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ABSTRACT

This paper gives the experimental condition for use of the cellulose nitrate film LR-115 type II as alpha particle detector. It was verified that the filme efficiency is a function of the alpha particle energy and etching conditions. The track counting was made in an optical screen microscope.

1 – INTRODUCTION

Energetic heavy ions moving through some insulating materials leave damage trails that can be rendered visible in an optical microscope by suitable chemical etching. The theories of track formation mechanisms[2] are based in the means by which heavy ions lose energy as they slow down and come to rest in a solid. If the damage produced by the particles along their trajectories is greater than a critical value the track may be developed by etching with a chemical reagent and made visible in an optical microscope. The chemical etching preferentially attacks the damaged material and less rapidly removes the surrounding undamaged matrix. The more widely used materials as track detectors are mica[6], glass[5] and polycarbonates[3,7] for fission fragments and cellulose nitrate for alpha particles. All of these materials are insensitive to light, X and gamma rays and electrons. This simple techniques has been used in a variety of fields like nuclear science, astrophysics, geology etc. In the present paper we report our studies of alpha particle registration in LR-115 – the trade name of cellulose nitrate film made by Kodak Pathé, France. Our purpose was the development of the technique for future applications like radon emanation mapping, neutron detection and nuclear physics experiments. We investigated the conditions for using, etching and track countig of this film detector.

2 – EXPERIMENTAL DETAILS AND RESULTS

The LR-115 film consists of a layer of cellulose nitrate strongly red coloured, and coated on an inert polyester base 100 μm thick. Therefore only one of the surfaces in sensitive. In LR-115 type I film the cellulose nitrate layer is 6 μm thick and this film is mainly recommended for alpha particles with energies between 0.5 and 2.0 MeV and in LR-115 type II film, the thickness of the layer is 12 μm good for alpha particles with energies between 2 and 4 MeV[4]. In this work we we used the LR-115 type II.

A thin ^{241}Am alpha source (5.48 MeV, 85% and 5.44 MeV, 13%) was used in these investigations.

The films were etched in NaOH at a temperature of (60.0 ± 0,1)°C. During the chemical attack the etching solution was gently agitade (≃ 15 r.p.m.) on the contrary of the Kodak recommendation[4], because when the foils were etched without stirring of the solution we observed blemishes in the surface.

The counting method used to determine the number of tracks was the observation through a screen microscope Reichert at an enlargement of x 140, with a grid numbered and counting the number of tracks in a serie of fields of view. The alpha track is recorded in the red part of the foil and after etching the film shows strong contrast like circles and bright points in red background (Figure 1).

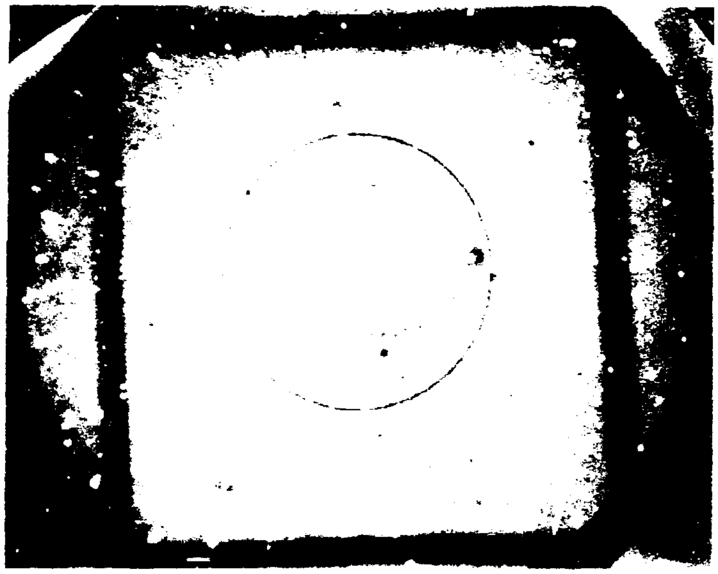

Figure 1 — Track-etched holes in LR-115 type II obtained with a screen microscope Reichert at an enlargement of X 140.

According the criterion of critical rate of energy loss[2] there is a minimum value of $|dE/dx|$ below which a charged particle will fail to have its trail developed by etching. The alpha particle ionization rate follows the Bragg curve then the response of the alpha sensitive films is energy dependent.

In the first experiment foils of LR-115 type II were irradiated in 2π geometry with alpha particles of ^{241}Am with Makrofol (polycarbonate $C_{16}H_{14}O_3$, ρ = 1.21 g/cm^3) foils between the source and the detector. In Figure 2 we can see that the greatest density of tracks is obtained with 14 μm of Makrofol ($E_\alpha \simeq 3{,}4$ MeV[1]), the etching was carried out in NaOH 10%, kept at (60.0 ± 0.1)°C during 90 minutes[4].

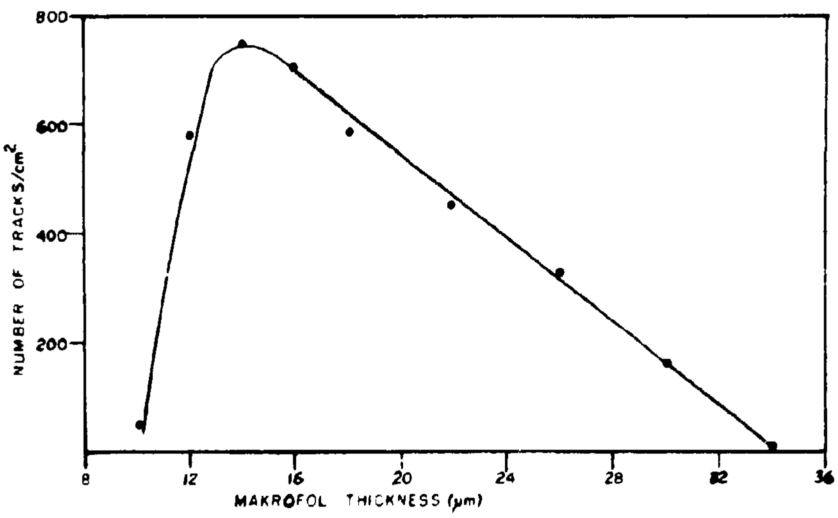

Figure 2 — Track densities recorded in LR-115 type II by exposure to a thin ^{241}Am source as a function of makrofol thickness interposed between source and detector.

We irradiated also foils of cellulose nitrate with collimated alpha particles, in air, at different distances from the ^{241}Am source. The etching conditions were the same of the previous experiment. Figure 3 shows the results, the maximum track density obtained corresponds to $E_\alpha \simeq 3.4$ MeV the same value obtained with Makrofol degrader foils.

High energy alpha particles pass through the 12 μm cellulose nitrate film without producing any length of etchabel damage. The 5.5 MeV alpha particles of ^{241}Am are not detectable. Figure 4 shows track densities recorded as a function of etching time for LR-115 type II foils irradiated with 10, 12, 14 and 16 μm Makrofol foils interposed between ^{241}Am source and detector. The etching solution used was NaOH (8.5%).

As the energy of the incident alpha particle decreases (as a consequence of Makrofol foil thickness being increased) a corresponding decrease is observed in the threshold etching time. The lower the alpha energy the earlier it will slow down sufficiently to attain in its path, the threshold rate of specific ionization.

The tracks belonging to alpha particles of different incident angles (therefore different energies) do not appear simultaneously at a given etching time; thus the initial part of the curves of Figure 4 can be explained. The decrease in track density for longer times of etching results from the fact that some tracks (the shallow oblique tracks) become too plain to be recognised.

As the Makrofol thickness is increased to 16 μm the curve shows a differente shape because more alpha particles traveling at oblique angles with the detector face get absorbed in the polycarbonate foil.

Non irradiated foils were etched during the same intervals of time (Figure 5). From Figure 4 we can choice 120-130 minutes for etching time, the track density of background for the same etching time is 80-90 tracks/cm^2.

We verified the proportionality of track densities to irradiation time until 25000 tracks/cm^2 the limit for a good visual counting in microscope (Figure 6).

The alpha sensitive plastic LR-115 type II suitable for application to low level alpha counting but for a precise quantitative analysis the detector must be etched under conditions that must be strictly controlled.

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RESUMO

~~Neste trabalho~~ Procurou-se determinar em que condições se pode usar o filme de nitrato de celulose LR-115 tipo II para detecção de partículas alfa. Verificou-se que a eficiência obtida com este detector é função da energia das partículas alfa que chegam ao filme e das condições de revelação do filme. A contagem dos traços foi feita em microscópio óptico com tela.

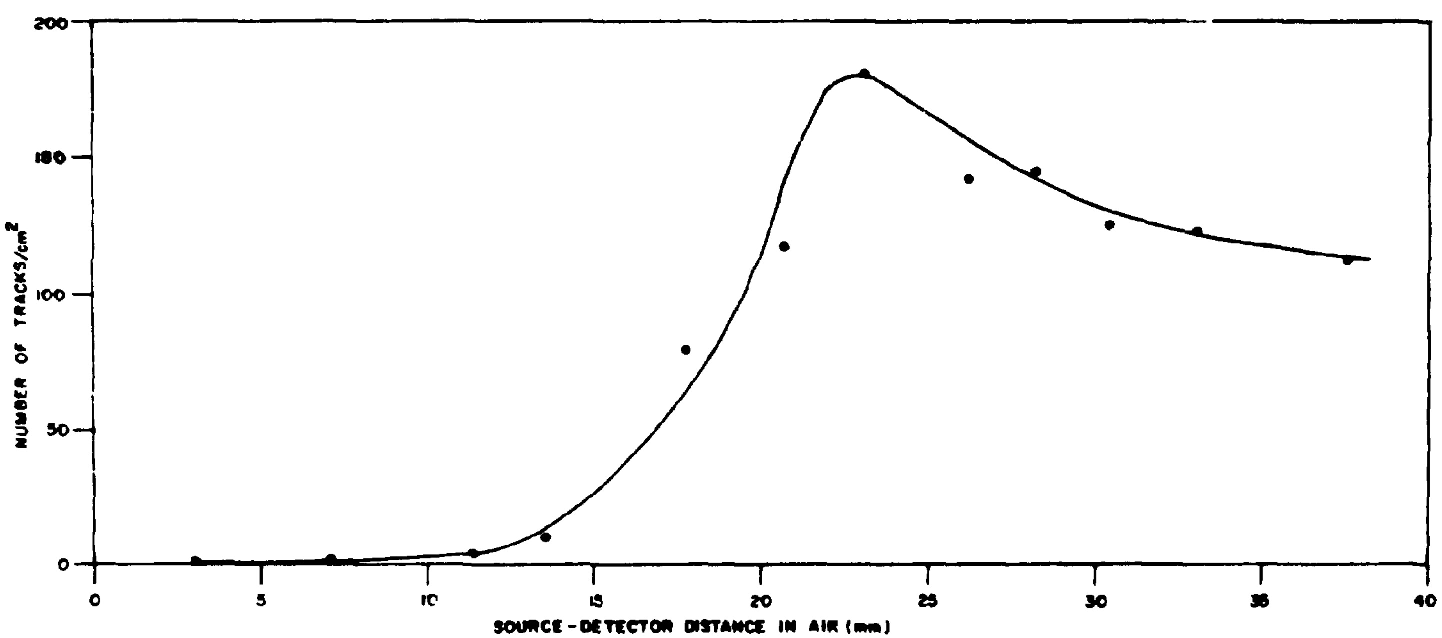

Figure 3 – Track densities recorded in LR-115 type II by exposure to collimated alpha particles, in air. The densities are corrected for geometry factor.

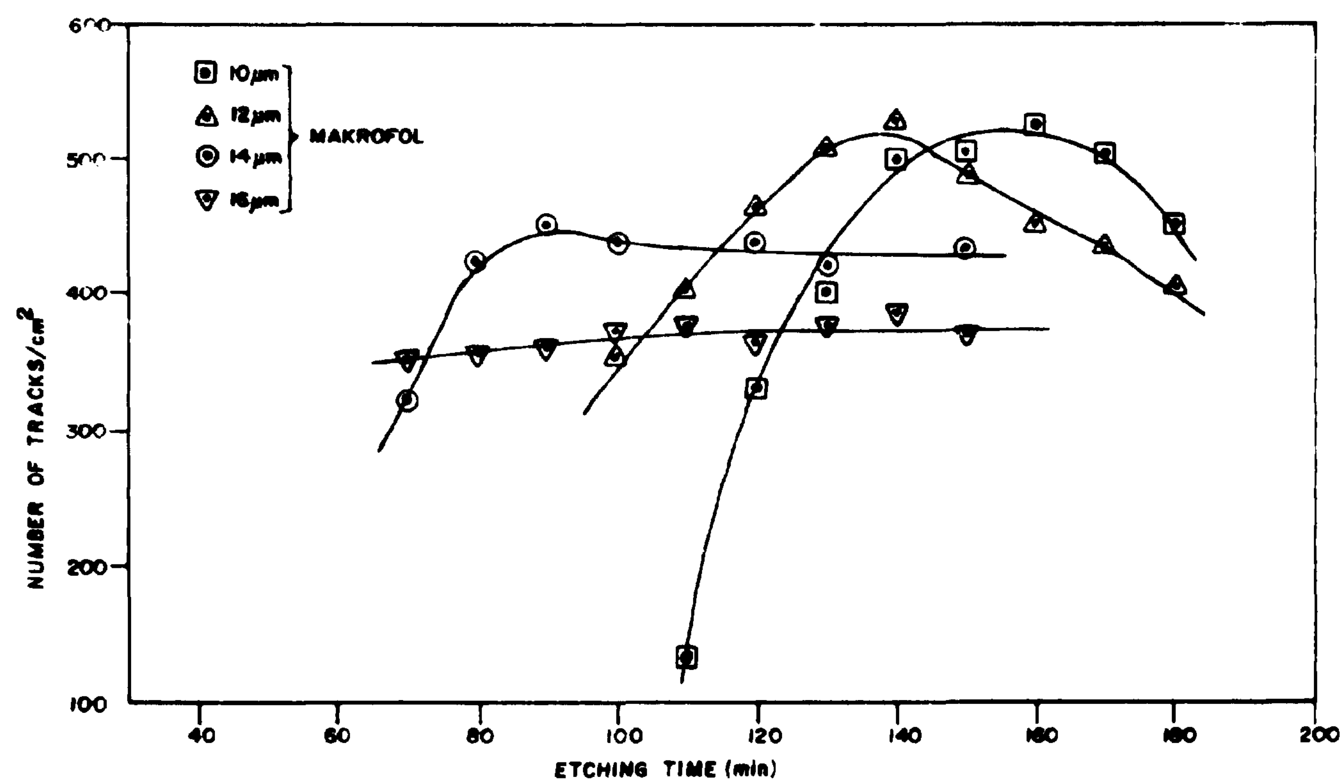

Figure 4 – Track densities obtained as a function of etching time. Cellulose nitrate LR-115 type II exposed to ^{241}Am with 10, 12, 14 and 16 μm of Makrofol foil interposed between source and detector.

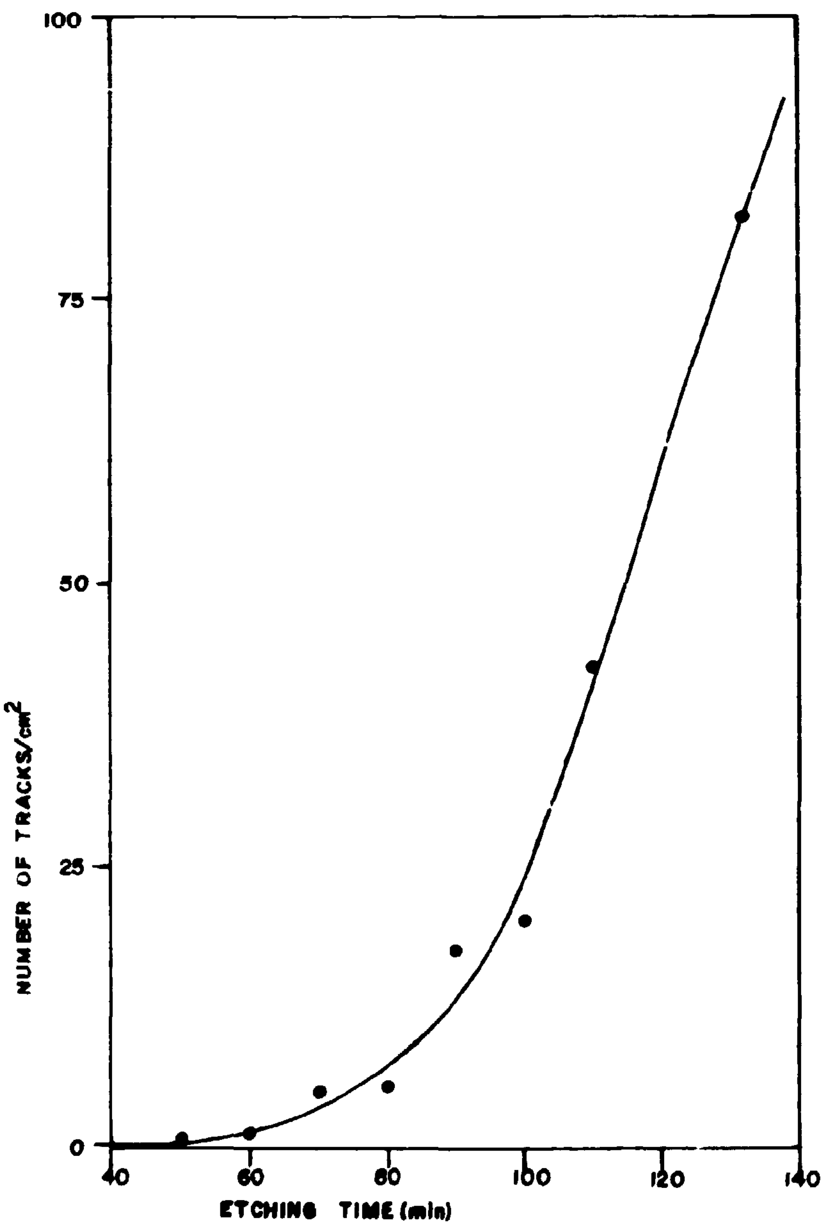

Figure 5 –Track densities in non irradiated foils as a function of etching time.

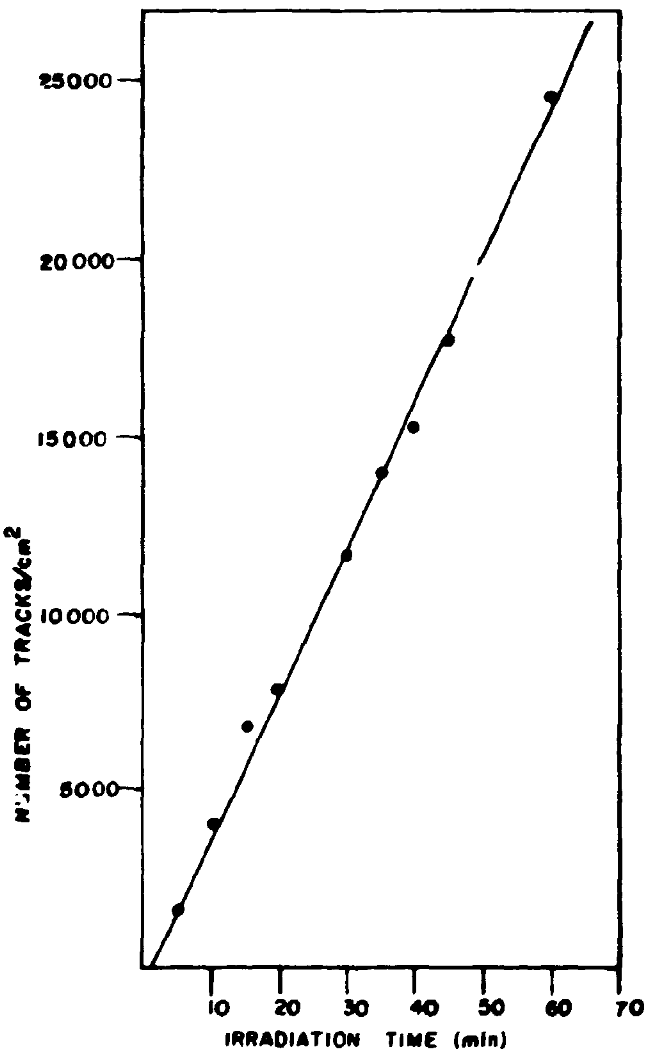

Figure 6 – Track densities recorded in LR-115 type II as a function of irradiation time.

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(*) Bibliographic references related to documents belonging to IPEN Library were revised according with NB-66 of Associação Brasileira de Normas Técnicas.

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