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Editorial

Boron Nitride Nanotubes for Biomedical Applications: Challenges Ahead

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Editorial

Introduction of nanomaterials in different areas of biology has resulted into addressing several challenging problems. While the use of nanomaterials has improved the efficiency and effectiveness of traditional drug delivery approaches, their introduction also has led into discovery of the fast and accurate imaging processes. The high surface ratio of these materials increases the interaction with their surrounding environment and improves their effectiveness in such applications. Carbon Nano Tubes (CNTs) are one of the most used nanomaterials in different bio applications including but not limited to drug delivery and transportation devices, cancer and gene therapy, tissue engineering, bio sensing and detection [1-5]. The unique combination of strength and high surface area alongside their thermal, chemical and optical properties has made CNTs to be investigated extensively for different bio applications [6].

After introduction of CNTs in 1991 by Iijima using arc discharge between two graphite electrodes [7], the search for new nanotubes has increased in order to find materials that one or more aspect of their characteristics can be enhanced for specific applications. One of such effort led to prediction of Boron Nitride Nanotubes (BNNTs) by rolling up a hexagonal BN nanosheet in 1994 [8] followed by its synthesis in 1995 using are-discharge process [9]. While both nanotubes possess comparable properties due to the similarity in their chemical structure (in BNNT, boron and nitrogen atoms substituting alternating carbon atoms in CNT), there are some differences caused by the nature of chemical bonds forming the structure of the two nanotubes (ionic bond between B and N in BNNT and covalent bond between C atoms in CNT) which makes each to be a better choice for specific application [10]. Unlike CNTs which can be semi-conductor or metallic depending on chirality and geometry of the tube, BNNTs are insulator. In terms of mechanical properties, BNNTs possess slightly lower Young`s modulus while they offer better structural flexibility and resilience under cyclic loads. BNNTs possess better chemical and thermals stability, better oxidation resistance and more importantly, better solubility. BNNTs are not only proved to be non-toxic, it is shown that the addition of these nanotubes into the Polylactide–Polycaprolactone Copolymer (PLC) as a scaffold for orthopedic applications improves both mechanical properties and cell viabilities as compared with bare PLC [11]. Due to above-mentioned properties, BNNTs can be used in many applications in biomedical fields including the one that CNTs already proven to be effective [12-14].

The unique properties of BNNTs have made them a promising material for revolutionizing different industries; however, there are few challenges that need to be addressed before any interesting results in research laboratories can be translated into commercial products for curing different diseases in human.

One of the toughest challenges ahead is finding a manufacturing method which is able to produce high quality (in terms of purity and homogeneity) BNNTs in large scale with affordable price. Currently, different techniques are being used to produce BNNTs with acceptable quality but the low production rate, high manufacturing cost, impurities and inconsistency in the product have made it difficult to rely on these methods especially for biomedical applications. Different fabrication methods have been studied by researchers for production of BNNTs including but not limited to chemical vapor deposition [15], laser ablation [16], are discharge [17], ball milling [18] and copyrolysis [13]. The majority of these procedures are based on incorporating a Boron precursor and heating at elevated temperature in presence of a certain gas as Nitrogen source. While the type of precursor and the required temperature can be altered by introducing a catalyst gas but there is still no reliable manufacturing method which is capable of producing large quantity, high quality BNNTs consistently.

Another important challenge for using BNNTs in biomedical application is their solubility in aqueousmedia. The solubility in water, homogeneity (size distribution of nanotubes) and stability of solution are some important factors which need to be considered for a given application [13]. While the solubility of nanotubes is very decisive step during their preparation for most biomedical application, making sure that they maintain their initial state in terms of solubility and even distribution is as important. The interaction between nanotubes due to vanderwal forces leads to agglomeration of tubes which in terms result in decrease in cellular up-take of BNNTs. Therefore it is absolutely essential to produce BNNTs with high solubility and stability for duration of its mission whether its drug delivery or sensing. In order to achieve this goal some avenues can be explored including use of surface modifiers through non-covalent bonding, polymer wrapping and pi-pi interactions [19,20].

Although many researchers have been conducted to investigate the different toxicity aspects of BNNTs (cyto and geno) and the results are promising compared to CNTs [20-22], it is widely believed that extensive laboratory and clinical experimentations is needed to be able to use these materials for full scale commercial applications [1]. One of the challenges in investigating BNNTs toxicity behavior is the lack of unanimity in literature where controversial results (sometimes contradicting with each other) are reported for these nanomaterials.

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Many of these inconsistencies are due to dependency of BNNTs toxicity behavior to factors such as nanotubes type, size, structure (presence of defects), preparation process and surface modification which shows the difficulty in finding a solid reliable approach for evaluating their toxicity [23-25].

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