Poster

DNA-ASSISTED PURIFICATION AND SELF-ASSEMBLY OF SINGLE-WALLED CARBON NANOTUBES ON GOLD

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The properties of nanotubes, as well as their applications have been the subject of many studies since the discovery of carbon nanotubes (CNTs) by S. Iijima in 1991.[1] CNTs possess outstanding structural, mechanical, and electronic properties. Nevertheless, to achieve the full potential of the CNTs, many problems still need to be solved, including the development of an easy and effective purification procedure, the design of functionalization chemistries that result in increased solubility of the CNTs in aqueous solvents without altering their properties, and the development of an easy methodology for the attachment of aligned CNTs on solid substrates that allows their integration with other circuit elements for electronic and sensing applications. DNA offers a solution to all of the previous challenges.

Recently, Zheng and coworkers reported the dispersion of single-walled carbon nanotubes (SWNTs) in aqueous solvents by the non-covalent functionalization of the tubes with DNA molecules.[2] On the other hand, the self-assembling technique has been previously used by our group to attach aligned DNA-CNT complexes on a solid substrate.[3,4] During our functionalization experiments, we found out that the methodology used leads to the DNA-assisted purification of SWNTs. The results to be presented indicate that the used method is a straightforward, easy and time-effective route for the purification of SWNTs at room temperature. The purified SWNTs will be characterized and subsequently attached to gold substrates via the formation of self-assembled monolayers (SAMs).

Briefly, aqueous solutions of DNA-CNT hybrids were prepared by a procedure similar to the one used by Zheng and coworkers [2], where as-received SWNTs were mixed with a disulfide modified-single-stranded-DNA (RSSDNA) solution and sonicated for 1 hour in an ice-bath. The mixture was diluted to prepare dispersions with different DNA concentrations and these were centrifuged to remove insoluble material (i.e amorphous carbon, catalyst particles, etc.).

Results for the characterization of the DNA-CNT hybrids are published elsewhere.[3] The individually dispersed DNA-CNT complexes had lengths smaller than 100 nm, as determined by atomic force microscopy (AFM) and transmission electron microscopy (TEM) images. The TEM results also show ropes of DNA-CNT of larger length. Additionally, the DNA-CNT complexes were analyzed with Raman, energy dispersive (EDS) and energy loss spectroscopy (EELS), and compared to as-received CNTs. Raman spectroscopy results show a decrease in the band around 1300 cm^{-1}(D-band), which corresponds to disordered carbon, for DNA-CNT in comparison to as-received CNTs. EDS results for the DNA-CNT complexes showed the absence of the bands corresponding to Fe (catalyst particles), which were present in the as-received CNTs. Additionally, the peak due to the π^* states for as-received CNT is smaller in size and is located at higher energy compared to DNA-CNT, which is consistent with a higher content of amorphous carbon, since as the sp^3 content increases, the π^* decreases in size and moves to higher energy. TEM and scanning electron microscopy (SEM) results also demonstrate a decrease in the impurities after functionalization with DNA. These results suggest that the wrapping of the CNTs by DNA might serve as a crude purification procedure.

In addition, the DNA-CNT complexes were used to form SAMs on gold. The AFM results show SAMs containing aggregates of DNA-CNT hybrids with surface coverage up to 10 % were obtained. The DNA-CNT complexes have a small length distribution (from 40 to 100

nm) and were attached to the surface at an ~20° angle from the surface normal. An overview of the results is presented in Figure 1. These results suggest that the DNA-CNT complexes might be promising materials for the design of novel nanodevices and sensors.

References:

[1] Iijima, S.; *Nature*, **354** (1991) 56.
[2] Zheng, M.; Jagota, A.; Semke, E. D.; Diner, B. A.; Mclean, R. S.; Lustig, S. R.; Richardson, R. E.; Tassi, N. G.; *Nat. Mater.*, **2** (2003) 338.
[3] Sánchez-Pomales, G.; Morales-Negrón, Y.; Cabrera, C. R.; *Rev. Adv. Mater. Sci.*, **10** (2005) 261.
[4] Sánchez-Pomales, G.; Cabrera, C. R.; *To be submitted.*

Figures:

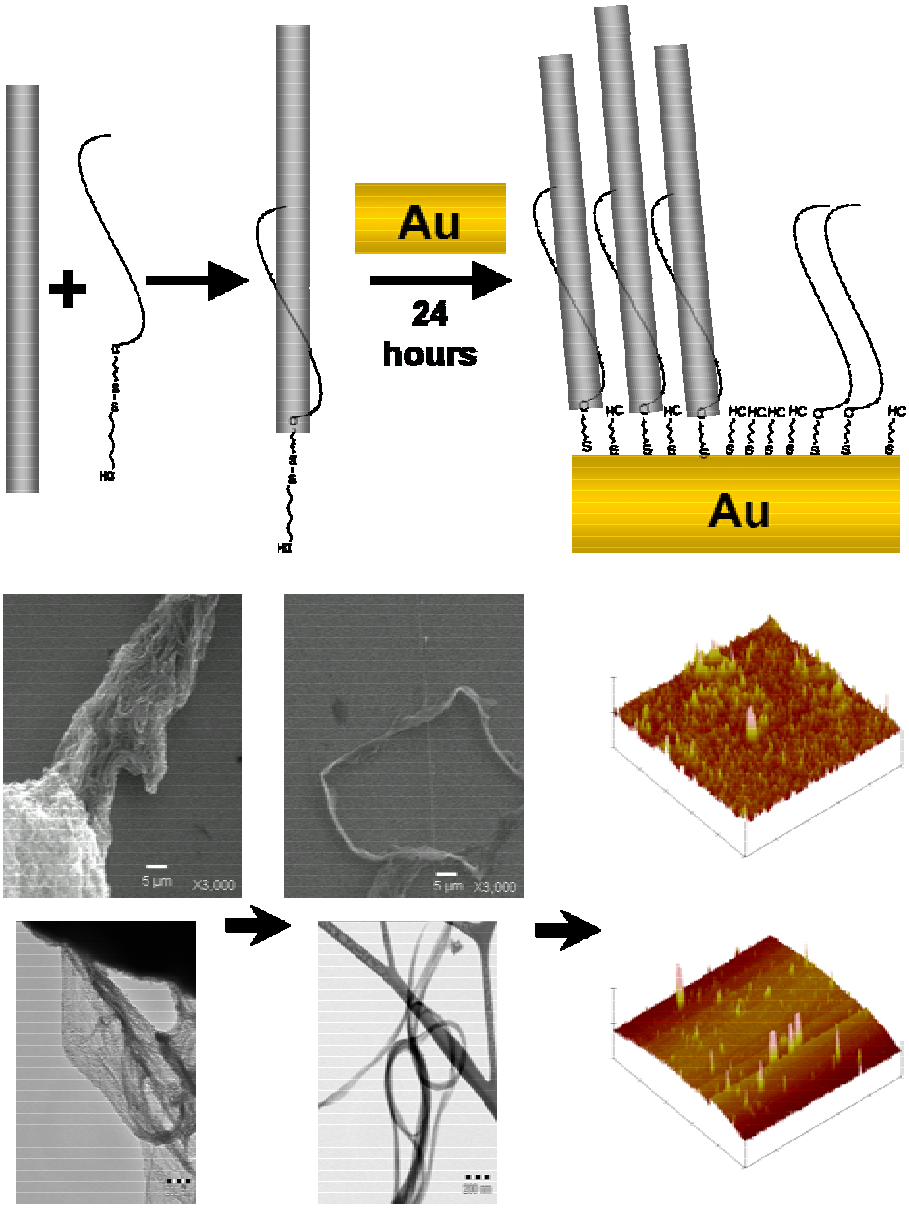

Figure 1: Overview of the methodology and the results, showing SEM and TEM images of the CNTs before (left) and after (middle) functionalization with DNA, and AFM results of the DNA-CNT SAMs on gold (right).