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The invitro evaluation of the physiochemical effects of drug loaded carbon nanotubes on toxicity

Chigumbu, Nyaradzo

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ABSTRACT

Carbon nanotubes (CNTs) have attracted significant attention as novel one-dimensional nanomaterials due to their unique structures and properties. Aggregate properties of CNTs such as high surface area, length, or chemical composition are further tailored to enhance their potential application in nanomedicine, through post synthesis chemical modification procedures. These modifications simultaneously alter their aggregate physiochemical properties and this has a direct impact on cytotoxicity of CNTs in cells. A lot of research has been done towards the toxicity of CNTs, however, there is need for results that are consistent and standardized if the application of CNTs in nanomedicine is to be a reality. Indeed the toxicology study of CNTs has been compromised by conflicting toxicity results due to lack of physiochemical characterization, regulation of the synthesis and standardized cytotoxicity assays. Herein, the effects of the physiochemical characteristics of riluzole loaded CNTs on their toxicity in neuronal cells is evaluated to elucidate a better understanding of CNTs toxicity. Furthermore the cellular uptake and overall efficacy of riluzole loaded CNTs is evaluated.

As prepared multiwalled carbon nanotubes (MWCNTs) synthesized by the Catalytic Chemical Vapor Deposition (CCVD) method were initially acid oxidized using strong acids at different temperature and reaction time so as to remove impurities whilst introducing carboxylic groups on to the surface. The drug riluzole was then conjugated to the oxidized MWCNTs via carbodiimide activated amidation. The purification and functionalization led to the isolation of physicochemical properties as characterized by the Transmission Electron Microscopy (TEM), Raman spectroscopy, BET surface area analysis and Thermogravimetric Analysis (TGA). These physiochemical properties i.e. length, surface area, degree of fictionalization and amount of chemical impurities were key determinants of the drug loaded MWCNTs' cytotoxicity.

The data from this study supports the hypothesis that physiochemical modifications of MWCNTs that occur due to the functionalization of the drug to its surfaces alter their toxicity in neuronal systems. The riluzole loaded MWCNTs with <15% metallic residue, 500-2000nm length, and high surface area (30-76 m^2/g) were found to cross the cell membrane without causing toxic effects as all the cells were viable compared to the untreated cells control. Covalently linking riluzole to MWCNTs and the consequent changes in the physiochemical properties did not lead to the generation of toxic effects in cells. Furthermore chemically binding riluzole to the MWCNTs did not deactivate the drug and reduce its ability to be antiglutamate. The identification of specific physiochemical properties governing CNTs toxicity presents the opportunity for carbon nanotube based drug delivery system designs or applications that reduce human and environmental impacts.