FRACTURE TOUGHNESS AND CRAZING BEHAVIOUR OF POLYSTYRENE THIN FILMS WITH DIFFERENT FILM THICKNESS AND TEARING SPEEDS

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The brittle fracture commonly observed in many glassy polymers under tension is due to the formation and breakdown of crazes. The broad aim of this study was to investigate the fracture behaviour of polystyrene thin films with different film thickness and tearing speeds by the trouser leg tearing test. Critical strain energy release rate (G_c) can be regarded as a material property, often equated with toughness. The thin films, required for the tearing test, were prepared on a glass slide. The glass slide was dipped and drawn with constant speeds using a motor driven lifter through a solution of polystyrene in toluene. The rectangular shape films (40 mm × 15 mm) were cut in to appropriate size and stripped off from the substrate onto the surface of a water bath. A cut of 10 mm was made along the centreline of the sample using a scalpel blade. Then two free ends were separated at different rates using a mechanical testing machine. The study revealed that of 14 wt-% solution of polystyrene in toluene is the moderate solution for the preparation of films. This study also revealed that the G_c value depends on the tearing speeds. When the films were torn at the speed of 0.03×10^{-4} ms^{-1}, very low $G_c$value was observed. At the tearing speed of 1.4×10^{-4} ms^{-1}, a sudden increase in $G_c$value was noted and thereafter it increased slightly. For higher tearing speeds, a plateau value was observed. The most likely reason why such low force was enough to propagate the crack at very slow tearing speed is, most polymer chains may disentangle rather than scission. In contrast, when the tearing speed was increased the fracture occurred mostly through polymer chains scission than chain disentanglement. At higher tearing speeds the fracture occurred mainly through polymer chain scission. The number of polymer chain ruptured may become saturated. Therefore, there is no big change in the strain energy release rate at higher speeds.

This study also revealed that the strain energy release rate was independent of film thickness in the range of 3.9 μm to19.5 μm. Therefore, strain energy release rate in the above film thickness range was a material property. Optical microscope study shows the formation of craze areas ahead of the crack tip in a torn virgin polymer film. The craze area in torn polymer films showed Birefringence indicating that there exists a certain degree of orientation of polymer chains in these areas. Crazes are the major toughing mechanism in the polystyrene amorphous polymer.

Keywords: Crazing, Fracture toughness, Polystyrene thin films, Strain energy, Trouser leg tearing test