NANOMEDICINE, VOL. 10, NO. 22 | COMMENTARY

Bioapplications of boron nitride nanotubes

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Published Online: 8 Oct 2015 | https://doi.org/10.2217/nnm.15.148

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Commentary

Nanomedicine

Bioapplications of boron nitride nanotubes

> "...we are fully confident that boron nitride nanotubes will become, within the next few years, a first-choice nanomaterial in a wide range of nanomedicine applications."

Keywords: biocompatibility • boron nitride nanotubes • nanovectors • tissue engineering

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Introduction: boron nitride nanotubes & nanomedicine

Theoretically predicted in 1994 and produced 1 year later for the first time, boron nitride nanotubes (BNNTs) have attracted an increasing interest in the scientific community for their comparable or even superior physicochemical properties to the better known structurally analogue carbon nanotubes (CNTs). BNNTs are indeed characterized by a high chemical stability, an elevate Young's modulus and tensile strength, resistance to extreme temperatures/oxidizing environments and a definite electronic behavior, independent of diameter and chirality. They have a large cross-section which makes them ideal targets for neutron irradiation; moreover, they can produce little currents when exposed to suitable mechanical stresses (direct piezoelectric effect) or undergo mechanical deformation when electric current is applied (indirect piezoelectric effect) [1].

Since our first bio-related investigations [2], all of these properties have increasingly been showing promise in the nanomedicine research field, where instead CNT applications have often failed, highlighting inadequate levels of safety. The aim of nanomedical research is indeed identifying, characterizing and exploiting novel materials for multifunctional treatment of pathological conditions while assuring consistent benefit/risk balance. Fundamental steps that must be undertaken when proposing innovative nanomaterials for medical applications consist in verifying first their stability in biological environment *in vitro*, second the lack of adverse effects on cellular viability and functions in both short and long term, and third the ability to promote recovery of anatomical and functional integrity of tissues/organs *in vivo*. To date, BNNTs have fully satisfied the first two instances for their application to human healthcare, and have recently started to show their great potential even *in vivo*, as it will be discussed in the following.

Biocompatibility of BNNTs

BNNTs are characterized by high chemical inertness and hydrophobicity, and are prone to precipitation in aqueous media. In order to use BNNTs in aqueous environments like the biological compartments, proper coatings/surface functionalization procedures are needed. First proofs of efficient, stable nanotube dispersions were achieved upon coating with surfactants, and with polymers of both natural/synthetic origin (i.e., glycol chitosan (GC) and B3 peptides). Good dispersions were also attained with phospholipids and with dendrimers, the latter being proven to mediate interaction of BNNTs with specific cell surface receptors [3].

Improvements in BNNT compatibility with biological environments were also provided by covalent modifications of the nanotube surface. In this regard, alterations of the B-N lattice were exploited, such as pending amine moieties residues from fabrication procedures [4], or functional groups have been purposely introduced on their surface, for instance hydroxyl groups upon a strong oxidation reaction [5]. These modifications were preliminary done to further reactions aiming at binding biologically relevant compounds, such as ferritin or fluorescent-track-

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