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Free-volume and mechanical properties of glass fibre reinforced polyamide 6 composites

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Increasing demands connected to various technological applications of polymer materials result in development of polymer composites reinforced with inorganic fillers. Polyamide is one of the basic engineering polymer materials. Its mechanical properties can be easily modified by using suitable fillers.

The external load in such heterogeneous polymer systems causes micromechanical deformation processes determined to a large extent by the properties of the matrix polymer. One of the factors taken into account while considering the mechanisms of inelastic deformation in amorphous polymers is free volume. The volume excess is an important factor that enables local shear transformations [1,2]. On the other hand local free volume properties of the material can be determined directly by positron annihilation lifetime spectroscopy (PALS).

The materials investigated in this study were polyamide 6 and polyamide 6 composites with 15 and 30% of glass fibre, i.e., ArtAMID6 15GF and ArtAMID6 430GF. The tensile tests were performed for the paddle shaped specimens injection moulded in accordance with the appropriate standards. The test allowed us to obtain the stress-strain curves and determine the tensile properties of the samples. The positron lifetime measurements were performed for the as received samples and for the samples in the vicinity of the break after they failed. Local free volume size exhibited some distribution which was initially narrower for the composite samples in comparison to the polyamide 6 sample and became broader as a result of the deformation. This indicates that after deformation actual sizes of the local free volume are scattered over a broader range of radii in spite of the small changes of their mean size. The deformation caused also increase of the ortho-positronium intensity in the obtained positron lifetime spectra.

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