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Synthesis of Coaxial Nanotubes of MoS_2 and Carbon

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In the recent years the discovery of carbon nanotubes by Ijima (1) has triggered a very important field of research in materials science. Indeed the many interesting properties of carbon nanotubes make them especially promising materials for different applications. In the same way, transition metal chalcogenides such as WS_2 and MoS_2 are able to generate tubular structures as a consequence of their two-dimensional molecular nature and their properties as useful catalytic materials remain under study. In the present work, we try to explore both tubular abilities to generate coaxial nanotubes in order to understand these new exotic structures.

The MoS_2 nanotubes were prepared using a nanoporous alumina template obtained by anodization of aluminum (2). A solution of $(NH_4)_2MoS_2$ in dimethylformamide (DMF) was used as solution-phase precursor. The alumina template was immersed into the solution for few seconds and then died at 70°C on a hot plate in order to evaporate the solvent. The sample was loaded into a furnace and submitted to a heat treatment in a mixture of 10% H_2/N_2 at 450°C. Once the MoS_2 nanotubes were produced in the nanoporous alumina template, the sample was submitted to a new heat treatment in a mixture of propylene-N_2 at 800°C. The MoS_2-C nanotubes were removed from the alumina template using a NaOH solution and characterized by HRTEM.

Tubular structures were found and they are showed in figure 1. The morphology of the nanotubes shows a very straight tubular structure with the typical MoS_2 contrast at the external walls of the tube. However a closer view shows the layer Carbon contrast in the internal part of the tube. The electron diffraction pattern shows the hollow structure of the typical nanotube but (002) reflection has internal structure that could be related with the chilarity of the tube. The (002) planes at the border of the tubes correspond to an average interplanar distance of about 7.4 Å instead of 6.25 Å expected for MoS_2 nanotubes interplanar distance. Hexagonal Moiré structure is also observed in the internal contrast of the tube.

Figure 2 shows a model of MoS_2 nanotube with an internal C nanotube using CERIUS2 (Molecular Simulations Incorporated). This model reproduces the contrast of the HRTEM image and is in a good agreement with the interplanar distance obtained experimentally for MoS_2 layers.

From the experimental and theoretical results we can explain the relaxation of the interplanar distance in the MoS_2 lattice due to an intercalation of C layer between two MoS_2 layers, however this remain unclear and we are still working on the characterization of this new kind of tubes.

References

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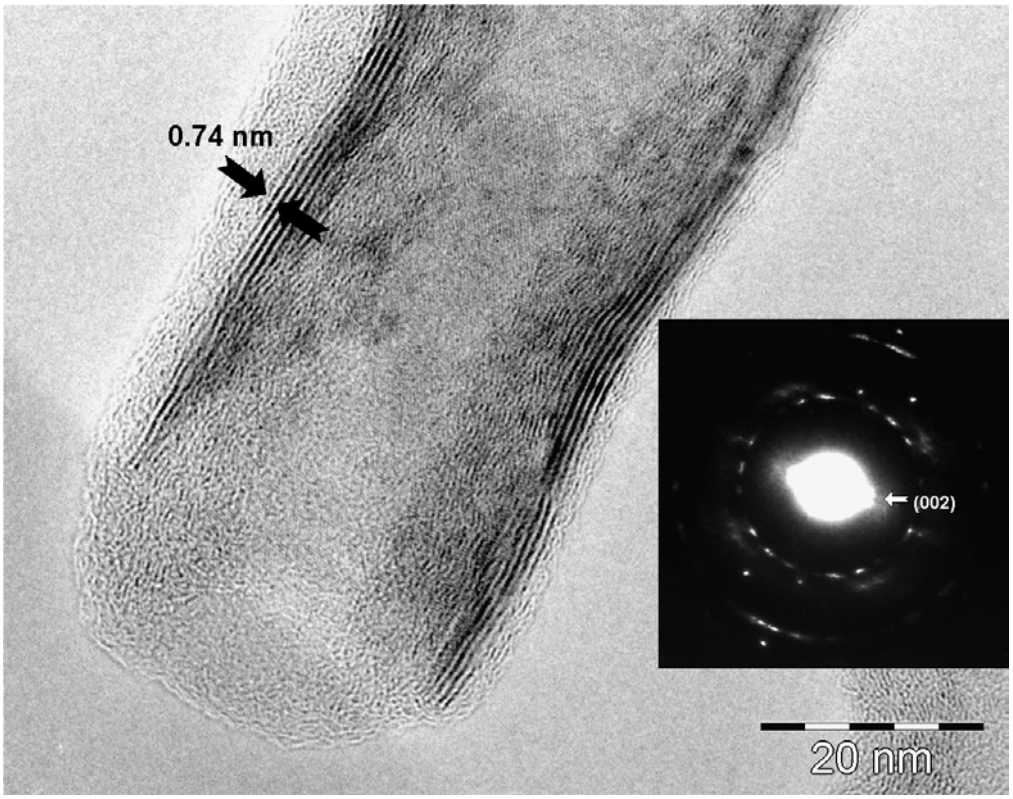

Fig.1 High resolution image of a coaxial MoS_2 – C nanotube.

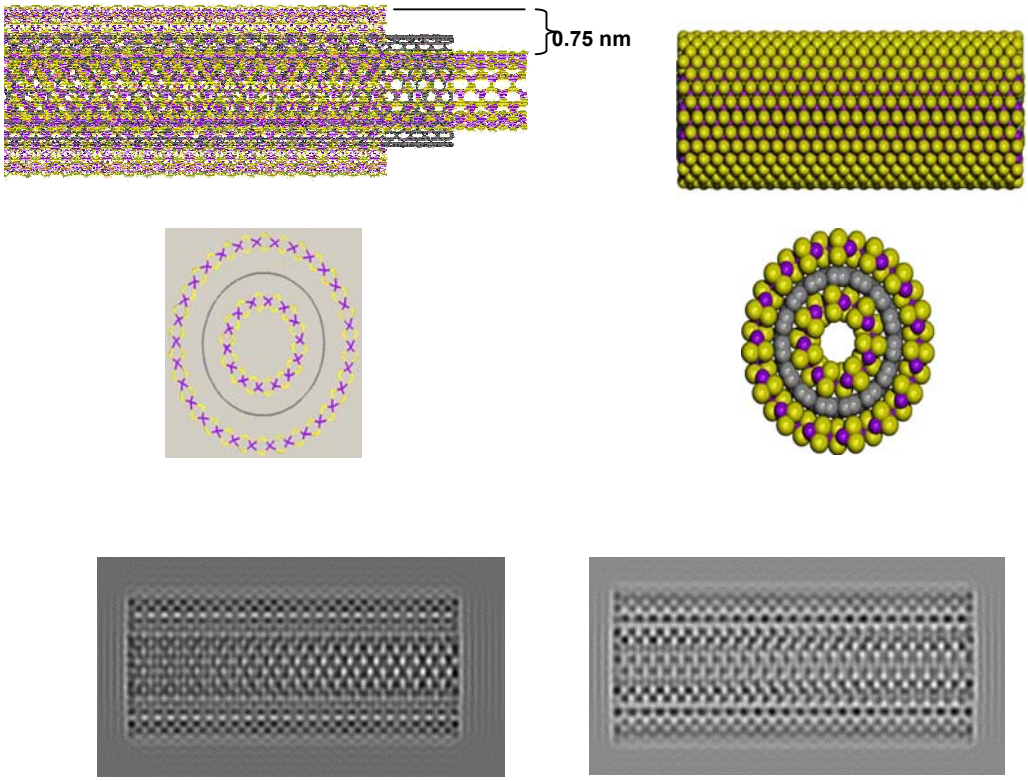

Fig. 2. Theoretical simulation of coaxial nanotubes of MoS_2 and Carbon using multislice method.

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