Conducting epoxy thermosets loaded with carbon nanomaterial functionalized with ionic liquids

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Carbon nanomaterials, as carbon nanotube (CNT), expandable graphite and graphene nanoplatelets (GNP) have been recently received a lot of interest for the development of epoxy-based conducting thermosets thanks to their unique characteristics which include excellent thermal and electrical conductivities and mechanical strength. Due to their strong tendency towards agglomeration, the dispersion of these nanofillers within a polymer matrix is not an easy task. The non-covalent functionalization of their surface with some specific compounds able to physically interact with the π-electrons has received special attention because the electric characteristics of the surface are kept. In this sense, ionic liquids have been reported as an efficient dispersing agent of the fillers in a polymer matrix[1-3].

The present work discusses the effect of the functionalization of GNP and CNT with different ionic liquids on the electrical rheological and morphological properties of the epoxy – based nanocomposites. Imidazolium-based ionic liquids with different anions such as Br-, BF_4 and TFSI- were used in systems cured with methyl-tetrahydrophthalic anhydride.

Table 1 compares the results related to storage modulus, thermal and electrical conductivity of epoxy loaded with 1% of carbon nanomaterial as a function of the ionic liquid. In all systems a proportion of carbon/IL =1:5 was used.

Table 1. Main properties of epoxy networks filled with carbon nanomaterials

filler	IL	E' (GPa)	σ (S/cm)	Thermal conductivity (W/mK)
-	-	1.68	1×10^{-12}	0.100
GNP	-	1.58	2×10^{11}	0.444
GNP	$bmimBF_4$	1.86	1×10^{-10}	0.286
GNP	bmim.Br	1.32	6×10^{-12}	0.249
GNP	bmim.TFSI	1.66	3×10^{-8}	0.358
CNT	-	1.70	7×10^{-6}	0.160
CNT	$bmim.BF_4$	1.90	3×10^{-3}	0.170
CNT	bmim.TFSI	1.91	-	0.356

The addition of GNP or CNT (1phr) did not exert significant influence on the storage modulus. However, the addition of functionalized CNT of GNP with bmim.BF4 resulted in composites with outstanding modulus, due to the better dispersion achieved with this ionic liquid, as illustrated in Figure 1.

The nature of the carbon nanomaterial influenced the thermal and electrical properties of the composites. In this sense, GNP is more efficient than CNT in improving the thermal conductivity, whereas the electrical conductivity is better for composites prepared with CNT.

The presence of bmim.BF4 or bmim.TFSI as the ionic liquid resulted in better electrical conductivity due to a better dispersion state of the filler.

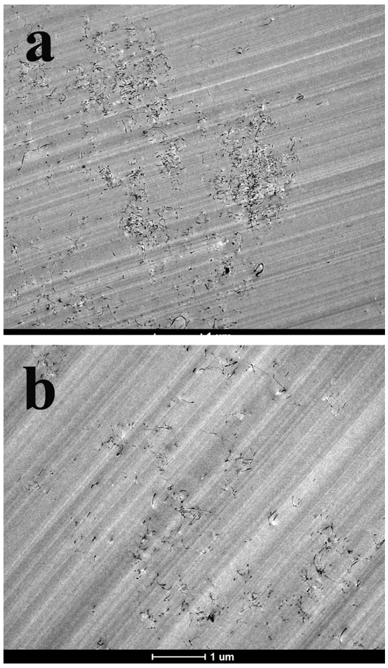

Figure 1. *Epoxy loaded with 1 phr of CNT: (a) without IL; (b) with $bmim.BF_4$.*

The functionalization of GNP with ionic liquid also resulted in composites with improved electromagnetic interference shielding effectiveness (EMI SE) in the range of 8 – 12 GHz. The reflection loss was improved by using functionalized ionic liquid. All system displayed two ranges of attenuation. The GNP functionalized with bmim.Br displayed the best reflection loss indicating better absorbing material.

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