How cracks propagate

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Introduction
In long-term loading, the lifetime of polymers is usually limited due to failure caused by slow crack growth (SCG) (fig. 1). Remarkably, applying a dynamic load increases the crack propagation rate, resulting in a decrease in lifetime (fig. 2). On this poster, a possible explanation is given for this phenomenon.

Crack propagation mechanism
A crack is regarded to be a craze propagating through the material. The mechanism behind crack propagation is schematically illustrated in fig. 2:
Due to a stress concentration at the crack tip, a), a plastic deformation zone forms, b). Since the material cannot deform in the thickness direction (plane strain), cavitation causes drawing of ligaments into fibrils, c). Breakdown of these fibrils, often stated to be caused by disentanglement and chain scission, results in growth and activation of the ligaments next to the deteriorated fibrils, d).

Dynamic loading?
A dynamic load results in stretching and compressing of fibrils, although the load is always in tension, because crack closure occurs during the minimum load (fig. 4). During crack closure the plastic zone at the crack tip is compressed, causing the fibrils to buckle and therefore faster deterioration of the fibrils. Fig. 5 shows the crack surface of a dynamically loaded polycarbonate sample, which shows the large plastic (“fibril-like”) zones and, at larger crack lengths, a fountain-like pattern due to plane stress.