Hindawi Publishing Corporation
International Journal of Polymer Science
Volume 2010, Article ID 148513, 2 pages
doi:10.1155/2010/148513

Editorial

Polymeric Biomaterials for Tissue Engineering Applications

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Received 24 August 2010; Accepted 24 August 2010

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The interdisciplinary field of biomaterials and tissue engineering has been one of the most dynamic and rapidly expanding disciplines during the past two decades. Polymers are especially useful in this area mainly because of their flexibility in chemical structure engineering and physical property design. Many noncytotoxic and biodegradable polymers can be fabricated into medical devices for numerous applications, including tissue replacement, drug delivery, cancer therapy, and nonviral gene therapy. As a result of rapid growth of polymer science and engineering in recent years, synthetic and supramolecular strategies have been developed for polymeric biomaterial exploration. By tuning polymer structural parameters and morphologies at different length scales, controllable physical properties for satisfying diverse clinical needs have been demonstrated. Polymeric biomaterials can also be incorporated with natural materials and inorganic nanoparticles to achieve novel, unique, and synergetic properties for better performance. Biomimetic and intelligent polymeric systems have also been investigated to advance our material design strategies.

Cell/tissue-material interactions are crucial in applying biomaterials to clinical uses. There are major factors such as surface chemistry, topology, and mechanical cues to influence cell responses to biomaterial substrates collectively. Through rational design of polymer surface properties, cell-material interactions such as cell adhesion, spreading, proliferation, migration, and differentiation can be modulated. Vesicular colloids self-assembled from amphiphilic block copolymers can be used as carriers for delivering drugs to desired targets. Polycations such as polyethylenimine can be used as nonviral gene delivery carriers. Polymer scaffolds with predesigned geometries and nanometer-scale or micron-scale structural parameters can be fabricated for bone, nerve, cardiovascular, skin, ligament, and cartilage tissue engineering applications.

The aim of this special issue is to highlight recent significant progress in the synergy between material design strategies and biological evaluations through contributions from active researchers in the field. This issue covers various topics related to biomaterials for tissue engineering applications. Six original research papers and three reviews are included to stimulate the continuing efforts in developing novel polymeric systems, which are crucial to improve our understanding on cell/tissue-material interactions and biomedical applications.

Combination of naturally derived and synthetic polymers is an efficient way to produce biomaterials that integrate excellent biocompatibility from the former component and good processing properties from the later. All of the six original research papers demonstrate the importance of this approach. The first three papers describe different polymer composites containing natural polymers and focus on their mechanical properties. In the first paper (ID 270273), X. Zhu et al. report the effects of composite formulation on the mechanical properties of biodegradable poly(propylene fumarate) (PPF)/bone fiber scaffolds. PPF is an unsaturated linear polyester that can be cross-linked. Mineralized bone fibers (MBFs) were from allograft bone while demineralized bone fibers (DMFs) were obtained from acidification of MBF. In this study, the authors studied the effects of various

parameters such as PPF molecular weight, incorporation of bone fibers (MBFs or DBFs), and the amounts of cross-linker, initiator, and porogen on the ultimate strength and compressive modulus of the composite scaffolds. In the second paper (ID 369759), Z. Wang et al. report chitin fiber enhanced chitosan 3D composite rods. In this study, chitin fiber/chitosan composite rods with a layered structure were constructed using an *in situ* precipitation method. The bending strength and modulus were increased by 23.6% and 26.8% by adding 0.5% chitin fiber to the chitosan matrix. In the third paper (ID175264), R. Khanna et al. report the *in situ* swelling behavior of chitosan-polygalacturonic acid/hydroxyapatite nanocomposites in cell culture media. Nanocomposite films were soaked in cell culture media, and *in situ* characterization was performed to demonstrate that nanoscale elastic modulus decreased by ~2 GPa over 48 days.

Electrospinning and salt-leaching are widely used techniques for the fabrication of porous structures for tissue engineering applications. In the fourth paper (ID 436178), B. Wulkersdorfer et al. applied a combined electrospinning/particulate leaching technique to fabricate biomodal porous scaffolds. In this technique, sucrose particles were mixed with poly(glycolic acid) and electrospun into fiber mesh. Deep cellular penetration was found in these biomodal porous scaffolds while no cellular penetration was found in the spun scaffolds without using sucrose particles.

In cardiovascular tissue engineering applications, surface modification is an effective approach to improve the blood compatibility of the polymers such as polyurethanes (PUs). In the fifth paper (ID 807935), F. Gong et al. report a method to immobilize hyaluronic acid (HA), a nonimmunogenic biomaterial naturally derived from mammalian tissues, onto the surface of amino-functionalized PU films. The modified PU films, without detectable cytotoxicity, could prolong the coagulation time in platelet-poor plasma and better support human vein endothelial cell adhesion and proliferation. HA immobilized PU is promising as a blood-contacting material for cardiovascular tissue engineering applications.

As one tissue engineering approach, oral therapy by delivering engineered microorganisms such as viable cells in microcapsules is promising in treating many diseases. In the sixth paper (ID 985137), H. Chen et al. report the investigation of genipin cross-linked alginate-chitosan microcapsule for oral delivery of live bacterial cells. The potential of this microcapsule system with strong stability was evaluated using a dynamic human gastrointestinal (GI) model for GI applications.

Review papers in this issue cover three different fields: chemical modification of polymer biomaterials, surface modification, and polymers for fabricating nerve conduits. The seventh paper (ID 423460) contributed by B. Hazer surveys chemical methods used to modify hydrophobic, semicrystalline poly(3-hydroxy alkanoate)s, a series of degradable biomaterials produced by microorganisms, to be amphiphilic. These amphiphilic poly(3-hydroxy alkanoate)s can be used for different tissue engineering applications. In the eighth paper (ID 296094), T. G. Vladkova reviews surface engineered polymeric biomaterials with improved biocontact properties. Numerous methods such as physicochemical modification and immobilization of biomacromolecules are discussed. The final paper of this issue (ID 138686) contributed by S. Wang et al. provides a comprehensive summary of polymeric biomaterials and fabrication methods that have been used for making synthetic nerve conduits. Learning from the existing polymer candidates, we can improve our material design strategies for developing novel biomaterials with optimal properties for nerve regeneration and repair.

Acknowledgments

The authors thank all the contributing authors and reviewers for their efforts in putting together this special issue.

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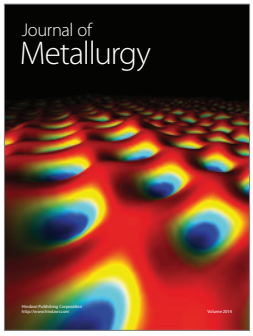

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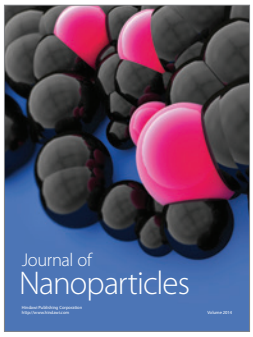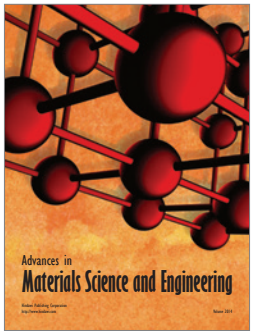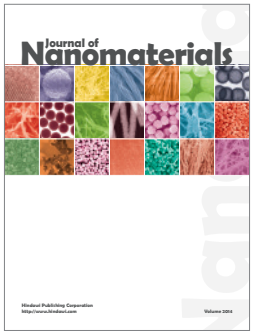
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