Controlled deposition of carbon nanotubes within a smectite nanoclay by means of a modified Langmuir-Schaefer approach

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Much of the research effort concerning the nanoscopic properties of layered materials focuses on their use as building blocks for the development of new hybrid nanostructures with well-defined dimensions and behaviour. The objective of this work is the synthesis of a new type of clay-based hybrid materials for application in gas storage/separation, heterogeneous catalysis and sensing: nanometer-sized clay platelets are sandwiched with carbon nanotubes through layer-by-layer deposition and intercalation chemistry to yield novel pillared carbon nanotube-clay structures.

A bottom-up approach (Fig. 1) was applied for the production of hybrid materials where smectite clay nanoplatelets act as the structure-directing interface and reaction media. This method, based on combining self-assembly with the Langmuir Schaefer technique [1], uses the clay nanosheets as a template for the grafting functionalized carbon nanotubes in a bi-dimensional array, and allows for perfect layer-by-layer growth with control at the molecular level.

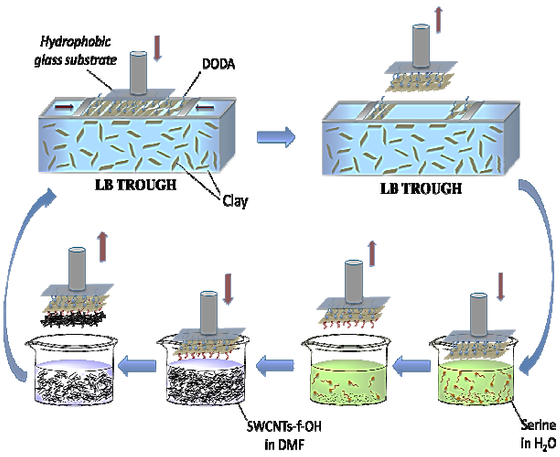

Fig. 1. Schematic representation of the synthetic procedure

Initially, CNTs were functionalized with phenol groups via 1,3-dipolar cycloaddition in a single step using commercially available reagents [2]. Sidewall functionalization provided stable dispersions of CNTs in water and other polar solvents. A dilute water solution of clay was used as subphase on the Langmuir-Blodgett deposition system while an appropriate amino surfactant (that binds electrostatically to the clay surface) was applied for the formation of hybridized organo-clay. After the horizontal lift of a hydrophobic substrate, a surface modification of the clay platelets was performed by bringing the surface of the transferred Langmuir film in contact with a second amino surfactant solution (capable of interacting strongly with the functionalized nanotubes). In the final step, the hybrid organo-clay film was lowered in the solution of the functionalized CNTs. Multilayer films were constructed by repeating this procedure.

Hybrid clay/CNT thin films deposited on various hydrophobic substrates were characterized by X-ray diffraction (XRD) and reflectivity (XRR), FTIR, Raman and X-ray photoelectron spectroscopies as well as Atomic Force Microscopy.

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