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Nanotechnology in drug delivery: present status and a glimpse into the future

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Keywords: drug delivery • nanoparticles • nanotechnology • therapeutic delivery

Nanotechnology for drug delivery deals with an entire spectrum of nanosized materials that have certain size-dependent properties of biological and biomedical relevance. This may include the improvement of intracellular delivery and subcellular targeting or the accessing of otherwise inaccessible sites in the body by overcoming various anatomical and physiological barriers. The barriers that need to be overcome often differ depending on the route of administration being explored. There have been several advancements in this field and yet there have been concerns related to the translational potential of the technology. In this special focus issue of *Therapeutic Delivery*, we are focusing on some of the new developments, unanswered questions and future potential of nanotechnology in drug delivery. A collection of articles including experimental papers, reviews and editorials have been invited from experts in the field to cover a wide range of subtopics of importance. These address emerging concepts and the recent advances in addressing important issues, allowing us to gain perspective on the current status and the future growth and success of the field.

The contributions are grouped under three broad areas: 1) those addressing fundamental properties of nanoparticles for drug delivery 2) new promising nanotechnology platforms for drug delivery systems and 3) Issues related to application of nanotechnology for specific problems and its translation into products.

The second article, which is an Opinion piece by Sourav Bhattacharjee (University College Dublin, Ireland), deals with certain essential properties of nanoparticles for drug delivery, and provides a critical evaluation of encapsulation and the variations in its nomenclature across the literature [1]. A clear understanding and adherence to a common set of guidelines is essential to ensure reproducibility and authenticity of data.

Three different platforms of nanoparticles, which have unique applications in drug delivery, have also been discussed in this issue. Giuseppe Cavallaro *et al.* (University of Palermo, Palermo, Italy) have reviewed various mesoporous inorganic nanoparticle platforms for drug delivery [2]. Halloysite, laponite and mesoporous silicates have been compared with respect to material properties, biocompatibility and efficiency as drug carriers. Though mesoporous silica particles have been studied widely for drug delivery, very few reports exist for the other inorganic platforms. These nanoparticle platforms have the potential to be exploited in many more applications for drug delivery.

Another platform that has been covered, in a Review article by Andras Lacko *et al.* (University of North Texas Health Science Center, TX, USA), is that of lipoprotein nanoparticles [3]. This is a biomimetic nanoparticle platform with interesting properties of cholesterol and triglyceride biodistribution. Understanding the natural role of these biocompatible self-assembled nanoparticles can allow us to tailor their design for the delivery of various hydrophobic moieties and cardiovascular conditions, exploiting their intrinsic properties *in vivo*.

The third platform discussed is by Mariana Medina-Sánchez *et al.* (IFW Dresden, Dresden, Germany), and is on the topic of micro- and nano-motors [4]. These fascinating nanoscale biomachines are a new generation of drug delivery system and have the unique ability to allow mobility in complex environments that mimic the intracellular milieu. These nanomotors have the exciting potential to lead to directional motion. However, at present most

of the work in this area is in the *in vitro* conditions and much more research is required to navigate the *in vivo* environments successfully for drug-delivery applications.

This special issue also focuses on specific applications of emerging interest in nanotechnology-based drug delivery. In an Editorial, Nitin Joshi (Harvard Medical School, MA, USA) highlights the present status, shortcomings and future potential of aerosols using nanoparticles as a platform for delivering drugs in pulmonary diseases [5]. The need for specialized evaluation of nanoparticle aerosols with respect to the pulmonary surfactant system have been emphasized in order to ensure the safe and effective development of aerosols for pulmonary drug delivery. Given the widespread prevalence of respiratory diseases as a leading cause of mortality and morbidity worldwide, there is immense need for the development of effective aerosol-based platforms.

Another area of major global relevance is the emergence of antimicrobial resistance. The indiscriminate use of antibiotics has led to the emergence of drug resistance and the presence of superbugs. Therefore, there is an immediate need to address this global problem through a multipronged approach addressing the route cause, as well as with the help of newer technologies that can help address some of the issues. In this issue, Didem Sen Karaman *et al.* (Åbo Akademi University, Turku, Finland) provide a Commentary on the role of mesoporous silica nanoparticles in bacterial infections, their mechanism of action, and potential advantages over conventional antibiotic regimes in bacterial infections and resistance [6].

Additionally in this issue, a Preliminary Communication by Ya Xiao *et al.* (Jiaxing University, Jiaxing, China) focuses on liver-targeted drug delivery [7]. Here, researchers synthesized a novel nanoparticle delivery system to carry and target puerarin to liver cells, and evaluated its anti-liver ischemia-reperfusion injury effects *in vivo*.

Lastly, Khaled Greish *et al.* (Arabian Gulf University, Manama, Kingdom of Bahrain) address the important issue of translation of nanotechnology for clinical applications in a Review article [8]. This paper discusses the obstacles facing translation and provides potential approaches that may help to overcome them. This is essential for the successful translation of nanotechnology-based drug-delivery systems and their successful adoption in clinical practice.

It has been a wonderful experience collaborating to make this special focus issue possible and we hope that readers enjoy this issue just as much as we did compiling it. It is hoped that this special issue will provide a glimpse into the multifaceted aspects of nanotechnology in drug delivery and emphasize the key aspects of this multidisciplinary field. Finally, we also hope that the papers compiled in this issue will motivate and inspire many new researchers to work in this interdisciplinary area and contribute to the success of new research developments and their translation to clinical practice.

Financial & competing interests disclosure

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No writing assistance was utilized in the production of this manuscript.

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