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Preface

Carbon nanotubes in medicine & biology — Therapy and diagnostics☆

This Special Issue of *Advanced Drug Delivery Reviews* is intended to highlight the wide range and multidisciplinary nature of interests that application of carbon nanotubes for therapeutic and diagnostic purposes have captured during the last decade. The articles were compiled in order to illustrate and discuss the potential of carbon nanotubes in medicine that ranges from transport of small and large therapeutic molecules to their use in tissue engineering, or as imaging and biosensing devices.

Carbon nanotubes (CNTs) have been explored in recent years as nanoscale tools for intracellular delivery, due to their ability to be internalised within cells in a variety of different mechanisms depending on their physicochemical characteristics. In addition, their large surface area offers an attractive platform for further chemical derivatization with a variety of molecules. Moreover, they have unique electrical, thermal and spectroscopic properties which further extend their potential in the detection, monitoring and therapy of disease.

The first review article in the issue by Battigelli et al. (http://dx.doi.org/10.1016/j.addr.2013.07.006) discusses how carbon nanotubes are made compatible with the biological milieu through chemical functionalization either covalently via chemical modification or non-covalently by adsorption of molecules onto the nanotube surface. The surface derivitization of CNT with small and large molecules for treatment of disease has also been suggested for drug delivery capabilities of CNTs and their ability to cross biological membranes. Next, biodegradation of CNT is considered, a critical issue for any delivery system. The eventual fate of nanoparticles following the transport of therapeutics or diagnostics to target sites will also determine their clinical adoption. Recent studies have shown that CNTs can be biodegradable in vitro and in vivo. Star and co-workers (http://dx.doi.org/10.1016/j.addr.2013.07.007) discuss the recent advances in enzyme-driven degradation of nanotubes and highlight recent in vitro and in vivo studies describing this important process.

Carbon nanotubes have shown great promise as sensors and in biomedical imaging since very early in their development, primarily due to their intrinsic properties as well as the attachment of imaging and diagnostic modalities onto their surface. These are reviewed in this issue with contributions from the Strano (http://dx.doi.org/10.1016/j.addr.2013.07.015) and Liu (http://dx.doi.org/10.1016/j.addr.2013.10.002) laboratories respectively. The next topic to be reviewed by Wong et al. (http://dx.doi.org/10.1016/j.addr.2013.08.005) is focusing on the in vitro and in vivo studies using CNTs as delivery vectors for small molecule drugs. Different chemical constructs have been built and some very interesting pre-clinical data have been published. There has been a lot of expectation on this front in the last few years, in particular towards nanotube-based therapeutics that could be utilised in oncology.

The review articles by Scheinberg et al. (http://dx.doi.org/10.1016/j.addr.2013.07.013) and Bates et al. (http://dx.doi.org/10.1016/j.addr.2013.10.003) aim to describe progress made in the use of CNTs as delivery vectors for large molecules (such as proteins and nucleic acids) for the design of nanotube-based vaccines and gene therapeutics, respectively. Interestingly, some of the most advanced pre-clinical work has been achieved using the nanotubes constructs featured in these reviews.

The last two reviews in this issue intend to cover two areas that are unique and very promising in terms of their clinical translation. First, Fabro et al. (http://dx.doi.org/10.1016/j.addr.2013.07.002) discuss the ability of carbon nanotubes to act as scaffolds for tissue engineering, in particular in the context of neuronal engineering and eventual neurological applications. They describe the state of the art in using CNTs for neuronal differentiation, growth and network reconstruction. Last but not least, the important characteristics of CNTs in the context of their unique thermal properties that have shown significant results in thermal tumour ablation therapy are featured. Singh and Torti (http://dx.doi.org/10.1016/j.addr.2013.08.001) examine the rationale of using CNTs to induce thermal ablation and review the basis for their use in hyperthermia-mediated cancer therapy.

During the last 10 years since the initial reports of nanotubes for medical purposes, hundreds of studies have appeared in the literature. Despite the fact that CNTs continue to constitute a niche technology, mired by doubts over their safety profile (that will be thoroughly addressed in the second issue of this Special Theme; http://dx.doi.org/10.1016/j.addr.2013.11.001), they offer a range of properties that were either unavailable or largely unexplored previously. This issue is not meant to be exhaustive in coverage of everything that has been published today, nevertheless representative of all the major areas of biomedical applications that have enjoyed the use of CNTs. We would like to thank all authors for their contributions in this Special Issue in *Advanced Drug Delivery Reviews* that we hope will be considered a milestone of the first decade in the utilisation of these interesting nanomaterials for therapeutic and diagnostic purposes.

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