Biological Interactions of Carbon Nanotubes

By

Pavan M. V. Raja

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Examining Committee:

Dr. Pulickel M. Ajayan, Thesis Adviser

Dr. Omkaram Nalamasu, Member

Dr. Deanna M. Thompson, Member

Dr. Anurag Sharma, Member

Dr. Steven M. Cramer, Member

Dr. Ravi S. Kane. Member

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Abstract

Carbon nanotubes (CNTs) are unique carbon-based nanostructured materials (CNMs) possessing valuable properties and potential applications. The rapid growth of the nanotechnology industry in general, and the CNT industry in particular, points to the need to anticipate, study and prepare for the impact of CNTs on human health and the environment. This study investigates these concerns using the interactions of ***single-walled carbon nanotubes (SWNT) with mammalian cells*** and ***bacteria*** as the respective biological models.

SWNT-mammalian cell interactions: This section shall focus on a comparative study of the impact of SWNTs and other CNMs on mammalian cell growth. The SWNTs, like other CNMs, typically form polydisperse aggregates in cell culture media, which can be partitioned into micro- and nanoscale aggregates by centrifugation and/or filtration. Each grossly partitioned size regime could have its own impact on cell growth. A comparison between these two partitioned regimes of different CNMs, previously unreported, revealed that fine material derived by centrifuging and filtering out microscale SWNT aggregates induced a reduction in smooth muscle cell (SMC) growth at comparable nanomaterial dosages, implying an inverse relationship between nanomaterial size regimes and adverse effects on cell growth. A comparison between effects of the SWNTs on two adjacent cells in vascular tissue – SMCs and fibroblasts, exhibited a ~50-75% reduction in growth in both cell systems, irrespective of initial cell seeding density, in relation to high nanotube dosages (0.05 and 0.1 mg/ml) over 3.5 days These two studies demonstrate that nanomaterial-mammalian cell interactions could depend on both the nanomaterial size regime, and the type of cell system tested.

SWNT-bacteria interactions: The environmental impacts of CNTs on the environment are still relatively unknown. Evaluating their long-term interactions with a model microbial system, and benchmarking these interactions with those of other CNMs could provide a simple approximation of their impact on the environment. This section

will focus on the impact of the nanotubes on morphology, growth, and nutrient consumption by *Escherichia coli* (*E. coli)*, a commonly used microbial model. The *E. coli* were found to exhibit enhanced growth over 200 days in the presence of pristine and acid-treated SWNTs, in relation to the control and other CNMs. Significant microbial elongation was also observed in some cases in relation to only the SWNTs and not the other CNMs. The enhanced growth could have been due to nutrient adsorption by the nanotubes, rendering the nanotubes as a good microbe-compatible growth substrate. Microbial elongation has also been reported in relation to microbial life forms in conditions of chemical agents, quantum dots, and extreme temperatures and pressure.

The above results indicate that while CNTs may not adversely affect microbial growth, they affect mammalian cell growth. Therefore, it is necessary to develop precautionary steps with regard to the handling, application, and disposal of CNTs in particular and nanomaterials in general.