IVd32-002

Compressive tests of hdpe/mmt nanocomposites using dynamic mechanical analysis and split hopkinson pressure bar – experimental results and simulations

Pereira, I.M.(1); Dias, R.R.(2); Carvalho, I.C.(1); Lavoratti, A.(3); Piazza, D.(3); Zattera, A.J.(3); Soares, B.G.(2);
(1) CTEx; (2) UCS; (3) UFRJ;

High-density polyethylene (HDPE) montmorillonite (MMT) nanocomposites for high impact resistant proposes were investigated. The matrix was chosen due to its low cost, high availability, easy processability and high toughness. Even though, the MMT nanoparticle is rarely studied for dynamic mechanical properties, the nanoparticle was selected because its ability to modify and improve the static mechanical proprieties of polymeric matrices. The developed nanocomposites aim to supply the demand for materials that undergo to complex strain states including compression and elastic wave deformation. Therefore, the study focused on the dynamic mechanical properties at low and at high deformation rate using dynamic mechanical analysis (DMA) and split Hopkinson pressure bar (SHPB). Using Ansys Explicit software and Cowper-Symonds plasticity strength, a numerical modelling of SHPB tests was established and compared to experimental results. As we are interested in describing the effect of the nanoparticle, exfoliation and distribution, on dynamic mechanical properties, the materials nanomorphology were investigated using synchrotron small angle X-ray scattering (SAXS). To understand the particle role on deformation, using SAXS technique, the nanomorphology was studied before and after SHPB test. The manufactured materials are strain rate sensitive. For small deformation amplitude, DMA showed no significant change between the nanocomposites and the neat polymer. At high strain rates, at room temperature, the dynamic compressive mechanical properties presented a threshold limit at 3%. At small strains, simulation showed a good agreement with the experimental results thus at higher strain the model failed to mimic the strain hardening behaviour. SAXS results, before deformation, presented isotropic pattern for any composition, suggesting no preferential processing orientation and nanostructure randomly distributed. Nevertheless, the HDPE/MMT-3% samples, at any test condition, exhibited higher exfoliated structure. SAXS results suggested higher crystal organization and higher crystallization degree for this composition, before and after deformation, we concluded that secondary crosslinks in the polymer networks obtained for highly exfoliated particles enhanced the toughness and were responsible for the viscous behavior at high deformation rates. The numerical model shown good agreement with experimental SHPB data.