# STRUCTURE OF POLYETHYLENE PREPARED BETWEEN NON-METALLIC ELECTRODES

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The X-Ray diffraction method has been applied to study the structural changes that polyethylene may undergo when prepared between glass and perspex electrodes at different temperatures. The results indicate that polyethylene does not undergo any considerable structural change under the prevailing conditions.

The properties of natural waxes are different from other existing solids in some respects[1]. The structure and properties of long chain saturated hydrocarbons have been extensively studied by Muller[2]. Bunn[3] has studied long chain polymers by X-rays and has deduced the electron density and lattice parameters of their structures. Charlesby[4] made a parallel study of a similar high polymer by electron diffraction and his results tally with those of Bunn[3].

The electron diffraction study[5] of polyethylene showed that as the temperature of the polyethylene film was raised, its structure was modified due to its tendency to form a pseudohexagonal structure. But at room temperature the presence of an amorphous phase along with the crystalline phase is indicated.

The factors which affect the transition in the structure of a polymer are : (a) temperature, (b) surface in contact with the specimen, and (c) the cooling condition of the specimen. The surface in contact has considerable effect in the case of waxes and high polymers. It is known that when a polymer film is removed from the metallic roller after its fabrication, it attains a volume polarisation[6—8]. A typical example of volume polarisation is the electret effect exhibited by waxes when subjected to heating and cooling on a metallic surface in the absence of an electric field[9]. Polyvinyl chloride when clamped on two sides and heated above the softening point and then cooled to room temperature acquires electrical charges of opposite signs[10] on the two surfaces and shows optical double refraction.

The volume polarisation has been reported for polyethylene when it is cooled in contact with a metallic disc of copper or chromium indicating some basic alteration in the structure. The literature on electretes shows that charged samples of waxes exhibit orientation when studied by X-ray diffraction. The degree of orientation does not appear to bear any relationship with the amount of charge appearing on the electretes[11].

The present investigation was undertaken to study the structural changes in polyethylene heated and solidified between non-metallic electrodes.

## EXPERIMENTAL DETAILS

Commercial polyethylene of thickness 0·18 mm supplied by ICI was used. The purity of the sample was checked by the powder pattern taken by Debye-Scherrer method using Phillips powder camera type 1024 of diameter 114·6 mm using $CuK_\alpha$ (1·54A°) radiation. Two series of samples of polyethylene of proper size and thickness (0·1×1×1 cm³) were prepared using the method developed in this laboratory by solidifying between two square plates of either perspex or glass. Seven samples were prepared between perspex electrodes from 95°C as beyond that temperature perspex starts softening. For glass electrodes fifteen samples were prepared from 90°C upto a maximum of 360°C, above which polyethylene vaporises. With a Phillips Unit type 11704 two types of X-ray diffraction patterns were taken for each sample, one with the direction of X-rays parallel and the other perpendicular to the thickness of the sample respectively marked parallel (||) and perpendicular (⊥). The variation of intensity around the circumference of diffraction rings was measured by measuring the photographic densities round the rings with a Gaertner's microdensitometer.

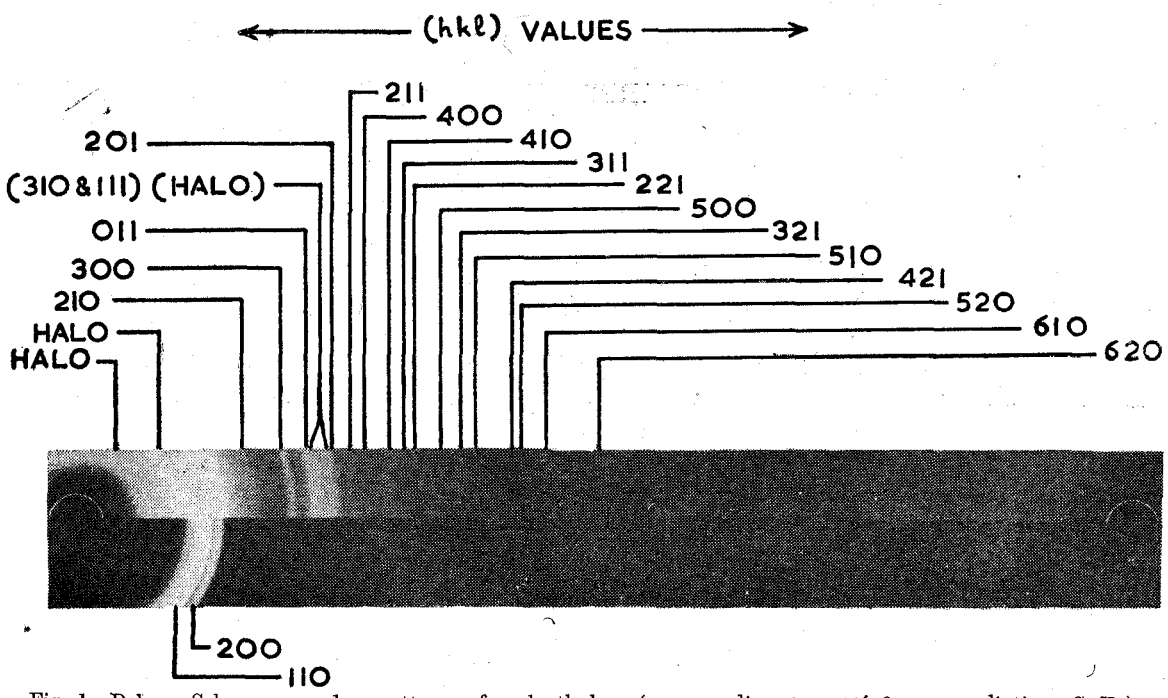


Fig. 1—Debye—Scherrer powder pattern of polyethylene (camera diameter *114·6* mm, radiation *CuKa*).

## RESULTS AND DISCUSSIONS

The powder pattern of polyethylene taken at room temperature is reproduced in Fig. 1. In this powder pattern three haloes and eighteen lines are present. The back reflections are absent which may be due to the lack of good reflecting planes. It is seen that there are only two powerful reflections i.e., 110 and 200, whereas the other reflections are weak. The 110 and 200 lines have been brought out from the negative by using the standard technique of giving different exposure to different parts of the same negative while printing. So for the density measurement only these two strong reflections namely 110 and 200 were taken. The *d* values calculated by us on the orthorhombic model for polyethylene are in good agreement with those of Bunn[3] and Charlesby[4].

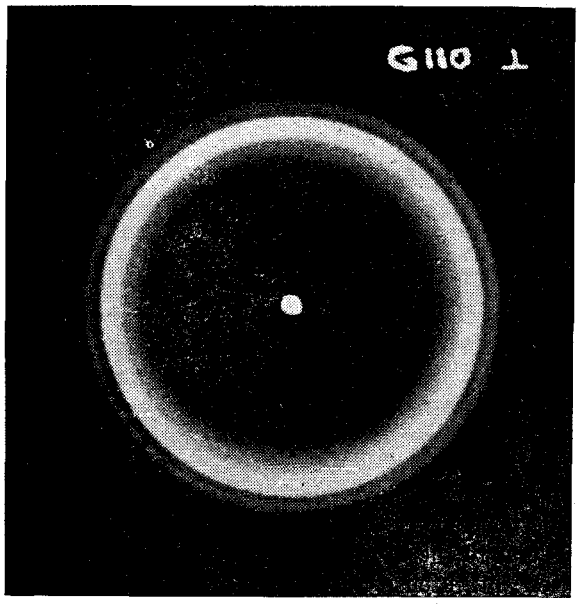


Fig. 2—X-ray diffraction photograph fo polyethylene prepared at 110°C between glass plates. X-rays perpendicular to thickness (distance r=4 cm).

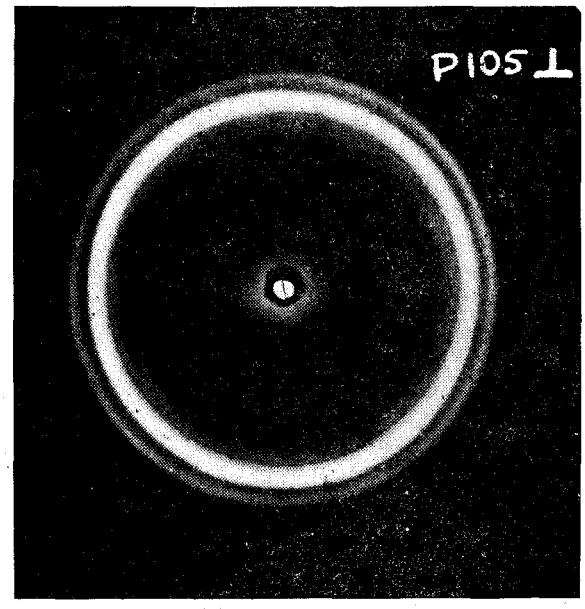


Fig. 3—X-ray diffraction photograph of polyethylene sample prepared at 105°C between perspex plates. X-rays perpendicular to thickness (distance r=6 cm).

An interesting result obtained in this study is the slightly enhanced orientation in 110 and 200 rings at 110°C (Fig. 2). When the specimen is mounted between glass plates in such a way that the X-ray beam strikes the specimen face perpendicular to the plane of the face. However, the enhancement is very small in specimen prepared between perspex plates at 105°C (Fig. 3). The intensity graph reproduced in Fig. 4 confirms this observation. A preferred orientation has been observed in the samples G 110 and P 105 (Figs. 5 and 6), being representative of the whole series.

The orientation of the observed diffraction patterns resembles the type B orientation[13]. The enhancement in the orientation is maximum at 110°C as evident from an analysis of the intensity measurements. Orientation in the (parallel) photographs has been found to be less than in the (perpendicular) photographs.

The $d$ values of all rings recorded on the photographic film obtained from different samples heated at different temperatures and between different non-metallic plates were calculated and compared. The values have been found to be consistent. Therefore, it can be concluded that the structure of polyethylene remains unaffected when it is cooled slowly between non-metallic plates from any temperature below 370°C.

## CONCLUSION

The results of our investigation indicate that polyethylene does not undergo any considerable structural change when it is cooled between non-metallic plates from any temperature below 370°C.

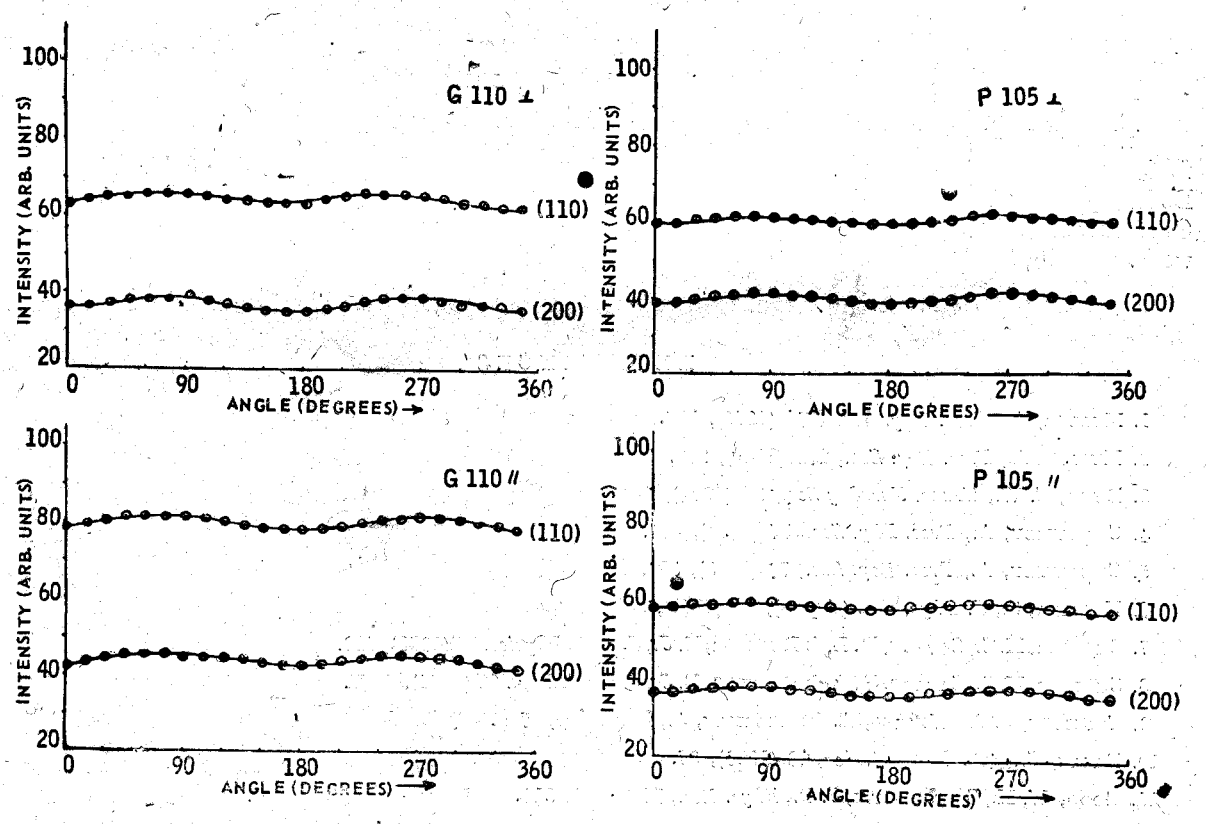


Fig. 4—Variation of intensity round the circumference of (110) and (200) diffraction rings of polyethylene heated between glass and perspex plates.

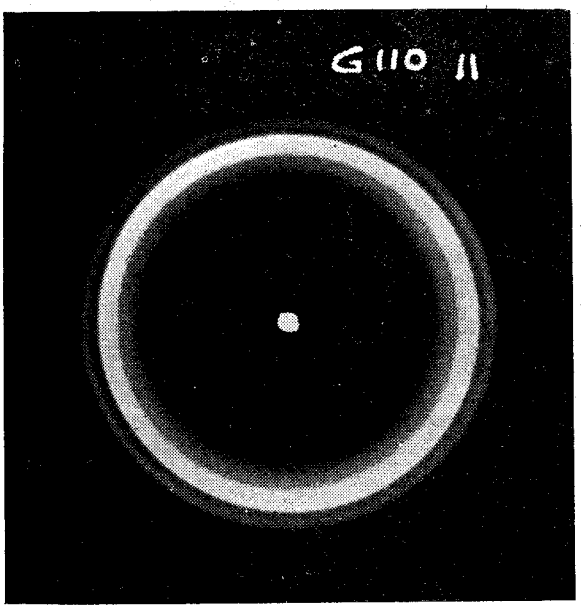


Fig. 5—X-ray diffraction photograph of polyethylene prepared at 110°C between glass plates. X-rays parallel to thickness (distance r=4 cm).

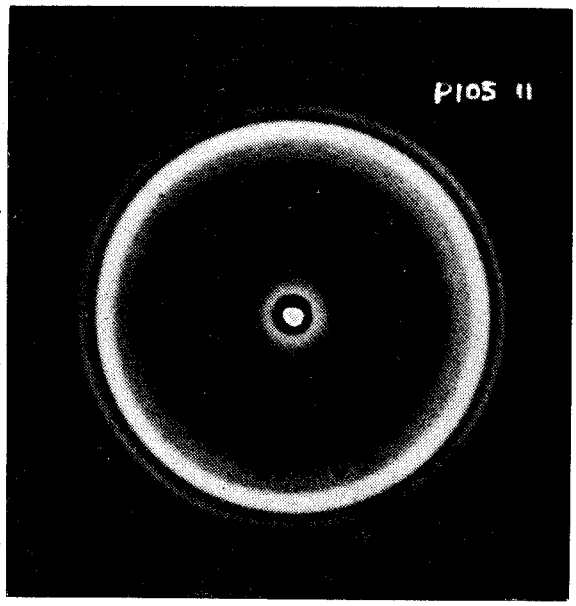


Fig. 6—X-ray diffraction photograph of polyethylene prepared at 105°C between perspex plates. X-rays parallel to thickness (distance r=6 cm).

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