DESCRIPTION FOR THE GENERAL PUBLIC (EN)

TYTUŁ PROJEKTU

Novel 3D biomimetic materials for potential use in advanced therapies of bone diseases - 3D BioBone

AIM OF THE PROJECT

The project's main goal is to develop a new 3D biomaterial mimicking bone tissue for potential use as a drug carrier in advanced bone tissue therapies.

Basic research to be carried out in this project:

- Development of an effective and repeatable method of obtaining multi-substituted nanocrystalline apatite (nanoapatite) with the structure, chemical composition, and physicochemical properties resembling bone apatite
- Development of methods for obtaining collagen / nanoapatite composites (with particular emphasis on the 3D printing method) with the desired physicochemical, biological, and mechanical properties. The improvement of biological, mechanical, and physicochemical properties of composites by using the additives, such as sericin, chondroitin sulfate, and/or beta-glucan.
- Development of 3D printing methods for collagen/nanoapatite composites containing metformin (standardly used as an antidiabetic drug; recent studies indicate its beneficial properties in the process of osteogenesis and angiogenesis) as potential carriers releasing the medicinal substance into the bone.

Main research methods:

Synthesis of nano-apatites: modified wet methods (controlled pH, reactants concentrations, maturation time, composition of the reaction mixture, composition of the solution above the precipitate, temperature, etc.).

Fabrication of composites: conventional methods and Low-Temperature Additive Manufacturing (LTAM) 3D printing technique- preparation of composites containing metformin.

Physicochemical analysis of composites and individual phases: powder X-Ray diffraction (PXRD), middle–infrared spectroscopy (FT-IR), Raman spectroscopy (R), solid-state nuclear magnetic resonance (ssNMR), mass spectrometry with plasma induction (ICP MS), electron microscopies TEM and SEM, mercury porosimetry).

Biological tests: testing of cytotoxicity and biocompatibility as well as angiogenic properties in vitro, on appropriate cell lines.

Drug Release: HPLC chromatography and UV/Vis spectroscopy.

Reasons for choosing the research topic:

Bone tissue is a natural composite of collagen I (fibrin protein) and biological nanoapatite (inorganic phosphate). The porous, hierarchical structure of this composite, containing collagen with deposited apatite nanoparticles, gives bone tissue unusual properties: lightness while ensuring adequate hardness and elasticity. It is worth mentioning that conventional treatment of bone diseases (cancer, metastases, bone infections, or osteoporosis) is not easy, among others due to its poor vascularization. In biomaterial engineering, whose task is, among others, the development of new materials filling bone defects is aimed at making the material biocompatible and facilitating its growth with newly created bone tissue. The material must have adequate porosity and surface properties and must have adequate mechanical strength. At the same time, it is extremely desirable that such material could act as a carrier for the drug substance that could be gradually released at the place of introduction of the material/implant.

Our research is completely in line with the research on multifunctional biomimetic biomaterials.

We hope that using the 3D printing method will allow the development of a composite material with the desired physicochemical, biological, and mechanical properties.

We expect the results of our research to be particularly important for the progress of materials engineering (design of bone substitute materials), pharmacy (designing new drug delivery systems), chemistry and biology (expanding knowledge on the structure and chemical composition of bone tissue and the physicochemical properties of its individual components).