11th International Conference on Advanced Materials

Rio de Janeiro Brazil
September 20 - 25

ICAM2009

Starch and Carbon Nanotube Nanocomposite Thin Films

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Abstract – In this work, we have produced carbon nanotube/starch composite thin films and measured their electrical and optical properties. The films were prepared by spray coating by using a suspension of multi-walled nanotubes and cassava starch in organic solvents. The films present sheet resistance in the order of ~ kohms and transparency of ~60-80%. The resulting films are not homogeneous but rather present a granular morphology, which may be the result of a "poor" dispersion of the CNTs and/or an effect of the drying of the aerosol drops.

The application of natural polymers, such as starch, cellulose, chitosan and pectin, as eletroactive polymers has been increasingly investigated, mainly due to the low environmental impact of such materials associated with their abundance and low cost. On the other hand, recently, it has been demonstrated that thin films based on carbon nanotubes (CNT) or polymer/CNT composites may present a combination of low electrical sheet resistance and high transparency which makes them suitable for applications such as touch-sensitive displays, light-emitting diodes, solar cells, etc [1,2]. In this work, we have produced starch/carbon nanotube composite thin films and measured their electrical and optical properties.

Several methods have been explored for the formation of polymer/CNT thin films such as spin-coating, filtration and casting. However, most of them are not practical for large area deposition. Thus, in this work, we have adopted the spray coating, which is a well established large-area coating method.

As starting materials, we have used multi-walled carbon nanotubes (MWNT) produced by chemical vapor deposition in our lab and commercially available cassava starch. In order to prepare the "ink" to be sprayed, MWNT and starch powders were initially physically mixed in a mortar and then a suitable organic solvent was added. The starch has two roles: to promote the stability of the CNT suspension and to provide a mechanically supporting film after deposition. Films with different thickness were produced and characterized by optical microscopy, scanning electron microscopy (SEM), UV-Vis spectroscopy, and 4-probe conductivity measurements.

Figure 1 depicts a plot that combines the results of the optical and electrical measurements for several films. The films present relatively low sheet resistance (in the order of kΩ), indicating that a percolated network of CNTs is being formed, whereas the transmittance at 550 nm is between 60 and 80%. For this level of transparency, however, the resistance values are still two orders of magnitude larger than the best obtained for CNT films made by vacuum filtration [1]. This result probably reflects the non-optimized morphology of the films. Optical microscopy images (Fig. 2) reveal that the films are not homogeneous but rather consist of a network of percolated clusters in the micrometer range. Such morphology may be the result of a "poor" dispersion of the CNTs in the precursor suspension and/or an effect of the drying of the drops drying. In addition, in the SEM images (Fig. 3), it is observed that the MWNT and the starch phases do not mix uniformly.

Current efforts are directed to optimize the preparation of the suspensions and the spray process in order to improve the homogeneity and morphology of the films.

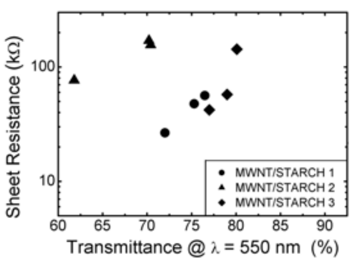

Fig. 1: Graphic of transmittance versus sheet resistance for several starch/MWNT thin films.

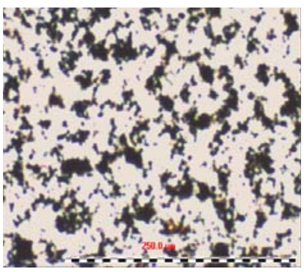

Fig. 2: Optical microscopy of a starch/MWNT thin film.

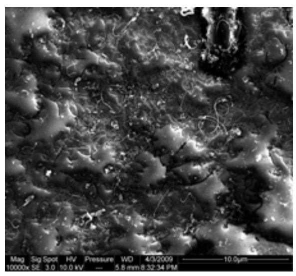

Fig. 3: SEM image of a starch/MWNT thin film.

References

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