ICAM 2009
11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25

The role of curing rate on the growth of percolated networks in epoxy/MWNT nanocomposites under an electrical field

Risi C.L.S[(1)]; Hattenhauer I.[(1)]; Coelho L.A.F.[(1)]; Ramos A.[(1)]; Pezzin S.H.[(1)*]

(1) Center of Tecnological Sciences, Santa Catarina State University – CCT, 89223-100 Joinville, Santa Catarina, Brazil. E-mail: pezzin@joinville.udesc.br

* Corresponding author.

Abstract – Due to the formation of electron percolation paths, the incorporation of small amounts (≤ 0.5 wt%) of carbon nanotubes (CNT) in polymer matrices can dramatically increase the electrical conductivity of these materials. In this work it was evidenced that crosslinking rate affects the formation of percolated paths and the final bulk electric conductivity.

Due to the formation of electron percolation paths, the incorporation of small amounts (≤ 0.5 wt%) of carbon nanotubes (CNT) in polymer matrices can dramatically increase the electrical conductivity of these materials [1,2]. Nevertheless, many factors influence the electron conductivity of the nanocomposites, including the polymer crosslinking process, which is directly linked to the matrix stiffness.

In this work, the formation of CNT percolated networks in epoxy matrix, under electrical field, varying the resin hardener (polyamine) concentration was investigated. Two levels of amine hardener concentration (ARADUR HY 956, HUNTSMAN), 20.0 and 13.3 wt%, were tested for curing a DGEBA epoxy resin (Araldite GY 251, HUNTSMAN). Multi-wall carbon nanotubes (MWCNT-CVD), provided by Bayer Baytubes® (with diameters between 5-20nm and lengths from 1 to 10μm), were firstly dispersed in acetone by sonication for 30 minutes at 225 W. 0.5 wt% of MWNT were then mixed with the epoxy resin under sonication and magnetic stirring for more 40 minutes. After the removal of the solvent by heating the system at 60°C under vacuum and magnetic stirring, the hardener was added. The epoxy/MWNT systems were then injected and cured in a metal reactor plate, under a 100V/cm sinusoidal electric field with a frequency of 1KHz (Tektronics 2221A). The acquisition of electric current was carried out using a True RMS multimeter ET-2907 (Minipa).

Figure 1A shows the electrical conductivity behavior of epoxy/MWNT systems as a function of time. Initially the electrical conductivity increases because the electric field induces a dipole moment on the MWNTs, favoring the formation of percolation networks. This behavior indicates the increase in the capacity of electron transport through the material by the growth of MWNT percolated networks. Transmission electron micrographs (Figure 1B) suggest the alignment of nanotubes under electric field. The saturation of the electric current flow is directly related to the gelation stage, when a sudden increase in temperature is also observed. The crosslinking process is responsible for the decrease in conductivity causing the disruption of percolated networks.

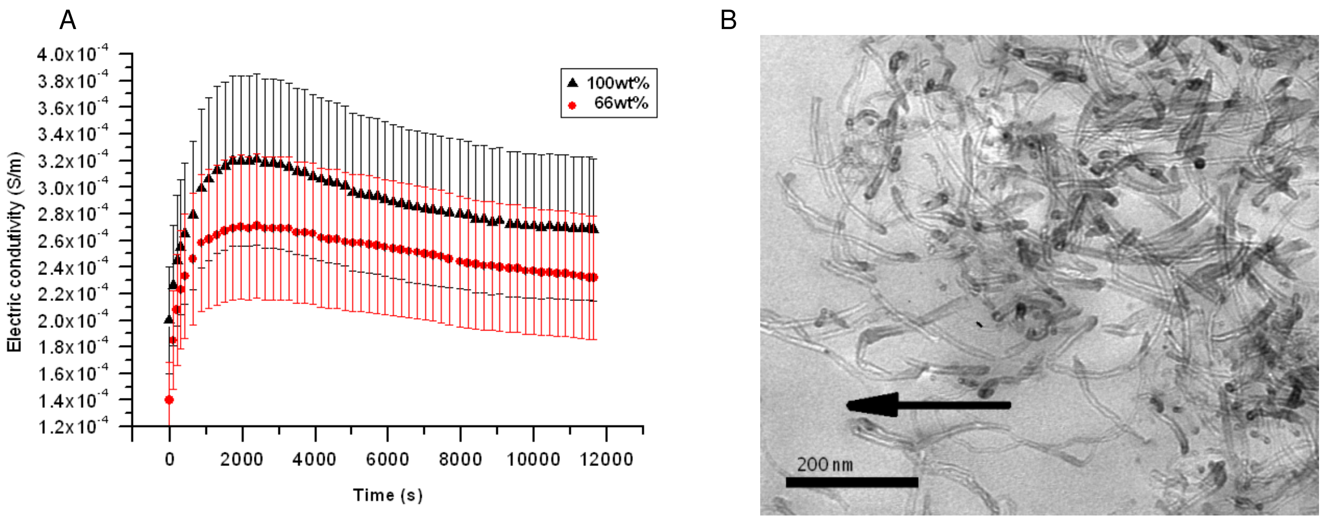

Figure 1 – A) Electron conductivity kinetic behavior of the samples with 20.0 wt% (100% of the stoichiometric amount) and 13.3 wt% (66% of the stoichiometric amount) of the curing agent. B) Alignment tendency of MWNT under electric field.

Acknowledgements: CNPq, CAPES-PROCAD, CAPES-DS e AEB-UNIESPAÇO.

References

[1] Allaoui, A.; Bai, S.; Cheng., H. M.; Bai, J. B., Composites Science and Technology, 62 (2002) 1993–1998.

[2] C.A. Martin, J.K. W. Sandler, A. H. Windle, M. K. Schawez, W. Bauhfer, K. Schulte, M. S. P. Shaffer, Polymer 46 (2005) 877-886.