DESCRIPTION FOR THE GENERAL PUBLIC

In addition to stimulating bone formation, next-generation biomaterials for bone tissue engineering (BTE) are also expected to possess additional biofunctionalities, such us antibacterial, anticarcinogenic, antioxidant, anti-inflammatory, and immunomodulatory activities, to increase the rate of bone regeneration and to obtain therapeutic effects. One of the strategy to obtain multifunctional scaffolds for BTE is to load active agents (antibiotics, chemotherapeutic and anti-inflammatory drugs, and biomolecules that actively support bone tissue regeneration) into them. Such scaffolds combine two functions – they act as a temporary extracellular matrix inducing the natural processes of tissue regeneration and development, while at the same time serve as matrices for sustained delivery of active agents. Despite significant improvements in active molecule bioavailability and/or positive aspect of avoiding side effects associated with systemic drug administration, there are still some limitations regarding usage in local delivery systems. These include increasing prevalence of antibiotic-resistant bacteria, toxic effect of antibiotics to cells in direct contact, the high toxicity of chemotherapeutic drugs to normal cells, drug resistance in cancer cells. Meanwhile, the main drawback of applying biomolecules are high instability and sensitivity to many factors (e.g. pH, temperature, enzymes), ability to provoke an undesirable immune response, and finally high cost. In the last decades, many efforts have been made to overcome above-mentioned drawbacks by using alternative active substances, among others, natural compounds derived from plants, especially polyphenols. Because of broad spectrum of biological activities (antioxidant, anticancer, anti-inflammatory, antimicrobial, as well as bone-stimulating properties) and minor side effects, polyphenols may be regarded not only as a replacement for the usage of conventional biomolecules but also as a promising replacement for drugs in bone tissue engineering. However, to this date, no studies fully investigating their applicability and exploring possibility of their controllable release at the target site had been undertaken.

The primary goal of our research is to design and fabricate multifunctional, bioresorbable composite materials enriched with polyphenolic compounds (PPh) derived from medical plants (sage/rosemary) and with individual polyphenols (rosmarinic acid and carnosic acid). The second equally important goal of our project is to evaluate the possibility to control the material and biological properties of polyphenol-loaded composite biomaterials with the use of different fillers – submicron particles of bioactive glasses (sm-BGs), nanoparticles of SiO_2 (n-SiO_2), and multi-walled carbon nanotubes (MWCNTs). Finally, we attempt to obtain fibrous composite scaffolds, as novel carriers for PPh delivery, using electrospinning method. Since polyphenols affect polymer solution properties that govern electrospinning process (solution viscosity, electrical conductivity and surface tension), the goal of this stage of the project is to optimize the electrospinning parameters to obtain uniform composite nanofibrous scaffolds with unique and tunable biological activities.

Thus, the broad spectrum of this project's objectives is expected to provide answers whether or not the PPh can replace conventionally used biomolecules (used to enhance biological properties of the scaffolds) and/or drugs (applied for the treatment of local bacterial infections, inflammation and/or to kill cancer cells). Moreover, the undertaken studies are expected to investigate if it is possible to control physicochemical and biological properties of materials, by binding PPh selectively to fillers of the composites. Thus, a completely new type of composite biomaterials, combining usage of the active agents and fillers (used to improve the materials' physicochemical and biological properties) is expected to be obtained. These new biomaterials are predicted to meet complex requirements for bone tissue engineering that to this date had not been fully met. We believe that successful completion of the presented project objectives should provide a significant improvement in the field of composite biomaterials for bone tissue engineering and may stem further development of this field of science. Results of the project may channel and dictate further progress in the field of PPh-loaded biomaterials which may become a highly effective and novel alternative to currently used therapies for the treatment of bone defects.