POLYCHAR 22 World Forum on Advanced Materials, 7-11 April 2014 Stellenbosch, South Africa

CHARACTERIZATION OF THE NONLINEAR RESPONSE OF PEEK AND POLYCARBONATE: LARGE PLASTIC FLOW, ANISOTROPY OF WAVE SPEEDS, WORK TOUGHENING, AND THERMAL AGING

Mehrdad Negahban[a], Wenlong Li[a], Laurent Delbreilh[b], Jean-Marc Saiter[b], Zheng Li[c]

[a]AMME-A-TEAM, Department of Mechanical & Materials Engineering, University of Nebraska-Lincoln, Lincoln, NE, USA, mnegahban@unl.edu, nastran1945@gmail.com.
[b]AMME-LECAP, EA 4528 International Laboratory, Institute of Materials Research FED4114, Université et INSA de Rouen, Faculté des Sciences, Avenue de l'Université BP 12, 76801 Saint Etienne du Rouvray, France, laurent.delbreilh@univ-rouen.fr, Jean-Marc.Saiter@univ-rouen.fr.
[c]State Key Lab for Turbulence and Complex Systems and College of Engineering, Peking University, Beijing 100871, PR China, lizheng@pku.edu.cn.

ABSTRACT

Polycarbonate (PC) and Poly(ether-ether-ketone) (PEEK), even though very different types of polymers, are both high performance tough materials. Polycarbonate with a glass transition of 147°C is an amorphous glassy polymer at room temperature with close to no tendency to crystallize, while PEEK with a glass transition temperature of 143°C is also in its glassy range, but has in the order of 40% crystallinity. Yet, both materials exhibit similar flow behavior that induces the development of a noticeable anisotropy (directional behavior) in their wave moduli. In PC this plastic flow is accompanied by a removal of aging, aging is typically characterized by an increase in the yield stress peak followed by a drop during flow, and a substantial work toughening. This toughening is also anisotropic so that the amount of dissipation of energy during fracture strongly depends on the direction of sample orientation relative to the axis and extent of plastic flow. This work toughening increases the dissipated energy during fracture by a factor up to fifteen times the aged system. The surprising result is that the conversion from a low energy brittle fracture mode to a high dissipated energy ductile fracture mode due to plastic working is reversed anisotropically with thermal aging indicating a distortion of the shape of the cooperative rearranging region (CRR) and also directionality to its aging. A clear picture of the importance of the developed anisotropy and the anisotropic loss in toughens can be seen in the directional Charpy results and their anisotropic drop shown in Fig. 1.

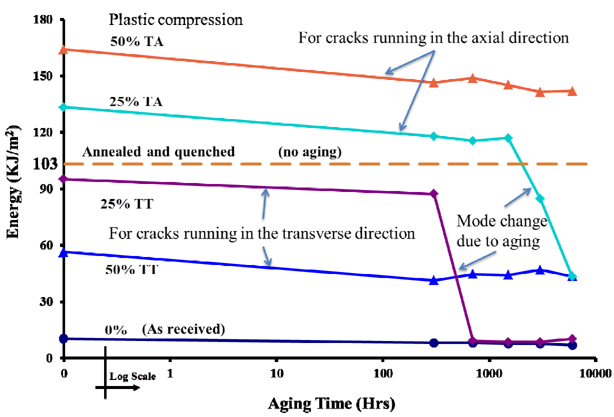

Fig. 1: Dissipated energy in Charpy impact tests for PC samples cut after plastic compression along and transverse to the direction of compression; shown after different periods of aging (Polymer Engineering and Science, 2013, DOI 10.1002/pen.23615).