

METHODS IN MOLECULAR BIOLOGY™

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Carbon Nanotubes

Methods and Protocols

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Preface

Since their discovery in 1991, carbon nanotubes (CNTs) have had an enormous impact in materials science. More recently, CNTs have successfully entered the fields of molecular biology, biomedicine, and bioanalytical chemistry. Much of the increasing interest in CNTs is owed to their rare combination of high chemical stability and exceptional optical and electrical properties. Another major factor that has promoted the utilization of CNTs in biological sciences is their unique structure. In fact, their high surface-to-volume ratio and high aspect ratio render them close-to-ideal candidates as active components of biosensors, or as “nanosyringes” enabling the injection of drugs or biological markers into living cells.

Over the last couple of years, a wide variety of high-quality CNTs have become commercially available, a fact that has strongly stimulated the recent development of biology-related CNT applications. However, the obtainable material often differs in purity, agglomeration state, as well as the length and diameter distribution of the tubes, all of which have a profound influence on important parameters like the tubes’ dispersability and surface properties. It is hence highly desirable to make reliable protocols, which include as many details on the used nanotubes as possible, available to a wide range of readers coming from different fields. We strongly hope that the present collection of protocols will contribute to the achievement of common standards and help to avoid discrepancies in future biology-related CNT studies.

This book is organized into five parts. The first part focuses on CNT chemical functionalization approaches, which are required to tackle a major obstacle for using CNTs in biology and medicinal chemistry, namely their inherent hydrophobic character and the resulting lack of solubility in most solvents compatible with the biological milieu. CNT functionalization based upon covalent or non-covalent schemes has proven to be highly effective for enhancing the water solubility of the nanotubes and thus transforming their biocompatibility profile. At the same time, non-covalent functionalization often serves as the basis for further purification of the tubes via centrifugation or chromatography. The second part is devoted to toxicity studies of CNTs. In the meanwhile, it is well established that various types of functionalized CNTs exhibit a capacity to be taken up by a wide range of cells and are able to traffic through different cellular barriers. Recent studies have demonstrated that the cellular uptake of CNTs is largely independent of the nature and density of the appended functional groups, which paves the way for nanotube-tube delivery of a broad range of agents, including proteins, DNA, and synthetic polymers. The intracellular traffic of functionalized CNTs will be the topic of the third part, encompassing three different methodologies. Part 4 deals with modified CNT networks as scaffolds for cell growth, an area that attracts increasing attention due to the future perspective of designing therapies for CNS regeneration or the development of neurochip devices. Finally, Part 5 provides protocols related to CNT-based biosensors, with emphasis on amperometric detection principles. One central topic here is the use of tube coatings to enhance the selectivity of the sensor response toward specific analytes.

Stuttgart, Germany

*Kannan Balasubramanian
Marko Burghard*

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