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FADING EFFECTS OF ALPHA PARTICLE TRACKS IN CELLULOID FILMS

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1. Introduction

In a previous paper[1] various basic properties of celluloid films (cellulose nitrate+camphor 25% by weight)*) for alpha particle track registration were studied. But in that paper some problems in fading effects of alpha particle tracks in celluloid films remain to be unsolved enough.

In this work, fading effects of alpha particle tracks by ultra-violet radiation, heating procedures in hot liquid and hot air circumstances are examined.

As an alpha emitter, radioisotope Am–241 of package type (alpha; 5.4∼5.5 MeV, intensity; 3×10^4 d.p.m.) was used. The irradiated films were etched in NaOH (6N) at 46°C for ten minutes. The etched tracks were observed under a view of optical microscope at magnification of $10\times20\sim10\times90$. In order to obtain the suitable energy of alpha particle track formation, two polyester films**) were inserted in ordinary experiments as the absorber material between celluloid film and the Am–241 source. And in the case of two absorbers the length of the etched tracks is determined as 11 microns in celluloid fimls.

2. Fading Effects by Ultra-violet Radiation

An ultra-violet light lamp with a wavelength of 2537 A (4.95 eV) was used as a radiation source. At the sample position the photon flux was 0.79×10^{18} photons/sec. cm^2. No increase of temperature of celluloid films could be detected during the ultra-violet irradiation. The celluloid films, which were irradiated previously by alpha source of Am–241, were exposed to ultra-violet radiation at room temperature for various exposure times. After the etching process the residual tracks were counted. The observed counts for respective exposure time were normalized with the maximum counts. In the irradiation of alpha particles, two, one and no absorbers were used and the fading effects by ultra-violet exposure are studied. The results are shown in Fig. 1.

It can be seen from Fig. 1, that;

1. there is the suitable energy region for alpha particle track registration in celluloid films,

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*) ♯610, Daicel Co. Ltd., Osaka, Japan. Film thickness; 100 microns, density; 1.32, molecular formula; cellulose nitrate $C_{12}H_{16}O_{18}N_4$, camphor $C_{10}H_{16}O$.

**) "Saran-Wrap" (polyester film), 10.0±0.7 microns in thickness and 1.7 (gr/cm^3) in density.

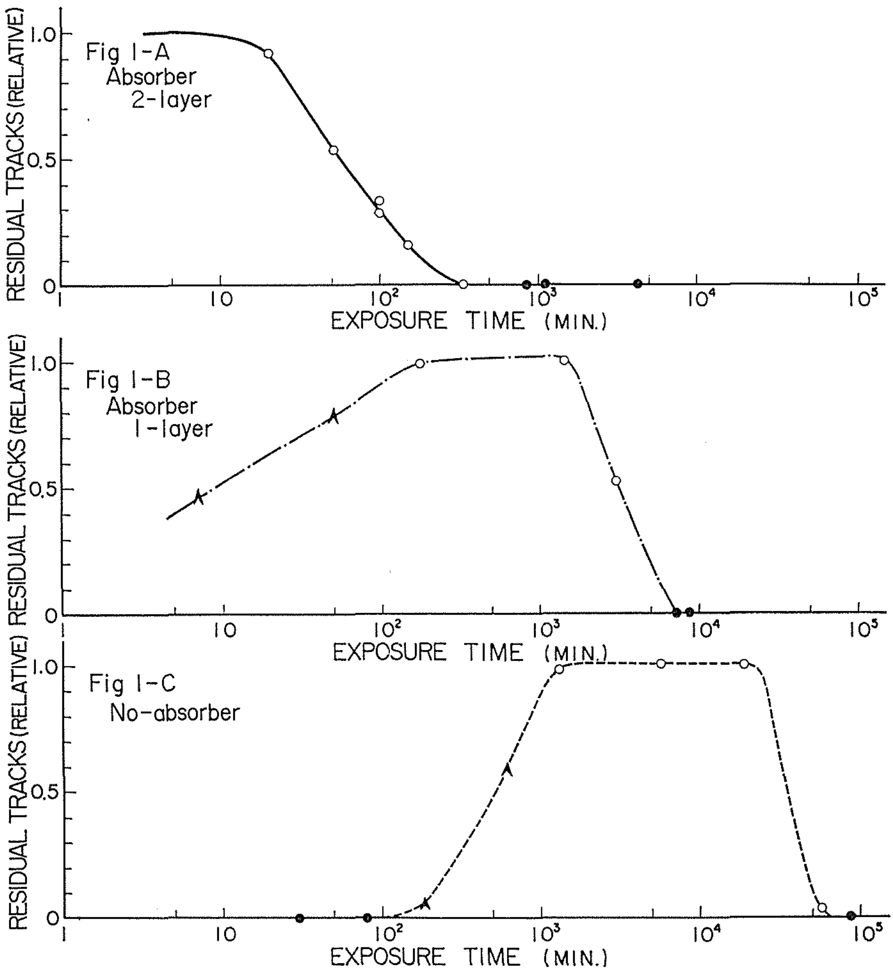

Fig. 1. The Residual Tracks after the Etching Process in Celluloid Films exposed by Ultra-Violet Radiation. (photon flux $=0.79\times10^{18}$ photons/cm^2, sec)
(● No track ⋀ Arrow-head shape track ○ Ball shape track)

2. the vicinity of 20 microns is necessary for energy loss, 3. the thickness of about 20 microns in celluloid films is equivalent to the etched out layer damaged by ultra-violet exposure in about 1000 minutes. 4. the range of alpha particles with 5.4 MeV in celluloid films can be estimated roughly from the ultra-violet exposure time of c.a. 2.5×10^4 minutes, and the dosage corresponds to c.a. 30 microns in thickness, which is consistent with a theoretical value of 29.8 microns.

The exposed films by ultra-violet radiation became dark brown in proportion as the dosage of ultra-violet radiation increased.**)

*) The exposure of ultra-violet radiation was done on the lustre and smooth surface of celluloid films.

**) This phenomena suggests an utility of "dye-dosimetry" of ultra-violet radiation by celluloid films.

The etched tracks after the exposure of ultra-violet radiation were expanded spherically.

Fading effect of alpha tracks in celluloid films are caused essentially from etching out of the film layers which contain the alpha tracks. The etching out of the film-layers and the expansion of the etched tracks are due to damage by ultraviolet radiation. Actually the mass of the celluloid films were decreased in air at the room-temperature, as the exposure of ultra-violet radiation was increased, even before the etching procedures.

And also the degrees of ultra-violet radiation damages were different between the lustre and smooth surfaces and the opposite, unpolished and rough surface of a celluloid film. In Fig. 2 the results are shown. For the exposure times longer than 100 minutes,

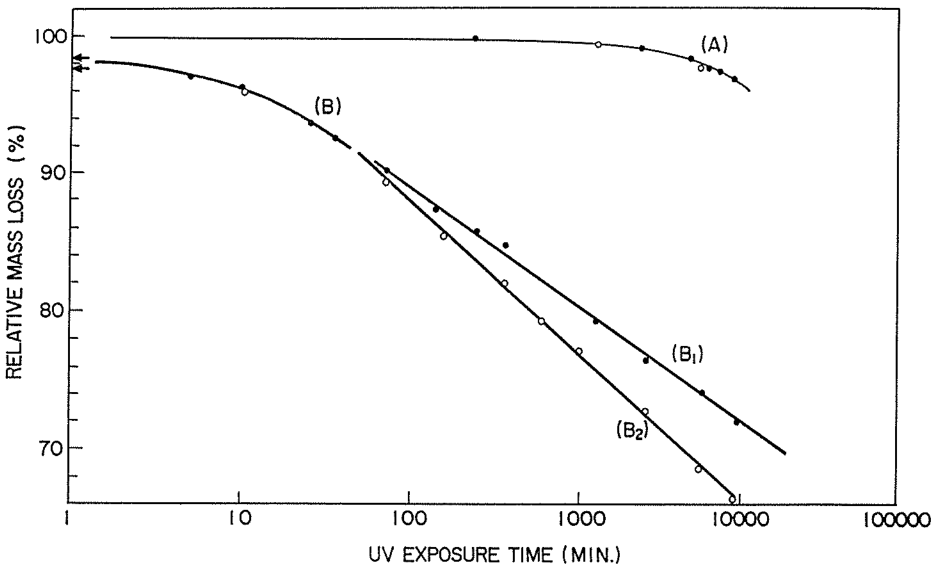

Fig. 2. MASS LOSS OF CELLULOID FILMS DUE TO ULTRA-VIOLET RADIATION
(A) before &
(B) after etching procedure.
(B_1); UV EXPOSURE TO LUSTRE & SMOOTH SURFACE (●),
(B_2); TO UNPOLISHED SURFACE OF CELLULOID FILMS. (○)

the relation between the residual mass of celluloid films and the dosage of ultra-violet radiation is assumed as an exponential form,

$$I = I_0 e^{-M/M_0} ,$$

where I=the dosage of ultra-violet radiation and M=the residual mass ratio to the initial mass of celluloid films after the exposure of ultra-violet radiation and the etching process. And I_0 and M_0 are constants.

In the case of exposure on the smooth surface, we have $I_0 = 3.82 \times 10^{29}$ (photons/cm^2) and $M_0 = 4.99 \times 10^{-2}$. On the opposite, rough surface, we have $I_0 = 6.40 \times 10^{28}$ (photons/cm^2) and $M_0 = 4.68 \times 10^{-2}$.

Hence the fading phenomena of alpha tracks in celluloid films*) by ultra-violet radiation can be explanied quantitatively by the etching out of the damaged film layers.

Benton and Henke observed that the etched track length increased by previous irradia-

*) Film thickness of celluloid film is 100 microns.

tion on latent tracks of lexan dielectric track detector.[2)]

In this work, however, not the length, but the diameter of the etched tracks are increased remarkably by ultra-violet irradiation.

3. Fading Effects in Hot Liquid Circumstances

The fading effects of alpha tracks are derived also from "boiling" procedures in hot liquid circumstances. In the boiling procedures celluloid films were solved so much that tracks were faded and vanished after the etching process.*) The features of solving away of celluloid films was obtained in hot water and hot liquid paraffin**) at temperature of 69 ±1 and 81±1 °C, which are shown in Fig. 3.

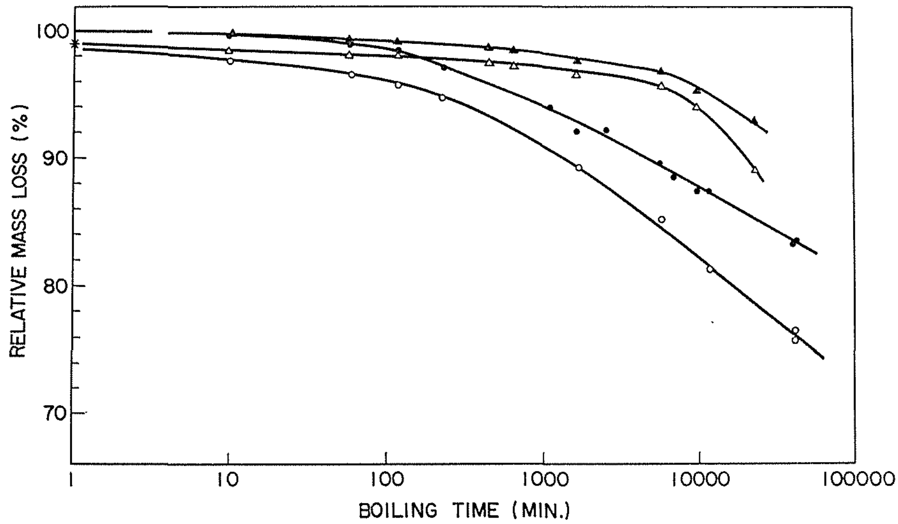

Fig. 3. MASS LOSS OF CELLULOID FILMS in hot (81±1 °C) WATER & LIQUID PARAFFIN

	(hot WATER)	(LIQUID PARAFFIN hot)
(before &	●	▲
after)	○	△

etching procedure.

As shown in the previous paper,[1)] the etched tracks were faded for the boiling times of 80 and 100 minutes at temperature of 79±0.5 and 76±0.5 °C respectively, and at 86 °C no tracks were observed for the boiling time of 3 minutes.

Celluloid films are dissolved in hot water indeed, but no tracks were observed for a boiling time longer than 5000 min. at 81±1 °C under a view of microscope, if no etching process was performed. This fact suggests that no latent alpha tracks can be grown selectively by a boiling procedure in hot water.

*) But it is unknown, that the solving away of celluloid films in hot water was caused from the solving away of camphor or cellulose nitrate and/or both components.

**) Liquid paraffin; ($C_nH_{2n\div 2}$)

The damage of celluloid films brought by hot liquid paraffin were more feeble by than hot water, which were found in the residual mass of celluloid films before and likewise after the etching process, as shown in Fig. 3.

4. Fading Effects in Hot Air Circumstance

The etched tracks heated for a long time in dry air were also faded.

The celluloid films, which were irradiated previously by alpha source of Am–241, were heated in dry air at 81±1 °C in a controlled bath. As the heating time was increased, the etched tracks became smaller and smaller. When the heating time exceeded, finally, from 65000 to 75000 minutes at 81±1 °C, the etched tracks were no more observed under a view of microscope.

In two points the etched tracks heated in dry air are different from the etched tracks irradiated by ultra-violet radiation and boiled in hot liquids. First, the image of the former tracks becomes more undersized and smaller than the ordinary etched tracks, while the latter tracks becomes expanded spherically. Second, the fading time, in which the etched tracks heated in dry air are faded out, is considerably long compared to the latter cases.

Fig. 3 shows the residual mass of celluloid films heated at 69±1 °C and 81±1 °C before and after the etching process.

It is not so inexplicable, that the fading phenomena of the alpha tracks at hot air circumstance is due to the mass loss of celluloid films, which may caused from evaporation of camphor component by heating and thereby some degradation of celluloid films occurs.

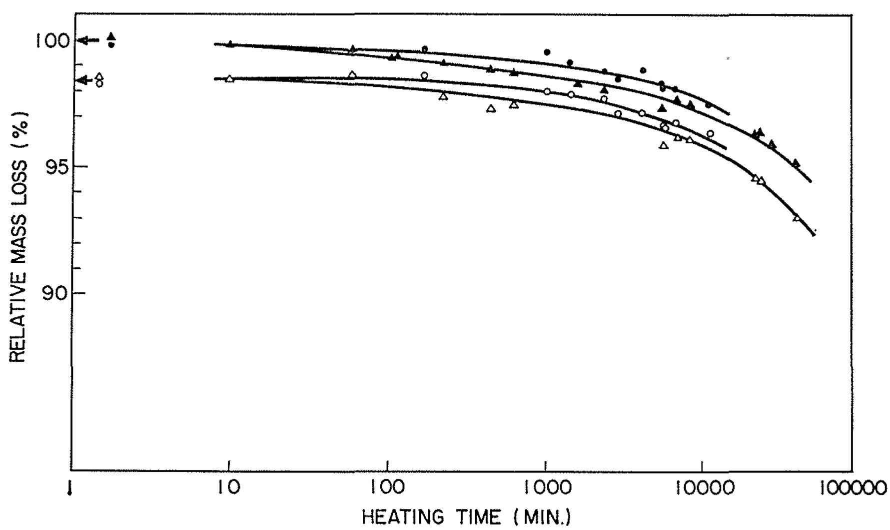

Fig. 4. MASS LOSS OF CELLULOID FILMS IN AIR heated at (69±1) °C & (81±1) °C.

	69 °C	81 °C
before &	●	▲
after	○	△

etching procedure.

5. Discussion

In this work, it is explained, that the fading effects of the etched alpha tracks, which are damaged before-hand under severe circumstances, i.e. ultra-violet irradiation or heating, are essentially due to the etching out of celluloid films.

It remains an iterest problem, that the etched tracks heated in hot air circumstance became undersized and finally vanished.

The features of the etched tracks, which are expanded spherically after the ultra-violet irradiation or boiling in hot liquid circumstances, suggest also sensitivity enhancement of celluloid films for ionizing heavy particles. Benton and Henke discussed also sensitivity enhancement of lexan films by ultra-violet irradiation in the presence of oxygen.[2] But as shown in this work, the "boiling" process in hot water is the most simple and effective method for sensitivity enhancement of celluloid films.

In this work the features of the fading effects of alpha tracks in celluloid films are studied. These informations on celluloid films are useful for selections of dielectric track detectors under various detection conditions.

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