BIOENGINEERING AND MEDICAL-SURGICAL SCIENCES

DISAT - Multifunctional bioactive materials with tailored biological activity

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Context of the research activity	The biological response to the implantation of a prosthetic device depends on various parameters, such as chemical composition, topography, porosity, surface properties, and grain size. Several inorganic materials, like certain silicate glasses and glass-ceramics, exhibit chemical properties such as bioactivity, bioresorbability, or the release of ions and biomolecules with biological activity, making them suitable for both hard and soft tissue engineering applications. Recently, significant advances have been made in the design and synthesis of bioactive glasses doped with various inorganic ions (e.g., Te, Fe, Zn, Sr, Mg, Ag, and Cu) or functionalized with different biomolecules with therapeutic properties (e.g., drugs, chemotherapeutic agents, or polyphenolic biomolecules), to be used as bulk materials, scaffolds, powders, nanoparticles, or as fillers in polymeric matrices. Numerous studies focus on the effect of these modifications on the biological performance of the implanted material, such as osteogenesis, angiogenesis, and therapeutic effects like antibacterial, antioxidant, antitumoral, or wound healing properties.
Objectives	Recent research efforts on bioactive glasses and glass-ceramics focus on modifying their composition, topography, and surface properties. Bioactive glasses are widely studied as substitutes for bone and soft tissues due to their ability to chemically bond with living tissues through unique surface reactivity. This involves ion exchange between the glass and biological fluids, leading to the development of a reaction layer that has an affinity with connective tissue. Various trace elements in different oxidation states can be added to glasses as network formers, modifiers, or as metal or oxide nanoparticles. Silica-based bioactive glasses and glass-ceramics doped with several trace elements can be produced using sol-gel methods or traditional melt and quenching techniques. These materials can also be enriched with therapeutic chemicals through in situ reduction of nanoparticles or surface functionalization. They can be designed for use as bulk materials, scaffolds, coatings, micro- or nano-sized powders, or as dispersed phases in organic

	matrices or injectable carriers. In the present project, silica-based bioactive glasses, prepared by melt and quenching or wet chemistry, will be designed, tailored, and modified to develop multifunctional biomaterials. These will combine bioactive properties with specific therapeutic actions, such as antioxidant, angiogenetic, antitumoral, or antibacterial properties, depending on their intended use. These properties will be achieved through physical and chemical treatments or surface tailoring to enrich the materials with trace elements, nanoparticles, or organic chemicals with therapeutic effects.

Skills and competencies for the development of the activity	Fundamental knowledge in materials science and technology, biomaterials and bionanotechnology. Familiarity with key methodologies for material synthesis, modification and assessment of biocompatibility, bioactivity, as well as the chemical, physical, and mechanical properties of materials. Capability to apply theoretical concepts to the design, creation, and evaluation of materials for biomedical use. Proficiency in critically analyzing scientific literature. Strong ability to work collaboratively in a team.