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Effect of Molecular Weight Distribution on Toughening Performance of Polybutadiene in Polystyrene

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Abstract : Polystyrene (PS) and related homopolymers are brittle materials that typically fail in tensile tests at very low strains. These polymers can be toughened by the addition of rubbery particles which initiate a large number of crazes that produce substantial plastic strain at relatively low stresses. Considerable energy is dissipated in the formation of these crazes, producing a relatively tough material that shows an impact toughness of more than 5 times of pure PS. While cross linking of rubbery phase is necessary in aforementioned mechanism of toughening, another mechanism of toughening was also introduced in which low molecular weight liquid rubbers can also toughen PS when dispersed in the form of small pools in the glassy matrix without any cross linking. However, this new mechanism which is based on local plasticization, fails to act properly at high strain rate deformations, i.e. impact tests. In this work, the idea of combination of these two mechanisms was tried. To do so, Polybutadiene rubbers (PB) with bimodal distribution of molecular weight were prepared in which, comparable fractions of very high and very low molecular weight rubbers were mixed. Incorporation of these materials in PS matrix in a reactive process resulted in more significant increases in toughness of PS. In other words, although low molecular weight PB is ineffective in high strain rate impact test by itself, it showed a significant synergistic effect when combined with high molecular weight PB. Surprisingly, incorporation of just 10% of low molecular weight PB doubled the impact toughness of regular high impact PS (HIPS). It was observed that most of rubbery particles could initiate crazes. The effectiveness of low molecular weight PB in impact test was attributed to low strain rate deformation of each individual craze as a result of producing a large number of crazes in this material. In other words, high molecular weight PB chains make it possible to have an appropriate dispersion of rubbery phase in order to create a large number of crazes in the PS matrix and consequently decrease the velocity of each craze. Low molecular weight PB, in turn, would have enough time to locally plasticize craze fibrils and enhance the energy dissipation.

Keywords : molecular weight distribution, polystyrene, toughness, homopolymer
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