LETTERS TO THE EDITOR

RADIATION INDUCED CROSSLINKING AND CLEAVAGE IN CERTAIN ARALDITES

EXTENSIVE experimental studies were carried out on several polymers by different workers, either to investigate specifically the radiation damage or to exploit any radiation induced change as an advantage, ever since Wigner[1] pointed out the radiation damage in materials. Aitken and Ralph[2] raported that crosslinking and cleavage would occur during the irradiation of a polymer and Van de Voorde[3] added that they would occur competitively.

In view of such interesting repoits and also since epoxy resins are widely used as adhesives and insulators in different fields, it is planned to examine the crosslinking and cleavage details by studying the variation of longitudinal and trarsverse elastic wave velocities in the Araldites of CIBA (India) Ltd., exposed to low intensity radiation. Two Araldites, Ay 103 (Plasticized) and Ay 105 (Unmodified) are selected with their corresponding hardeners for the present study. The description of the specimens studied is given in Table I. The compositions chosen relates to the specimens of these Araldites which exhibited the highest values of elastic constants as reported earlier[4-6]. The specimens are cast in the form of parallel faced plates of side 5 cm, and thickness 5 mm, and they are irradiated by thermal neutrons from a Radium Berrylium neutron source with wax as moderator. The irradiation is carried out at room temperature, under normal atmospheric conditions, in steps and each step corresponds to a time integrated neutron flux of $0{\cdot}2776 \times 10^{12}$ nvt.

TABLE I

Description of Araldite-Hardener specimens

Specimen number (as shown in graphs)	Araldite	Hardener	Composition (parts of hardener per 100 gm. of the resin)	Cure temp. °C
1.	Ay 103	Hy 956	18	55
2.	Ay 105	Hy 953 F	60	55
3.	Ay 103	Hy 951	9	55
4.	Ay 103	Hy 951	9	75
5.	Ay 103	Hy 951	9	85
6.	Ay 105	Hy 951	10	75
7.	Ay 105	Hy 951	10	85

The longitudinal and transverse elastic wave velocities are determined in these specimens, at the end of each step of irradiation and also initially, by the ultrasonic rotating plate method and the results are presented graphically in Figs. 1 and 2. The details of the method, accuracy, calculation of elastic wave velocities and hence the elastic constants were already published[7].

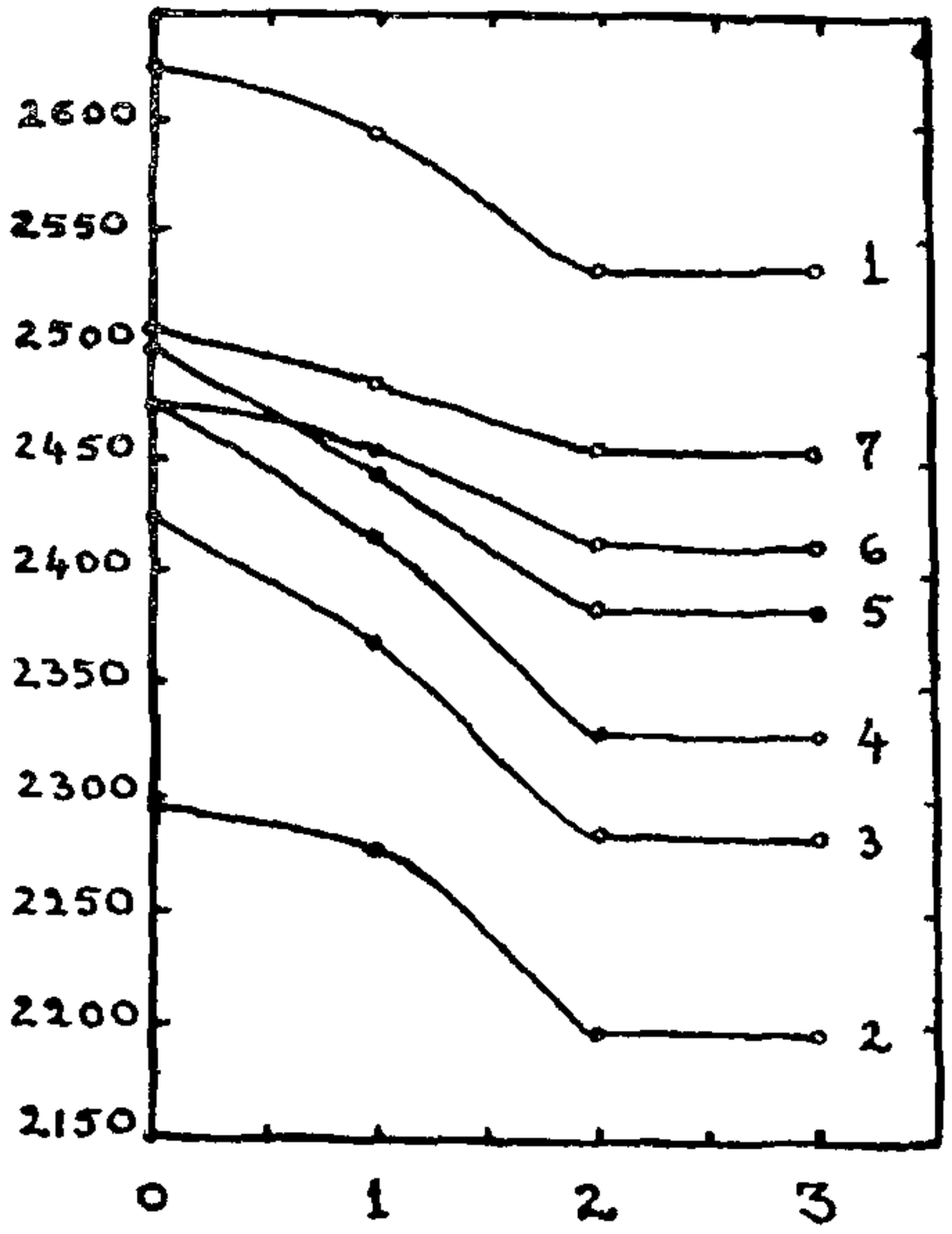

FIG. 1. Variation of longitudinal wave velocity (M/sec.) with time integrated neutron flux (nvt.).

Referring to the curves 1 to 3 relating to the specimens cured at 55° C, the longitudinal wave velocities decreased continuously from their original values upto an exposure corresponding to $0{\cdot}5552 \times 10^{12}$ nvt. But the transverse wave velocities have shown a rise in their values upto an exposure of $0{\cdot}2776 \times 10^{12}$ nvt. Thereafter they started decreasing along with the longitudinal wave velocities. Considering the first step of irradiation in detail, the tendency of fall in longitudinal wave velocities indicates a radiation induced defect in the materials leading to cleavage, while the rise in transverse wave velocities indicates the process of crosslinking. Hence, during the same interval of

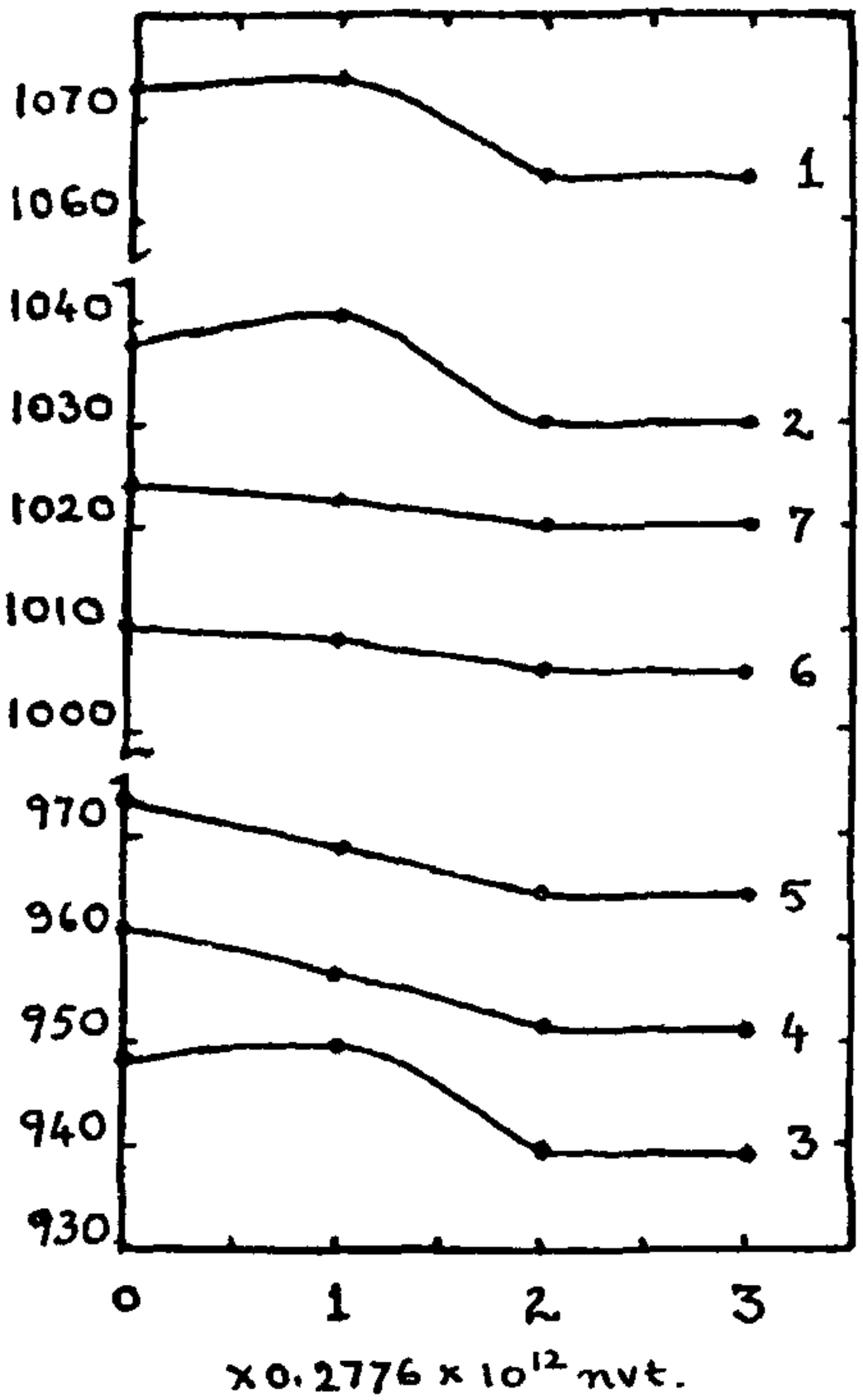

FIG. 2. Variation of transverse wave velocity (M/sec.) with time integrated neutron flux (nvt.).

low intensity irradiation, both the processes of crosslinking and cleavage occurred simultaneously. Incidentally, the result on crosslinking may be seen to be in agreement with the proposal of Bopp and Sisman[8] that the steady state concentration of the activated molecular segments to crosslink will be likely approached at low intensity of irradiation. Further, it may be observed in any of these specimens the rate of fall of longitudinal wave velocity is lower during the first interval of irradiation than during the second interval. This is due to the competition between the processes of crosslinking and cleavage during the first interval of irradiation, since the falling tendency of longitudinal wave velocity is opposed by the rising tendency of transverse wave velocity. The rapid fall of longitudinal wave velocity during the second interval of irradiation is due to the absence of such competition, since the transverse wave velocity is also falling along with the longitudinal wave velocity indicating the absence of crosslinking but only the process of cleavage in the materials. Hence, the present results set a typical example for the occurrence of crosslinking and cleavage simultaneously and competitively when a polymer is irradiated upto a certain dose.

Curves 4 to 7 relate to the specimens cured at higher temperatures. Here, both the velocities have shown a continuous decrease from their original values indicating cleavage alone with increasing neutron flux, leading to a conclusion that it is not possible to exploit beneficial effects by irradiating an Araldite specimen when it is cured at higher temperatures

A comparison of the curves 1 to 3 (Fig. 2) reveals that the improvement in elastic properties obtained due to radiation of an unmodified resin is more than that of a plasticized resin.

The above observed changes in the Araldites may be mainly attributed to the thermal neutrons with which the samples are irradiated. The radiation chemical effects produced by slow neutron caputure and recoil mechanism are well known. Since the Radium Berrylium neutron source used in this investigation produces substantial high energy gamma background, some effects due to gamma radiation may also be anticipated. However, since Araldites contain only low–Z elements, these effects may be marginal.

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FRANCK-CONDON FACTORS AND *r*-CENTROIDS FOR THE B-X BAND SYSTEM OF ScO

A KNOWLEDGE of Franck-Condon factors, *r*-centroids and the intensity distribution enables one to obtain information about the variation of electronic transition moment in a band system. In view of the above-mentioned usefulness of the data, the Franck-Condon factors and *r*-centroids have been calculated for the