Multi-Scale Molecular Modeling of Rosette Nanotubes

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Rosette nanotubes (RNTs) are supramolecular nanomaterials formed through a network of non-covalent interactions, such as hydrogen bonds, π-π interactions, and hydrophobic effects. They form from Watson-Crick inspired guanine-cytosine (G∧C) motifs, which undergo hierarchical self-assembly to form supermacrocycles, also called rosettes. The latter self-organize into ring stacks (RSs) or helical coils (HCs). The RNTs were shown to be biocompatible and have been used in wide variety of biological applications. For example, they have been proven to enhance osteoblasts and endothelial cells growth, which makes them good candidates as coatings for orthopedic implants and vascular stents. Due to the less hydrophilic nature of the RNTs' cavity, hydrophobic drugs such as dexamethasone (DEX) and tamoxifen (TAM) can be encapsulated inside the RNT channel as shown in published preliminary studies.

Several factors of studying the RNT and its interaction with other molecules need to be considered. Surface chemistry, size, and surface area effects, media exposure, and cellular entry mechanisms are of particular interest. Several studies have suggested approaches to analyze these factors by changing the temperature, pH, and solvent system during self-assembly. These studies were verified using NMR spectroscopy, mass spectrometry, scanning electron microscopy (SEM), atomic force microscopy (AFM), transmission electron microscopy (TEM), UV-vis melting studies, dynamic light

scattering (DLS), and circular dichroism (CD). In support of these experimental techniques and to aid the design, synthesis, and characterization of RNTs, multi-scale molecular modeling techniques can be used. With new applications, ease of synthesis, and mass production of RNTs in mind, novel derivatives of G∧C modules are constantly being developed in the Supramolecular Nanomaterials Laboratory. In this study, molecular mechanics (MM), molecular dynamics (MD), and the statistical mechanical theory of solvation or the 3 dimensional reference interaction site model (3D-RISM) theory will be applied to predict the structure of various RNTs in different solvents and provide insight to the self-assembly process. The possibility of using RNTs as drug delivery vehicles for anti cancer drugs, specifically, paclitaxel (PTX) (Figure 1) and doxorubicin (DOX), will be also investigated.

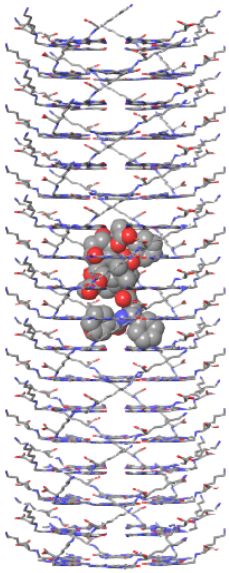

Figure 1. Model of lysine functionalized RNT (K1-RNT) with guest molecule paclitaxel (PTX).