Streszczenie w języku angielskim

An universal method was developed to determine the elastic modulus of amorphous regions (E_a) of semicrystalline polymers. The method is based on the selective swelling (deformation) of disordered regions in a suitably chosen low molecular weight substance, leading to changes in interlamellar distances while preserving the continuity of the crystalline phase. The observed changes in structural parameters (long period) and mechanical properties (yield stress) were used to calculate local strain and stress in the amorphous regions during the swelling process.

For a model system of high-density polyethylene (HDPE)/hexane, E_a value of 39.6 MPa was obtained, which is an order of magnitude higher than the modulus of the bulk amorphous phase of polyethylene (unconstrained by crystals, 3 MPa). The observed differences were correlated with the microstructure of the interlamellar regions. The universality of the developed method was confirmed by determining E_a for other semicrystalline polymers, such as polypropylene (PP), low-density polyethylene (LDPE), and ethylene-octene copolymer (EOC), with E_a values of 50.3 MPa, 11.8 MPa, and 4.2 MPa, respectively.

The correlation between E_a and the microstructure of the crystalline component was then investigated. This study was conducted for three polyethylenes that differ in macromolecular architecture and thermal history. For HDPE and LDPE, a linear increase in E_a was observed with increasing crystal thickness (in the range of 4–20 nm). This phenomenon was linked to the activation of the α -relaxation process in the crystals. In the case of EOC samples with the smallest crystal thickness (2–3 nm), the modulus of the interlamellar amorphous phase was close to that of the bulk amorphous phase - in these materials, the α relaxation process was not observed.

The influence of deformation on the mechanical properties of amorphous regions was analysed using PP as a case study. The samples were subjected to compression in a channel die, creating materials with varying residual compression ratios (RCR). Changes in the microstructure of PP with increasing RCR were analysed using X-ray techniques and Raman spectroscopy. At low RCR values, a significant decrease in E_a was observed, primarily due to the fragmentation of lamellar crystals without substantial orientation of the crystalline or amorphous components. For higher compression ratios, where further crystal fragmentation was absent, the gradual increase in molecular orientation in both the crystalline and amorphous

components along the modulus measurement direction stimulated a significant increase in E_a . Consequently, the E_a value for the material with the highest compression ratio was about 20% higher than that of the undeformed material.

The effect of temperature on the modulus of the amorphous phase of PP was also determined. A nearly linear decrease in E_a was observed with an increase in temperature in the range of 25 ° C to 75 ° C. This reduction in modulus was attributed to changes in the mobility of macromolecular segments induced by the α relaxation process in lamellar crystals. On the contrary, a significant increase in E_a at 0 ° C (by nearly 70 MPa compared to E_a at 25 °C) was caused by proximity to the glass transition temperature of the polypropylene amorphous regions.