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Editorial

Special Feature: Permanent and Long-Term Biodegradable Biomaterials

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1. Introduction

During the past few decades, the increased aging of the world population has prompted the search for novel and improved materials for orthopedic implant applications [1–3]. Research has focused on finding materials free from cytotoxic elements, with good biomechanical compatibility (i.e., with mechanical properties that approach those of bone to minimize stress shielding effects), and eventually displaying antibactericide characteristics. Concerning materials for permanent implants, novel, non-toxic, biocompatible compositions, and suitably engineered microstructures are needed to increase the longevity of the inserts. Alternatively, some metallic alloys (e.g., Mg- or Fe-base) and polymers (e.g., polyglycolic acid (PGA), polylactic acid (PLA), poly-β-hydroxybutyrate (PHB), poly (lactic acid-co-glycolic acid) (PLGA) or poly-ε-caprolactone (PCL)) are biodegradable, and can be used to manufacture implants that do not need a second surgery for its removal, thereby reducing the overall cost of the treatments and further improving the patient's comfort. In many cases, to optimize their properties and functionalities, implants are coated with suitable films which enhance osseointegration and offer enhanced biofilm resistance. In fact, at present, more than 50% of all healthcare-related infections are associated with implants and the improper use of medical devices. The most critical pathogenic event in the development of implant-related infection is biofilm formation [4,5], which starts immediately after bacterial adhesion on an implant and effectively protects the harmful microorganisms from our immune system and systemic antibiotics. Control of infections caused by bacteria colonizing an implant is often difficult. To diagnose and treat these infections represents an important societal challenge to be tackled.

2. New Advances Presented in This Special Issue

In this Special Issue, novel approaches for the development of implants (i.e., design, manufacturing procedures, surface engineering methods) with optimized performance in terms of mechanical and corrosion resistance, as well as antibactericide properties, are presented. Reports dealing with theoretical aspects, fabrication, characterization, and clinical performance of permanent and long-term biodegradable biomaterials, from multidisciplinary points of view (chemistry, physics, materials science, and biology) are included. The biocompatibility of such materials, usually coated with functional or bioactive films, is investigated in response to different cell lines, and sometimes the antibactericide properties are also assessed.

In particular, X. Song et al. [6] report on the properties of objects comprising Poly (lactic acid)/Walnut shell powder biocomposite filaments. The study involves the assessment of the tensile, flexural, and compressive strength of the biocomposites, their thermal degradation characteristics and the ability of using these materials to create porous scaffolds with controllable porosity and pore size. In a separate paper [7], A.G. Ahmed et al. investigate the ability of using biphasic calcium phosphate combined with hyaluronic acid to regenerate bilateral femoral condylar bone defects in rats (i.e., bone healing properties).

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This material induces no inflammatory reaction within the bone defects even after 10 weeks from the implantation, while a significant bone regeneration (i.e., % of newly formed bone area) is observed compared to control samples.

In turn, S.K. Pazhanimala et al. [8] report on the fabrication of synthetic substrates for cell cultures that mimic the natural environment for in vitro intestinal models (i.e., the basement membrane topography), based on nanofibrous scaffolds (comprising polycaprolactone, gelatin, and poloxamer 188 blends) prepared by electrospinning. The obtained scaffolds exhibit high cell proliferation when using colorectal carcinoma cells.

F. Boschetto et al. [9] focus on the growth of coatings based on chitosan/polyethylene oxide nanofibers with incorporated bioactive glass particles and the efficiency of these coatings in enhancing the antibacterial and osteoconductive properties of Ti-based alloys for dental and orthopedic applications, in particular against Staphylococcus epidermidis and SaOS-2 human osteosarcoma cell line. The essays reveal a clear decrease in bacterial growth, while the incorporation of bioglass in the coatings promotes biomineralization and stimulated osteoblasts to produce a higher amounts of bone matrix (i.e., mineralization).

N. Shiraishi et al. [10] study the beneficial effect of coating Ti implants with functionally graded CaTiO3 films on the cell differentiation and degree of osseointegration when using mouse bone marrow stromal ST-2 cells. This result shows the potential of CaTiO3 as a suitable coating for biocompatible biomaterial medical applications, such as dental implants.

Concerning biodegradable metallic implants, Q. Wang et al. [11] show that the mechanical performance of bioresorbable magnesium alloy coronary artery stents can be significantly enhanced through suitable stent pattern designs involving the use of tubular and planar curved geometries, based on three-dimensional finite element models to predict optimized mechanical response. Experimentally, the efficiency of the designs is tested using crimping and expanding deformability, radial scaffolding capacity, radial recoil, and bending flexibility. In turn, L. Liu et al. [12] show that the corrosion and degradation rates of metallic biodegradable implants (e.g., Zn, Mg, and Mg-alloys) can be assessed in detail using a combination of methods, such as micro-computed tomography, eudiometry (to measure the hydrogen evolution from the reaction in of the alloy with Hank's solution) and final mass change. The authors conclude that while mass loss and volume loss provide consistent corrosion rates with need of only a few measuring points (to minimize the damage during the testing process), the use of a eudiometer can provide better real-time assessment of the alloys' corrosion rates according to hydrogen volume evolution.

In an original work [13], González-Locarno et al. investigate the effects of edible coatings, based on essential oils and chitosan, deposited on the surface of cape gooseberry in avoiding physical and microbial decay of the fruit during the post-harvest stage and market storage. Application of the coating, at suitable concentrations of chitosan and oil, is found to preserve the antioxidant properties of gooseberries under storage even after 12 days from the surface treatment.

Finally, I.M. Garcia et al. [14] are co-authors of a review paper (based on MEDLINE/Pubmed and Scopus literature) to assess whether the residual presence of eugenol (one of the most common materials used as a root canal sealer in endodontics) may compromise the bond strength of resin-based restorative materials. The analysis is restricted to specimens with reduced size and micro-tensile bond strength experiments of adhesive systems and resin-based restorative materials applied to coronary dentin including eugenol-based contaminants. While data show some statistical heterogeneity, it is concluded that eugenol can indeed negatively affect the bonding of resin-based restorative materials to dentin.

3. Future Perspectives

Research in biomaterials is extensive and it involves a multidisciplinary approach to tackle a variety of challenges (involving physical, chemical, and biomedical aspects) in an efficient manner. While much progress has been made in recent years, it is still of paramount importance to dedicate further efforts on achieving an in-depth understanding of the correlation between composition, microstructure, and properties of the studied materials, as well as engineering new types of coatings that enhance osseointegration, antibiofouling properties, and corrosion resistance (in the case of permanent implants). Further progress in the field will probably come with the advent of bio-nanotechnology and, in particular, the development of nanocomposite materials that will benefit from the synergetic properties of the different constituents. Self-healing implants, eventually incorporating body-sensing characteristics and a variety of drugs to treat target diseases will probably offer new avenues in the forthcoming years.

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