Recent developments on the encapsulation of materials within carbon nanotubes

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Much of the wide interest in Carbon Nanotubes (CNTs) derives from their exceptional mechanical properties as well as their unique electronics since CNTs can present a range of conductive behaviours spanning from semiconductor to superconductor 1D nanostructures [1,2]. This makes them potential candidates for an incredible range of applications. Furthermore, these nanostructured graphitic materials represent an ideal model for the verification of theoretical concepts on low-dimensional physics and materials science.

Amongst the most promising applications of carbon nanotubes is their integration on nanoscale electronic circuits to build the computers of the XXI century. The CNTs tubular interior could be used to accommodate and template encapsulated materials creating a system of composite nanowires with tunable electronic properties. This has been the main driving force for much of the research effort being done by several groups accross the globe on the encapsulation of materials inside carbon nanotubes [3].

In this respect the Oxford group is a major actor in filling nanotubes with non-fullerenic materials having already shown that numerous differents substances can be put inside CNTs [4]. These encapsulated materials have furthermore been thouroughly characterised using a state-of-the-art resolution enhancement technique of HRTEM images that enables the extraction of detail near the information limit of the microscope [5]. The image restoration procedure uses of series of HRTEM images taken at different defocus which are then computionally analysed in order to calculate the non-aberrated surface exit wavefuntion resulting in a reconstructed phase image with superior resolution and inverted contrast.

The recent discovery of selective synthesis procedures for Double Walled Carbon Nanotubes (DWNTs) has finally enabled the exploration of this type of CNTs [6]. Being thinner than MWNTs yet more mechanically resistent than SWNTs, these nanotubes are believed to be the perfect intermediates between MWNTs and SWNTs presenting several advantages for applications - one practical use where DWNTs have proved superior behaviour is for field emission materials [7]. Another possible use would be in scanning probe tips. Additionally, the thought of functionalising the outer shell whilst keeping the inner shell intact could give rise to interesting technological developments.

Taking into account the availability of DWNTs and the potential of filled nanotubes, we have started a program of research on the encapsulation of various materials in DWNTs. We have been succesfull in encapsulating several materials inside DWNTs which range from metal halides to inorganic oxides.

Here we wish to present the most recent developments regarding the filling of DWNTs. For this a brief outline of the optimization of an arc-evaporation synthesis method and the development of a purification methodology for DWNTs will be made. The synthesis conditions for the filled nanotubes composites will also be described followed by the presentation of the results on the structural analysis of the encapsulated materials. A discussion will follow on possible considerations of the structure and properties of the material as well as how it compares to other examples reported.

References

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