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SOME STUDIES ON THE REGISTRATION OF PARTICLES ON MAKROFOL E

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ABSTRACT

Alpha particles, fission fragments and fast neutrons tracks have been studies in Makrofol E**, 200 μm thick, polycarbonate detector, using as track etchant a solution of 15% KOH+40%C_2H_5OH+ 45% H_2O. Chemical or electrochemical etching technique were used depending on the detector use.

KEYWORDS

Makrofol E, chemical etching, electrochemical etching, alpha detector, fission fragments detector, fast neutron recoil track detector.

EXPERIMENTAL PART AND RESULTS
ALPHA PARTICLES

In these investigations an ^{241}Am alpha source has been used in a 2π-geometry of irradiations. Polycarbonate foils (Makrofol KG) degraders were used to obtain different energies. The detectors exposed to alpha particles of energies from 5.48 MeV to 1.10 MeV were chemically developed in a 35% KOH solution in water, kept at (70±1)°C. The etching time was of the order of 4 hours for 2.4 MeV particles and 7 hours for 4.8 MeV particles. The observed background increases very rapidly with the etching time.

Using the PEW solution recommended by Somogyi (Somogyi, 1977), 15% KOH, 45% water and 40% ethyl alcohol (per cent by weight) at 70°C, the surface remotion is markedly altered. The alcoholic solution provides much larger tracks and increases the etching rate along the surface, considerably compared to the KOH water solution. Table 1 gives the optimum etching time values obtained for a suitable track diameter (10-20 μm). Figure 1 shows the efficiency of the film irradiated in the 2π-geometry as a function of the alpha particle energy for different etching time. From this figure one can see a considerable reduction in the registered number of tracks at energies lower than 3.0 MeV. This is due to a partial loss of alpha particles which fall into oblique angle incidence on the degrader and are absorbed.

Using thermal neutrons from the IEAR-1 research reactor, at São Paulo, we irradiated Makrofol E with a borated converter screen and obtained the same efficiency for etching times between 20 and 60 minutes for the tracks of alpha particles of energy 1.47 MeV obtained from the $^{10}B(n,\alpha)$ reaction. Background track density was about 10 tracks/cm^2 for films chemically etched from 60 to 140 minutes.

Some recent studies on the electrochemical etching of alpha particles tracks in polycarbonate foils have shown promising results (Sohrabi and Khajeian, 1981, Stillwagon and Morgan, 1979). Using a chamber similar to one described in (Tommasino and Armellini, 1970) we were able to perform simultaneous electrochemical etching on up to four plastic detectors, each having about 1.5 cm etched diameter. The high voltage generating system was the PWO model of 3E - equipaggimenti, elettrici et elettronici, which can supply output voltage of 0 to 5 kV(pp) with frequencies varying from 1 to 10 kHz.

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** Manufactured by Bayer AG, Leverkusen, Fed. Rep. Germany.

In our investigations using PEW solution at room temperature (~ 25°C) no alpha tracks have been observed up to an eletric field of 25 kV/cm at 2 kHz for 3 hours. The voltage, frequency and the etching time are the parameters that must be studies as a function of the alpha particle energy. Working at room temperature we observed tracks of alpha particles with energies up to 3.7 MeV.

Figure 2a shows the background variation as a function of the field strength, the frequency remaining fixed at 2 kHz. One can see that the background track density increases with field strength. From figure 2b it can be seen that background track density is pratically independent of the frequency variation from 1 to 6 kHz, at fixed field strength.

The maximum track diameter increases with increasing field strength and also with etching time as shown in figure 3. A field of 30-35 kV/cm is adequate considering the background, however a proper etching time must be chosen in each experiment. We were also interested in the alpha particles detection from $^{10}B(n,\alpha)$ reaction which in turn can be used in boron determination, thermal neutron dosimetry, etc. The results in figure 3 were obtained with 1.1 and 1.6 MeV alpha particle using 30 μm and 28 μm thick Makrofol KG as degrader between source and detector. This was done keeping in mind the alpha particle energy from $^{10}B(n,\alpha)$ reaction which is 1.47 MeV.

FISSION FRAGMENTS

Makrofol E can also be used as fission fragments detector with excelent results. The irradiations were performed with a ^{252}Cf source in a 2π-geometry. Using the same PEW solution as described earlier, we found 50 minutes at 70°C as optimum conditions for the chemical etching. For the purpose of fission fragments angular distribution measurements the electrochemical etching was found unsuitable because the efficiency is the same but the background is higher than observed in the chemical process.

FAST NEUTRONS

The electrochemical etching for fast neutron recoil track detection seems to be more suitable than the use of conventional chemical track etching technique. The main advantage of electrochemical etching is the possibility of amplifying the nuclear tracks into large discharge spots. The track reading of the detectors becomes considerably simpler, faster and more reliable than with the chemical etching. The plastic foils were irradiated with a ^{241}Am-Be source always in the same relative film-source position. The electrochemical etching apparatus and etchant solution are the same as described before.

Figure 4 presents a set of data showing the variation of track density as a function of frequency. The results obtained have a maximum in the track density, this resonance type effect was also found by Somogyi (Somogyi et al, 1975) and Sohrabi (Sohrabi, 1981) using other materials.

Figure 5 shows the dependence of track density on the field strength applied during the 2 hours etching period with an applied field strength higher than the threshold value, the track density increases in the range of 25 to 90 kV/cm, at 2 kHz, at room temperature.

CONCLUSION

On the basis of our observation on background and the particles detection we conclude that, in the case of our unwrapped Makrofol E, the electrochemical etching must be used with some caution because the background is considerable higher, however the process is very convenient and with suitably selected conditions can be used with advantage over the chemical etching.

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TABLE 1 - Etching time values for chemical etching in PEW solution 15% KOH, 45% water and 40% ethilic alcohol at 70°C

Alpha particle energy	Etching time
from 5.48 MeV to 3.10 MeV	120 minutes
from 3.40 MeV to 2.8 MeV	80 minutes
from 2.80 MeV to 1.1 MeV	40 minutes

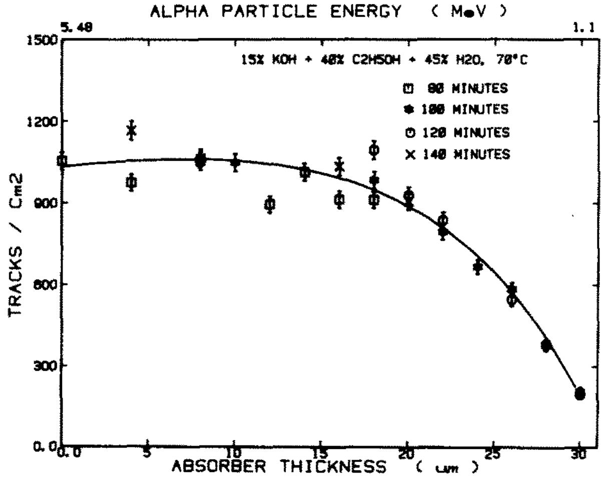

Fig.1 - Track density as a function of the alpha particle energy.

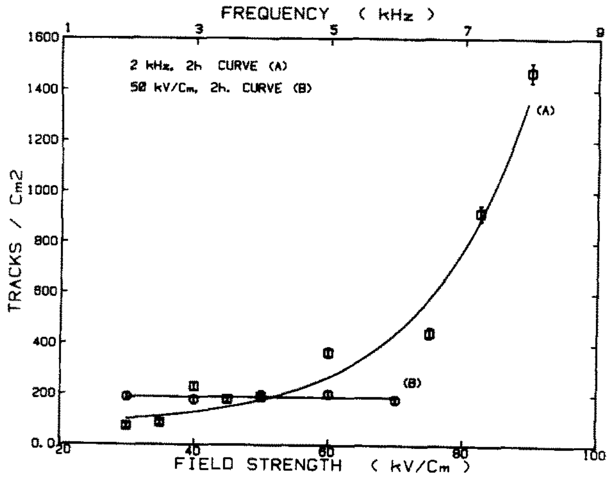

Fig.2 - Background track density(a) as a function of the field strength and (b) as a function of the frequency of voltage applied to Makrofol E sheets in the course of electrochemical etching.

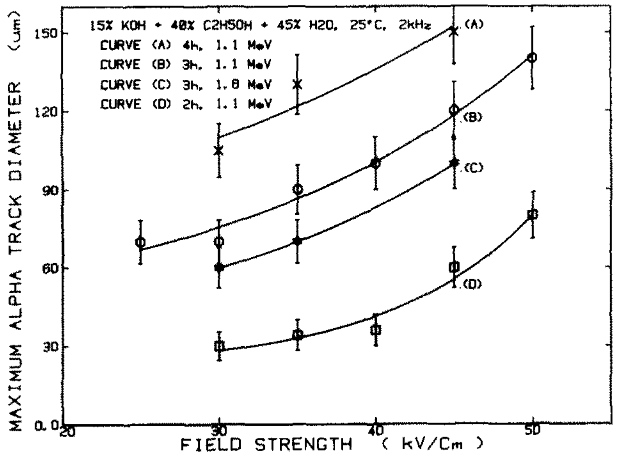

Fig.3 - Maximum etched track diameter as a function of the field strength applied to Makrofol E sheets during the electrochemical etching.

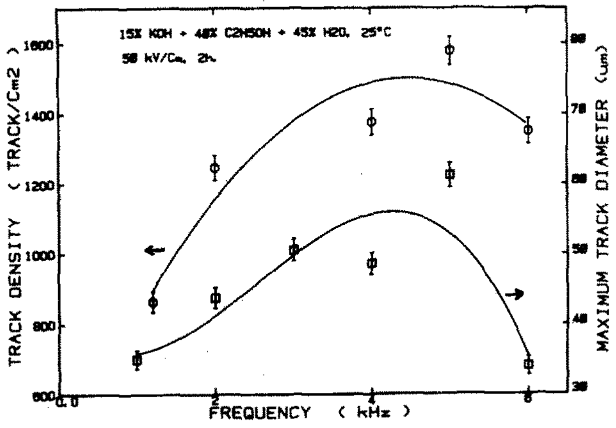

Fig.4 - (a) Track density as a function of the frequency of voltage applied to the film of Makrofol E exposed to Am-Be neutrons (b) Maximum etched track diameter as a function of the frequency.

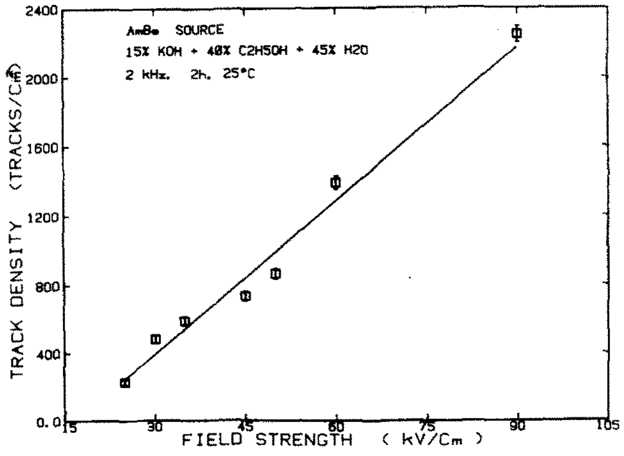

Fig.5 - Track density as function of the field strength applied to Makrofol E sheets, exposed to Am-Be neutrons, during the electrochemical etching.