Summer 2017 URP Proposal

Modeling Carbon Nanotubes Assemblies for Delivery of Anticancer Therapeutics

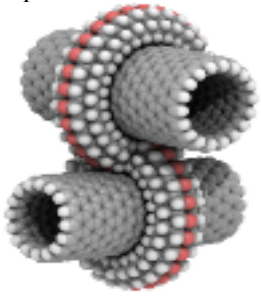
Dr. Tom Rybolt contact: Tom-Rybolt@utc.edu publications: www.utc.edu/faculty/tom-rybolt/

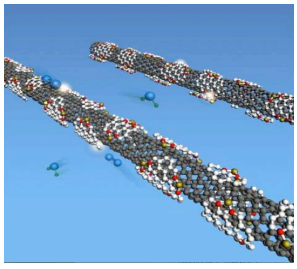
One aspect of nanotechnology (materials having at least one dimension in the 1 to 100 nm size range) and more broadly nanoscience is the possibility of devices or materials that self-assemble from individual components. Supramolecular chemistry deals with systems made of assembled molecular subunits. A supramolecular structure is something beyond a regular molecule or collection of molecules. Such structures may be held together by noncovalent forces such as hydrogen bonding or intermolecular van der Waals (vdW) forces. Since these structures are not "locked in place" by covalent bonds, they may find unique applications through both ease of assembly and disassembly. For example, carbon nanotubes (CNTs) may be used to noncovalently bind anticancer molecules for transport and subsequent delivery by release through disassembly at a target location.

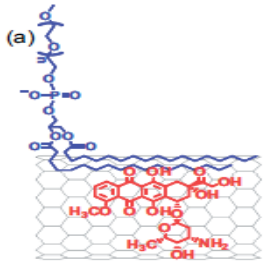
Various biotech companies are exploring "nano-enabled" technologies that include nanosized objects as one of the key components for drug delivery or biolabeling. It has been previously shown that carbon nanotubes can be functionalized for aqueous solubility by noncovalent binding of appropriate surfactants. In one study supramolecular structures were prepared consisting of CNT-surfactant along with the cancer chemotherapy drug doxorubicin held to the CNT surface by van der Waals forces. Their in vitro studies showed that the **surfactant-CNT-doxorubicin** system (see image a) could be transported into cells via endocytosis (process by which a cell engulfs and brings in some external material). The presence of the therapeutic agent doxorubicin was able then to bring about apoptosis (programmed cell death) of the tumor cells. With recognition moieties for selected cancer cell receptors added then this nano-enabled technology can target cancer or selected cells and significantly reduce toxicity to all other non-targeted cells. Currently many cancer treatments go throughout a patient's body and not just to the cancer cells needed for elimination. In H. Dai's work (2007), the CNT loaded doxorubicin was able to bring about selected cell destruction. Assembling of surfactant and doxorubicin on CNT created a supramolecular structure and disassembling inside a cell then released the cancer-killing molecule.

Our interest is the molecular modeling of doxorubicin-CNT interactions along with other of the more than 200 anticancer drugs in use. We wish to create models that represent the loading and binding energies of therapeutic molecules and compare to experimental data to be able to make predictions about effectiveness of the retention of these drugs on various size CNTs. Loading and release can depend on CNT lengths as well as CNT diameters. We wish to examine the amounts that might be loaded based on molecule size, functional groups, solubility, and binding energies calculated from our model systems. Our interest is in using molecular mechanics software to computationally build and study nanostructures of thousands of atoms.

We may also examine other structures that could be formed by combinations of carbon allotropes and molecular linkers. Carbon allotropes examples include single atom thick graphene, carbon nanotube (CNT), or C_{60} Buckyball. While the individual carbon allotropes and the individual molecules would be held together internally by covalent bonds, the larger nanostructures formed by their combination would be held together by noncovalent interactions. Pure CNT bundles and modified bundles of CNT could have unique and useful applications as filters, molecular wires, chemical sensors, transport agents, electromagnetic receivers, drug carriers, nanotechnology structural building blocks, etc. With this computational and modeling approach, we will explore new nano-architectural designs that we create.







images from varied web sources and H. Dai (2007) article