Interfacial interactions in the nanocomposites based on thermosetting polyurethane and multi-walled carbon nanotubes with surface functionalization

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The multi-walled carbon nanotubes (MWCNTs) have excellent thermal, magnetic, electric, mechanical properties which made them the outstanding candidates as nanofillers for polymers. However in the direct mixing of MWCNTs into host matrix it is often difficult to separate agglomerated MWCNTs due to their intrinsic hydrophobic surface. The most effective approach to improve dispersivity of MWCNTs and interfacial interactions in MWCNT-polymer nanocomposites is the chemical functionalization of the outer walls of CNTs that allows covalent attachment of polymer to the nanotubes and as result high impact of nanofiller to the material’s properties. The thermosetting Polyurethane-MWCNT nanocomposites with 0.01 - 0.25 wt. % of nanofiller were prepared and studied using chemical analysis, SEM, TEM, DMA, stress-strain testing. Via acid oxidation and reduction chemical procedures hydroxyl, carboxyl, phenol functional groups to be used as cross-linking sites to the matrix were generated on the MWCNT surface. Good nanotubes dispersion in the PU matrix were observed by SEM and TEM for the nanocomposites with ultralow contents of functionalized MWCNTs (0.01 and 0.1%) whereas both individually separated nanotubes and their small agglomerates were presented in the matrix at 0.25 % nanotubes (Fig. 1). The strong dependence of nanocomposite’s glass transition and dynamic mechanical performance on variations in the nanotube surface chemistry was demonstrated: the large impact of MWCNTs was observed only at direct covalent bonding between PU matrix and nanotube lattice. The pronounced dynamic heterogeneity within the PU glass transition was registered by DMA analysis. The mechanical properties testing indicated that small amount MWCNTs (0.01%) could significantly improve the mechanical performance of the matrix. The tensile strength was increased from 2.0 Mpa to 4.0 Mpa (Fig.2). The best results were obtained for nanocomposites containing MWCNTs which covalently bounded to the matrix:the Young’s Modulus increased by 2–4 times depending on concentration of nanotubes. Conclusion: chemical functionalization of the outer walls of MWCNTs allows covalent attachment of polymer to the nanotubes that provide good dispersion in the matrix and enhancing of mechanical properties of the nanocomposites.

Fig. 1 TEM images of PU containing (a) 0.1 and (b) 0.25 wt% MWCNT-ox.

Fig. 2 Stress-Strain curves for the native PU (1) and for the nanocomposites with 0.01 (2), 0.10 (3) and 0.25 (4) wt% of MWCNT-ox

Acknowledgement The project N 6.22.7.21 of the STSTP “Nanotehnology and Nanomaterials” is acknowledged