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NANOSTRUCTURES, NANOTUBES

Dispersion of Single-Walled Carbon Nanotubes in Biocompatible Environments

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Abstract—The unique physical and chemical properties of carbon nanotubes (CNTs), including SWCNTs (single-walled carbon nanotubes), allow their applications in many fields, including biomedicine. The optical properties of SWCNTs are attractive for application in the field of nanobiotechnology compared to MWCNTs (multi-walled carbon nanotubes). An important objective of SWCNT application for biomedical purposes is obtaining homogenous dispersions characterized by bioavailability and biocompatibility. The possibility of obtaining homogenous dispersions of different types of SWCNTs in biocompatible media for further use in different biomedical experiments and applications has been investigated. The sizes of SWCNT agglomerates in prepared dispersions were measured by the method of dynamic light scattering; bioavailability was studied by dark field microscopy in BEAS-2B bronchial epithelium cells. The dispersions were analyzed for the presence of bacterial contamination. Biocompatible and bioavailable dispersions have been obtained on the basis of cell culture media and 1% bovine serum albumin, which can be used in experiments on assessing the safety of SWCNTs at biological objects but have a number of limitations in the field of biomedicine. Dispergents based on lung surfactant components, which could be used in biomedical applications (DPPC and Survanta®), did not show efficency.

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INTRODUCTION

Carbon nanotubes (CNTs) possess unique physical and chemical properties that allow them to be used in many fields, including construction, composite materials, and nanoelectronics [1]. The possibility of using CNTs in biomedicine has been actively studied in recent years [2]. The most promising is the use of CNTs as systems for delivery of various biologically active molecules into cells, including drugs [3], DNA and RNA for gene therapy [4]. Depending on the number of graphene layers that CNTs consist of, single-walled carbon nanotubes (SWCNTs) and multi-walled carbon nanotubes (MWCNTs) can occur. SWCNTs have a number of advantages due to unique optical properties, which makes them more attractive for applications in the field of nanobiotechnology compared to MWCNTs [5]. The properties of SWCNTs such as Raman scattering, near-IR photoluminescence and high optical absorption can be used in the procedures of biomedical molecular visualization in vitro and in vivo, e.g., as optical labels [5] or contrast agents [6] for detection and visualization of different biomolecules, including proteins and DNA [7]. In addition, high optical absorption of SWCNTs in the near-IR region [2] allows them to be used in photothermal therapy for cancer treatment, which is minimally invasive compared to other methods such as radiation therapy and surgery [8]. SWCNT applications in biomedicine are promising for biosensor development [7].

The serious problem that limits the use of SWCNTs in biomedicine is obtaining homogenous dispersions, where SWCNTs become bioavailable for biological systems. The bioavailability of SWCNTs in a dispersion is also an important parameter of dispersion quality in the studies of SWCNT biosafety (biocompatibility), which are an obligatory stage before entering the market of new nanomaterials. One especially relevant issue is to obtain bioavailable and biocompatible dispersions in biomedicine, where SWCNTs are introduced into humans. At the same time, the bioavailability of SWCNTs will depend on SWCNT type, functionalization, and dispersion methods [9, 10].