The need for mechanical and dynamic analyses of carbon nanotubes acting as carriers or capsules for targeted drug delivery applications

S. Ceballes and A. Abdelkefi

Department of Mechanical and Aerospace Engineering, New Mexico State University, Las Cruces, NM 88003, USA

Abstract. In this research effort, we study the need for considering mechanics, dynamics, and vibrations points of view in the consideration of carbon nanotube-based targeted drug delivery systems. In this work, we consider the CNT acting as a type of capsule or carrier for solid or liquid drug particles that require a targeted release in the body to an unhealthy site, say a tumor. It is well known that since their initial discovery, CNTs have been considered for numerous applications owing to their unique chemical, material, thermal, and magnetic properties. In reference to drug delivery applications, CNTs are considered as strong candidates due to their high surface-area-to-volume ratio that allows for a high concentration of particle loading. Additionally, after a functionalization process, CNTs have increased solubility and decreased toxicity in the body: an important consideration for biological applications. Now, it should be mentioned that a majority of the studies involving CNT-based targeted drug delivery are performed heavily from a chemistry, biology, and experimental points of view. Researchers studying this topic from a dynamics and vibrations of view are often overlooking the points of view of these other researchers and thus are developing models for non-physical systems with unrealistic assumptions. Therefore, one of the highlights of this research will be the identification of realistic representations of the CNT-based system at different stages of the drug delivery process. This can include, but is not limited to, identifying the effective properties before and after functionalization and loading and developing nonlinear reduced-order models to characterize the static and dynamic stability of the system as it travels through the bloodstream and reaches the injection site. Primarily, we will focus on modeling the CNT-based system using an appropriate continuum-based shell theory that accounts for attached or encapsulated particles and size dependent phenomena using Eringen's nonlocal elasticity. We consider this is a considerable contribution to the field, especially for those that have previously studied these types of systems from a mechanics, dynamics, and vibrations point of view that have been making non-physical assumptions. Though there are over 10 existing shell theories, most of them have not been modified to include the size-dependent phenomena using Eringen's nonlocal elasticity. Depending on the CNT aspect ratio, number of walls, and wall thickness, we will adopt the appropriate shell theory and integrate Eringen's nonlocal elasticity in the model. After deriving the governing equations for the system, we will analyze what types of thermal or magnetic loading can be used to release the particles from the CNT once reaching the target site. In analyzing the results for this system, we will be able to share our points of view with experimentalists, chemists, and biologists to advance this growing field more quickly and effectively.