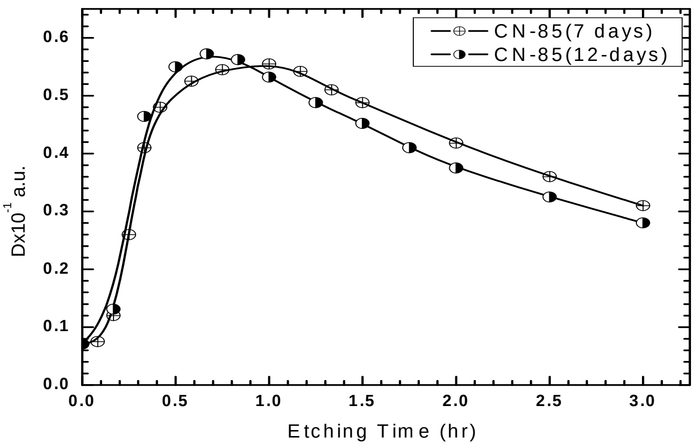

Fig.(2):- optical density as function of etching time forCN-85 detector irradiated with two different dose of α -particles.

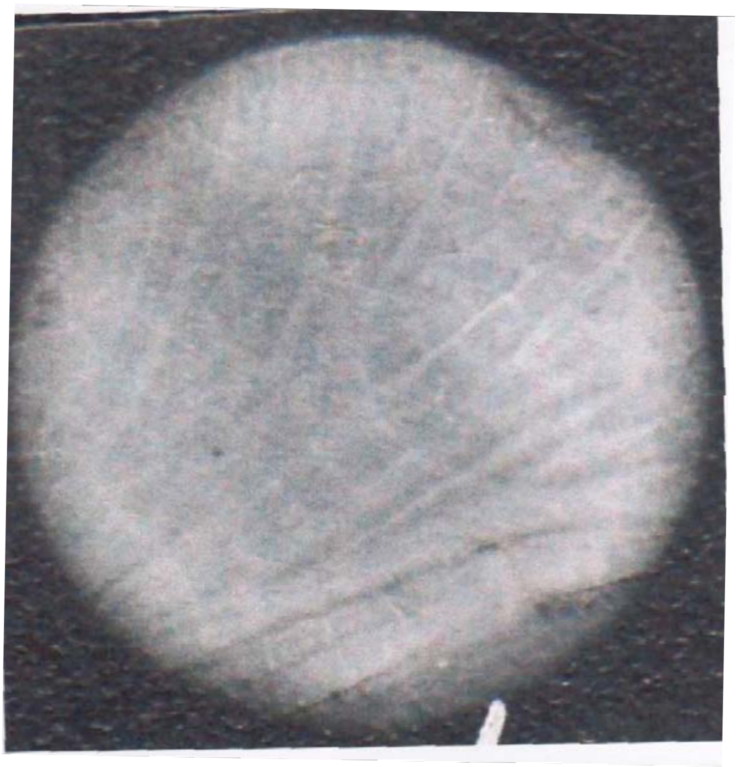

Fig.(3):-photograph taken by α- particles radiography registered on CN-85 track detector.