Materials with applications in hard tissue engineering

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Abstract

In recent decades, research in materials engineering has expanded significantly, particularly studies in the field of biocompatible materials. Traditional biomaterials were made from polymers, ceramics, or metals; however, the current biomaterials incorporate therapeutic agents, including biomolecules.

Currently, biomaterials represent a unique class of materials that closely interact with the human body to replicate the functions of a tissue by regenerating it in the case of a medical condition. They can be made from various biocompatible polymers, such as polyhydroxyalkanoates and polysaccharides, and also from non-metallic and inorganic solid materials, which form the class of bioceramics.

Polyhydroxyalkanoates (PHA), polyesters of aliphatic hydroxy acids, characterized by biodegradability, biocompatibility, and bioresorbability, make them suitable biomaterials for medical applications, such as in tissue engineering, including tissue reconstruction and drug delivery systems, where they can be combined with therapeutic agents to enhance regeneration processes.

In this context, the thesis topic fits into one of the most dynamic directions of development in medical research, focusing on the use of biomaterials in regenerative medicine for hard tissue. The main objective of the doctoral dissertation is the development and testing of experimental models that integrate the specific conditions for obtaining materials suitable for use on damaged hard tissue. As a result, the following experimental strategy was adopted:

1. improving the biocompatibility of a metallic material (titanium) by coating it with bioceramics (wollastonite and cobalt-doped zinc oxide);
2. biosynthesis of polyhydroxyalkanoates for biomedical applications on hard tissue, optimizing the production of polyhydroxyoctanoate (PHO) through microbial synthesis using the bacterial strain Pseudomonas fluorescens;
3. development and characterization of polymeric materials based on PHO and hydroxyapatite (HAp) loaded with curcumin for tissue engineering applications/implantable devices;
4. development and characterization of polymeric nanoparticles based on PHO/pullulan loaded with curcumin.

Based on the experimental models and analysis procedures, the results demonstrate originality and innovation through the following:

- Improvement of titanium biocompatibility by coating it with bioceramics (wollastonite and zinc oxide);
- Biosynthesis of PHO using the Pseudomonas fluorescens strain, a process patented by ICCF;
- Innovative combinations of materials, including hydroxyapatite (HAp) and polyhydroxyoctanoate (PHO), to create biomaterials useful in tissue engineering by incorporating curcumin;
- Microbial polymeric nanosystems (PHO, PHN, PHH, and pullulan) loaded with curcumin, were developed for controlled delivery of the active substance.