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Orientation and conformation changes within a craze in poly(ethylene terephthalate) as revealed by synchrotron infrared and Raman microspectroscopies

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Crazes constitute one of the most common failure mechanisms in polymers. Since crazes act as fracture precursors, they provoke severe impairment of the mechanical properties of the material. Thus, a deeper understanding of chain rearrangement occurring inside crazes is of fundamental and practical importance. In this work, we have applied synchrotron infrared microspectroscopy (SIRMS) and Raman microspectroscopy to investigate the changes in orientation and chain conformation taking place inside micron-sized crazes in poly(ethylene terephthalate), PET. These crazes developed naturally during cold drawing of the material, i.e., without making a notch in the specimen prior to uniaxial deformation.

In the case of SIRMS we have exploited the natural polarization properties of the bending magnet radiation (BMR) for the orientation analysis, thus taking advantage of the complete synchrotron flux available, which is crucial when employing small microscope apertures.[1,2]

Regarding the conformational rearrangement within crazes, we have observed a promotion of the fully-extended chain conformational structure at the expense of mainly the trans amorphous conformers of the mesomorphic phase. In addition, the conformational changes were accompanied by an increase in crystallinity of around 4 %. Overall, these results are consistent with a local strain-hardening phenomenon, although some dissimilarities have been found regarding the conformational rearrangement along the deformation neck in drawn PET samples below Tg. Our results suggest that different conformational transformation pathways could occur during crazing.[3]

References

[1] G. Ellis, G. Santoro, M.A. Gómez, C. Marco, IOP Conf. Ser.: Mater. Sci. and Eng.14, 012019, 2010.
[2] G. Santoro, I. Yousef, F. Jamme, P. Dumas, G. Ellis, Rev. Sci. Instrum. 82, 033710, 2011.
[3] G. Santoro, I.M. Ochando, G. Ellis, Macromolecules 48, 1162, 2015.

Caption (s) - Add figures as attached files (2 fig. max)

Figure 1. SIRMS results. Left: orientation parameter spatial distribution as a 2D false color map. Right: spatial distribution of the 1340 cm⁻¹ to 1371 cm⁻¹ band ratio (25x25 μm² map) and of the degree of crystallinity (20x8 μm² map) as 2D false color maps. The maps are superimposed on optical microscopy images.

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