MORPHOLOGICAL CHANGES IN CARBON-NANOTUBE/SILICA COMPOSITES AT DIFFERENT MATRIX POROSITIES

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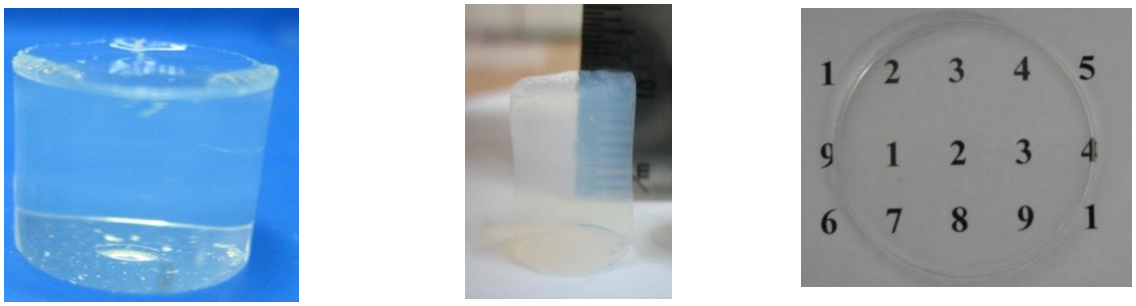
Abstract

Carbon Nanotubes (CNTs) have become very attractive fillers in various host materials, commonly in organic polymers, due to their ability to enhance electrical [1-2], thermal and mechanical properties [1] and moreover, they have shown to posses nonlinear optical properties [2-3]. However, electro-optical applications of organic polymers are limited since they lack optical quality and thermal stability. In contrast, glassy matrices have favorable properties for electro-optical applications. Sol-gel technology is a novel method for fabrication of glassy materials at temperatures below 100°C with controllable porosity, from highly porous silica to completely sealed glass [4-5]. A major issue in CNTs composite fabrication is the ability to achieve homogeneous dispersion of the CNTs within the matrix, since CNTs tend to form aggregates. This problem poses even a greater challenge in the case of sol-gel glasses, as the CNT dispersion must occur simultaneously with gelation.

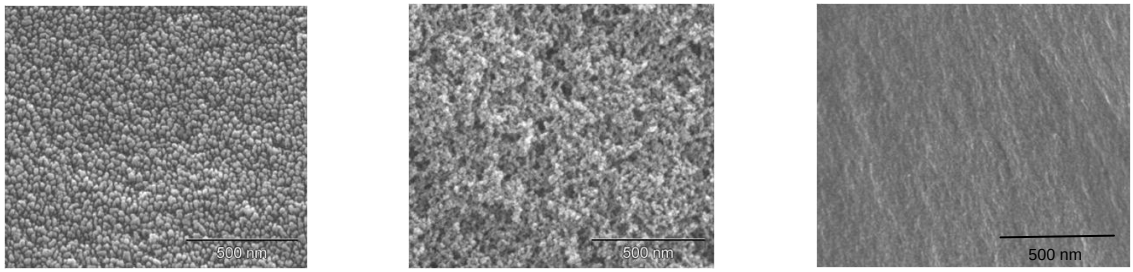
In this work we present preparation methods and some characterization of MWNT/Aerogel, MWNT/Xerogel and MWNT/Fast-Sol-Gel composites. The sol-gel technology allows fabrication of various glassy materials with variable porosity regulated by the fabrication procedure. By using a slow drying procedure at ambient conditions, semi porous silica, named Xerogel, is obtained (Figure 1a). A supercritical drying results in highly porous silica, named Aerogel (Figure 1b). While using the Fast-Sol-Gel process [6], which involves rapid drying with, elevated temperature and pressure, a non porous matrix is obtained (Figure 1c). The aforementioned materials have a characteristic surface morphology, as can be seen from Environmental Scanning Electron Microscopy (E-SEM) images given in Figure 2.

The Xerogel has a typical grained surface with small pores of about 2-3 nm diameter (Figure 2a). The Aerogel matrix, demonstrates a sponge-like surface with pores of about 20 nm diameter (Figure 2b). While the Fast-Sol-Gel matrix posses a flat and dense surface without notable porosity (Figure 2c).



(a) (b) (c)

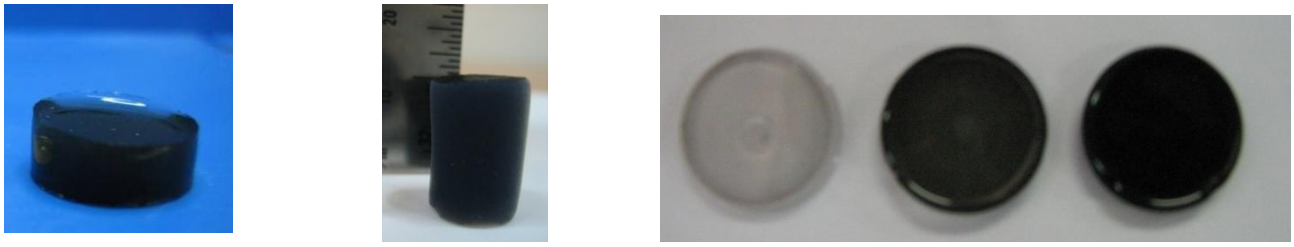
Figure 1. Optical images of glassy materials prepared by sol-gel technology differing in their porosity: (a) Xerogel, a semi porous matrix, (b) Aerogel, a highly porous matrix, (c) Fast-Sol-Gel, a hybrid organic-inorganic non porous matrix.



(a) (b) (c)

Figure 2. E-SEM images of glassy materials prepared by sol-gel technology with different porosity: (a) Xerogel, grained surface, (b) Aerogel, sponge-like surface, (c) Fast-Sol-Gel, smooth surface. The scale bar for all figures is 500 nm.

CNT/Silica composites with varying porosity were prepared by the sol-gel routes described above. We have successfully prepared CNT/Xerogel (Figure 3a), CNT/Aerogel (Figure 3b), and CNT/Fast-Sol-Gel composites (Figure 3c). For each composite we adapted a different approach to incorporate the CNTs. Finally, to characterize the morphology of the new composites we used gas adsorption analysis and electronic microscopy imaging. From the morphological results we found a correlation between the CNT concentration and the glass porosity. These aspects and more will be discussed in more details in the talk.



(a) (b) (c)

Figure 3. Optical images of CNT/Silica composites by sol-gel technology differing in their porosity: (a) CNT/Xerogel, (b) CNT/Aerogel, (c) CNT/Fast-Sol-Gel, with various CNT concentrations.

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