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EDITORIAL BIOMATERIALS AND TISSUE ENGINEERING

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Nano LIFE is a new journal for synergized nanotechnology and biomedical sciences, which, in its Chief Editors' words, "will speak to researchers in a broad spectrum disciplines including materials, chemical, biological and medical sciences, and engineering".[1] When we were invited to organize a special issue for *Nano LIFE*, we pondered over the theme. Considering popular research topics in the biomedical field and also our respective research experience, we quickly decided to produce a thematic issue on "Biomaterials and Tissue Engineering". Once the theme was decided, we sent emails to various parts of the world, inviting leaders of established groups to consider contributing a research article or a review paper from their group to the thematic issue. The response was good; with the strong support from our friends and fellow researchers on several continents, we are able to gather a diverse collection of fine papers for the journal *Nano LIFE*. All submissions underwent *Nano LIFE*'s normal peer-review process and only those that attained a standard of publication for well-regarded international journals were accepted for this thematic issue.

Biomaterials is now a well-established discipline, which underpins the development of many medical treatments and health technologies. Biomaterials include metals, polymers, ceramics, and composites, which are used in different forms (e.g., nonporous structures, porous scaffolds, thin coatings, etc.) in the biomedical field. With the growing interest in nanoscience and nanotechnology in recent years, research supported by industry and government in nanobiomaterials has been gathering momentum. The benefits of employing novel nanobiomaterials in healthcare can be enormous, and we are only at the beginning of an exciting nanobiomaterials era. Since its emergence 20 years ago, the field of tissue engineering has made significant progress. Biomaterials and porous scaffolds, a pillar of tissue engineering, have been the focus of many research groups in the international biomaterials community. The advantage of using nanobiomaterials in the tissue engineering field is obvious, and the use of nanocomposite materials for bone tissue engineering has been intensively examined. The scope of this thematic issue has gone beyond the traditional biomaterials application areas. For example, materials for gene therapy increasingly attract the attention of researchers; articles on this topic are included in the thematic issue. Other topics such as nanostructures for biosensing and nanoparticles for theranostics are also included.

The articles in this thematic issue are grouped under different topics, including nanosized materials for diagnostic and therapeutic applications; nanoporous materials for biosensing; materials, nanoparticles, and microparticles for gene therapy or biomolecule/drug delivery; tissue engineering scaffolds; dry-powder biomaterials library fabrication; as well as metal surface modification and patterning. The thematic issue starts with a review paper on graphene-based nanomaterials. In this review paper, Bao *et al.* summarize the recent progress involving biomedical applications of graphene and graphene-based materials in selected areas.[2] Two areas of application are given particular attention: biosensing and gene therapy. They point out that despite the numerous reports that contain exciting results, the use of graphene for biotechnology applications is still at its infancy. Opportunities do exist in the biomedical field for graphene and graphene-related nanomaterials; however, great challenges lie ahead. The second article is also a review paper in which Li and Wang examine wet-chemical synthesis and biomedical applications of highly branched metal nanoparticles.[3] These monometallic, bimetallic, or multimetallic nanoparticles, due to their unique physicochemical, optical, and other properties, can be used for the new generation of theranostics, which have great potential for applications in oncology and other medical fields. The successful development of various theranostic devices based on metal nanoparticles will enable early and accurate diagnosis together with specific and efficient treatment, providing significant benefits to patients and the healthcare system. Nanoporous membranes are now used for many biosensing applications, including DNA hybridization, cancer marker detection, single-molecule analysis, and bacteria detection. Yang and Tan have conducted a timely review on nanoporous membrane−based biosensors.[4] Surface functionality for bioanalyte immobilization, biocompatibility, mechanical and chemical stability, and anti-biofouling capability are vital for successful biosensing applications of nanoporous membranes. Cho at Seoul National University, Seoul, South Korea, has conducted considerable research into gene therapy; he and his co-authors have written a review on a group of nonviral vectors, degradable polyethylenimine derivatives.[5] In this article, they give an account of recent development of degradable polyethylenimine derivatives as non-viral vectors and summarize the transfection efficiency of DNA and silencing efficiency of small interfering RNA based on the kinds of degradable linkage between low-molecular-weight polyethylenimine and crosslinking agents.

The next three research articles form a group of papers on drug delivery. For achieving controlled release of drugs, Lim's group at Nanyang Technological University, Singapore, adopted a strategy of encapsulating drug-containing E2 protein cages in poly(lactide-*co*-glycolide) (PLGA) microspheres.[6] The influence of fabrication parameters on microsphere morphology and E2 protein release profile were studied. Using their fabrication method, they believe that E2 protein is not dissociated upon encapsulation within PLGA microspheres. Cai's group at the Chinese Academy of Sciences, Shenzhen, China, fabricated and studied poly(lactide-*co*-glycolide)-lecithin-poly(ethylene glycol) core-shell nanoparticles for delivering chemotherapeutic agents.[7] They demonstrate that particle size, surface charge, and surface functional groups were easily tunable in a highly reproducible manner by varying the formulation parameters. *In vitro* studies showed cell targeting of drug-loaded nanoparticles. Ho and her co-workers investigated an electrospraying method to produce chitosan nanoparticles for drug delivery.[8] They found that the molecular weight of chitosan significantly affects the size and morphology of the chitosan particles. Using indomethacin as a model drug, the *in vitro* drug release profile of an electrosprayed indomethacin−chitosan delivery system was established; an initial burst release of indomethacin was noted in this study.

The next three papers form another group, focusing on the design, manufacture, and performance of tissue engineering scaffolds. Lendlein *et al.* produced a review paper on scaffolds with hierarchically organized structures.[9] This review highlights current achievements involving hierarchically organized scaffolds with respect to scaffold preparation and morphological characterization. With their own experience and expertise, Lendlein and co-workers believe that utilizing multifunctional stimuli-sensitive biomaterials that can react to changes in the biological environment has great potential for scaffold development. Wang and his co-workers at the University of Hong Kong have investigated various tissue engineering materials and different scaffold fabrication technologies. In the paper by Tong and Wang, they presented their research that involved use of negative voltage electrospinning (NVES) to construct nanofibrous scaffolds.[10] Various biopolymers (gelatin, chitosan, PLGA, and polybutylene terephthalate) were used in the investigation; their work indicates that NVES may not be applicable for some polymers. The significance of this research is that negatively charged fibrous scaffolds, which have potential use in tissue engineering, can be obtained directly through NVES. From the same research group, Duan *et al.* report on research involving using selective laser sintering (SLS, a rapid prototyping technology) and an osteoconductive nanocomposite to form bone tissue engineering scaffolds.[11] They demonstrate that SLS-formed nanocomposite scaffolds with a loading of bone morphogenetic protein-2 could enhance the proliferation of human umbilical cord−derived mesenchymal stem cells as well as their alkaline phosphatase activity; their work indicates the effectiveness of this bone tissue engineering strategy.

For high-throughput biomaterials discovery and screening in the bioceramics field, Li and Yang investigated the use of an ultrasonic dry-powder microfeeding system (dry-powder printer) to fabricate hydroxyapatite and β-tricalcium phosphate libraries.[12] Their work demonstrates the feasibility of dry-powder biomaterials library fabrication. It is shown that the ultrasonic dry-powder microfeeding system could dispense as low as 0.1 mg per dose of nanosized bioceramic powders. A few different library layouts were designed and fabricated, indicating the potential of this technology to serve as a platform for high-throughput experiments.

There are three papers on the topic of coatings for implantable metals in the thematic issue. The first paper is from Wang's group at University of British Columbia, Vancouver, Canada, which presents a comparative study of alendronate-containing coatings that are formed on porous tantalum using two different methods.[13] The effects of the two coatings on new bone formation and implant fixation were investigated using a rabbit model. The two types of coatings exhibited different *in vitro* alendronate release rates and different *in vivo* implant fixation results. Huang's group at University College London, UK, used a template-assisted electrohydrodynamic atomization (TAEA) spraying technique to form nanosilicon-substituted hydroxyapatite patterns on titanium substrates.[14] *In vitro* experiments show that nanosilicon-substituted hydroxyapatite pillars or tracks promote the attachment and growth of osteoblast cells. TAEA processing has great potential for producing new bioceramic coatings with a desirable surface topography for biological performance in medical implants. Thian and his co-workers at the National University of Singapore, investigated the drop-on-demand coating technique for metal implants.[15] With a drop-on-demand micro-dispensing system, they produced a functionally graded hydroxyapatite−titanium oxide coating on titanium using titanium oxide as the "bond coat". Through optimizing processing parameters, coatings with uniform thickness and graded composition could be achieved.

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