Range-Energy and Other Relations for Electrons in Kodak Nuclear Plates

KODAK Nuclear Track plates of type *NTP* 2, 30 μ in thickness, have been exposed in a low-resolution β-ray spectrograph using uniform magnetic fields of 279 and 302 oersteds. The focused line had a half-breadth of about 1 mm. The rays entered the plate at a grazing angle, the central ray meeting the plate at 6°. 'Line' sources of thorium (B + C) and radium E were used to provide continuous spectra. Exposure times were such as to give, in the 80-keV. energy region, about 2×10^5 β-rays per sq. cm. on a surface normal to the central ray. The plates were developed for 20 min. at 18° C. in 'Kodinol' developer.

Emulsions of two different sensitivities were used, the normal *NTP* 2*a*, and an experimental emulsion having larger grains and higher sensitivity than the *NTP* 2*a*. The chemical constitution of the two emulsions was the same. In the *NTP* 2*a* plates, electron tracks could be followed easily up to 50 keV., and with some difficulty up to 80 keV. energy. In the more sensitive emulsion, the upper energy limit for the range measurements was set by the thickness of the emulsion. The longest observed track was of 94·4 μ with corresponding energy almost certainly greater than 150 keV. (see below). Fig. 1, from a radium E plate, shows a 'background' track (probably of a secondary electron due to high-energy *Bremsstrahlung*). This track is 81·4 μ long and contains about 65 grains. Fig. 2 shows an 80-keV. track from radium E (27·8 μ and 32 grains).

Measurements were made of the ranges of unbranched tracks (a branch could not be identified with certainty if its energy were below about 20 keV.) starting in the surface of the emulsion and having an initial direction within 40° of the central ray direction. Working from grain to grain, observations were made of projected lengths and differences of depths. Depth measurements were corrected for shrinkage of the emulsion in processing. The range data from the higher sensitivity plates are given in Table 1. Because of the limited thickness of the emulsion, the 100-keV. range may be somewhat low, and is therefore enclosed in brackets.

Table 1

No. of tracks observed	Mean energy of tracks (keV.)	Mean range of tracks (μ)*	Standard deviation of ranges	Mean No. of grains per track*	Standard deviation of number of grains
25	30	6·90±0·33	1·67	10·8±0·4	2·0
25	40	11·00±0·57	2·84	14·4±0·4	2·0
25	50	15·78±0·50	2·51	20·4±0·7	3·6
25	60	22·15±1·12	5·62	22·4±1·0	4·9
25	80	32·65±1·55	7·74	35·5±1·4	6·9
25	100	(42·09±1·99)	9·94	41·0±1·6	7·9

* With standard error.

The grain density along the 100-keV. tracks was analysed in 5 μ portions of the tracks, working backwards from the last grain of the track. The results are given in Table 2.

Table 2

Portion of track from the last grain	Mean number of grains per 5 μ*	Standard deviation of number of grains
0–5 μ	7·0±0·3	1·7
5–10	5·3±0·3	1·3
10–15	5·2±0·3	2·5
15–20	4·6±0·3	1·3
20–25	4·3±0·2	1·0
25–30	4·3±0·3	1·3
30–35	4·1±0·3	1·1
35–40	3·7±0·3	1·0

* With standard error.

The relative stopping power of the emulsion may be defined as $\Delta R_a/\Delta R$, where ΔR_a is change of range in air at 760 mm. mercury pressure and 15° C., and ΔR is change of range in emulsion for the same change of energy of the β-particles from V_A to V_B. Thus defined, the relative stopping power is a function of the mean energy $V = \frac{1}{2}(V_A + V_B)$. Values of relative stopping power given in Table 3 were deduced from the data in Table 1 and from calculated mean ranges of electrons in air given by Tsien, Marty and Dreyfus[1], and shown by Tsien[2] to be in close agreement with experimental values in the region of energy up to 50 keV. If the 100-keV. range in Table 1 is low, the 90-keV. stopping power in Table 3 will be high.

Table 3

V in keV.	Relative stopping power of emulsions, with standard error
35	2640± 420
45	2720± 430
55	2290± 440
70	3130± 570
90	(3840±1030)

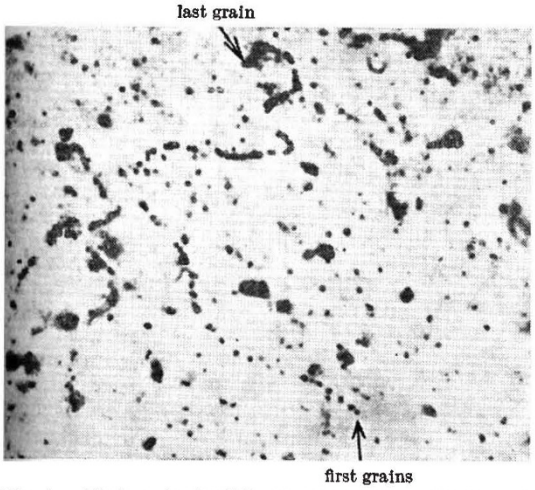

Fig. 1. Electron track of length 81·4 μ; magnification 1,260

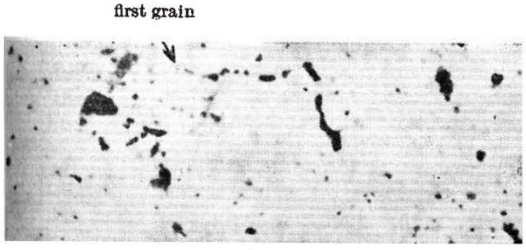

Fig. 2. Electron track of 80-keV. energy; magnification 1,260

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[1] Tsien San-Tsiang, Marty, C., and Dreyfus, B., *J. Phys. et le Rad.*, **8**, 269 (1947).
[2] Tsien San-Tsiang, *Ann. de Physique*, **19**, 327 (1944).