Carbon Nanotubes in Materials Science and Nanomedicine

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Nanometer-scale structures represent a novel and intriguing field, where scientists and engineers manipulate objects at the atomic and molecular levels to produce innovative materials for composites, electronic, sensing, and biomedical applications. Carbon nanomaterials such as carbon nanotubes constitute a relatively new class of materials exhibiting exceptional mechanical and electronic properties and are also promising candidates for gas storage and drug delivery.

However, processing carbon nanotubes is severely limited by a number of inherent problems: purification from a variety of byproducts, difficult manipulation and low solubility in organic solvents and in water are only some of these problems. For these reasons, several strategies have been devised to make nanotubes “easier” materials.

Covalent and supramolecular functionalization of carbon nanostructures are the basic synthetic techniques for solubilization and use in different fields such as donor-acceptor systems or drug delivery. The conjugation of nanotubes with various electron donors has led to a new generation of donor-acceptor nanohybrids which can be used for the development of carbon-based photovoltaic cells. Upon illumination, these systems give rise to fast charge separation and slow charge recombination. The first results are very promising and further research in this field to obtain practical conversion of light energy into electricity is not only justified but also desirable. In addition, in combination with inorganic oxidation catalysts, carbon nanotubes serve as an ideal active support in the important process of splitting of water, for the production of hydrogen as a clean fuel.

Also in biomedical applications carbon nanotubes are set to play an important role. Their use as drug delivery scaffolds and substrates for vaccines has already been demonstrated. Nanotubes functionalized with bioactive moieties are particularly suited for targeted drug delivery. In fact, not only they become less toxic, but also exhibit a high propensity to cross cell membranes. The use of carbon nanotubes as active substrates for neuronal growth has given so far very exciting results. Not only nanotubes are compatible with neurons, but they play a very interesting role in interneuron communication.

The chemical modification of carbon nanotubes is a very young field, but carbon nanotubes represent today a class of materials expected to play a significant role in innovative discoveries. Future studies will determine the opportunities as well as the limitations of such materials.