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Spherulitic cracking in high density polyethylene

A recent report [1] has shown that cracks occur in spherulites of nylon 6 deformed in tension. These were observed to appear as circumferential defects in sectors of ±30° to the tensile direction on the surface of yielded bulk specimens, and were suggested to allow the formation of larger cavities leading to eventual fracture. We wish to report a similar phenomenon on the surface of HDPE deformed in plane-strain compression.

The surface of the polyethylene was prepared by etching in a beam of argon ions [2], and positive metal replicas similar to those described by Wu *et al.* [3] were made of the surface at

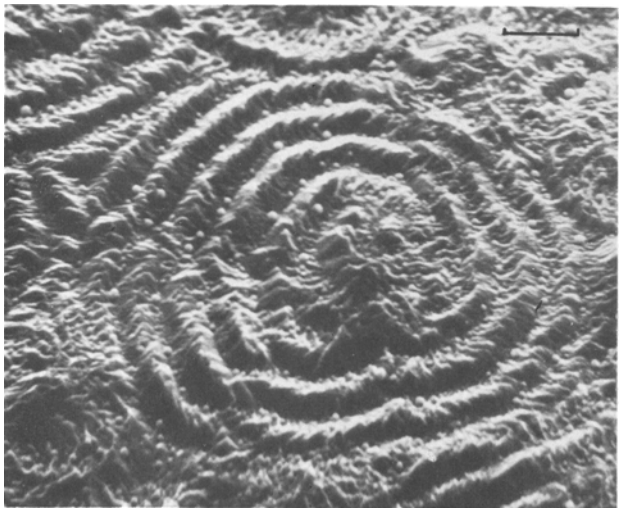

Figure 1 Scanning electron micrograph of an undeformed spherulite of HDPE. The small spheres are artefacts. Scale = 10 μm.

Figure 2 The same spherulite compressed to a strain of 30% showing deformation cracks (refer Fig. 3). Scale = 10 μm.

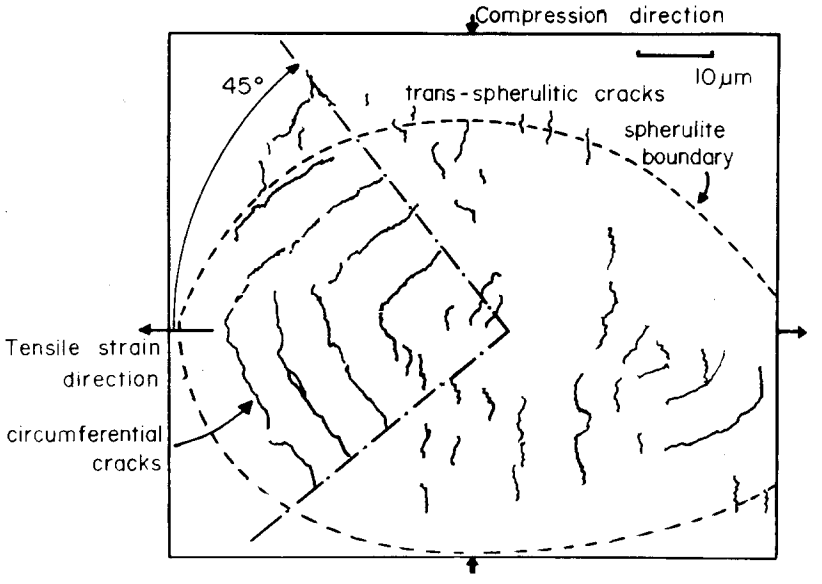

Figure 3 Diagram of the spherulite in Fig. 2 showing the type and location of deformation cracks.

various strain values. A single spherulite is shown in Figs. 1 and 2 before and after a 30% compressive strain was applied. Circumferential cracks are evident, and Fig. 3 shows the distribution of cracks within the spherulite. If the direction of tensile strain is taken as that perpendicular to the compressive strain (since plane-strain conditions hold), then the circumferential cracks are found to lie within a sector of $\pm 45^\circ$ to the tensile axis. There are also some additional cracks perpendicular to the tensile axis near the middle of the spherulite, and there is evidence to show that the cracks may also occur in the centre of bulk specimens.

The structure revealed by the ion beam shows that the cracks occur in the regions of the surface where the lamellae lie parallel to the surface as a result of their twisted morphology. It is suggested that in these areas the lamellae must be more susceptible to cracking because of their orientation, and this would explain the curvature and parallel spacing of the cracks observed here and in [1].

The similarity between the strain at which both cracking and yielding begin, about 10%, indicates that the former may provide a mechanism for the yielding and subsequent drawing behaviour of HDPE. This will be reported in full at a later stage.

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