

Along with the rapid development of the economy and the continuous improvement of living standards, health awareness has gradually increased, and oral health has become an important topic. Especially since the discovery of osseointegration in the mid-1960s, dental implants are often used for oral rehabilitation in patients who have partially or completely lost their teeth. Ceramic materials are widely applied due to their high biocompatibility and aesthetics. However, they are still characterized by low temperature degradation due to loss of structural stability and corrosion in acidic and humid environments, as well as brittleness. On the other hand, 3D printing is becoming an increasingly common solution for implant fabrication. It enables the production of customized implants, making it possible to create implants with accurate dimensions in a short time. Nevertheless, at present, 3D printing parameters still provide insufficient strength and resolution. Acrylate monomers characterized by high polymerization shrinkage are used as the matrix of the composite material, which can cause defects and distortion of printouts, and commonly used radical initiators (e.g. TPO) exhibit toxic effects.

Therefore, the aim of the project is to develop innovative bioceramic materials for dental implants and to develop technologies for obtaining dental implants through photo-cured 3D printing and post-processing (sintering). The proposed project was developed in response to the demand for a new class of photo-curable bioceramic materials, characterized by high reactivity, reduced polymerization shrinkage, providing dental implants with high biocompatibility and porosity for effective osseointegration and high mechanical strength (without defects and cracks).

Halting the degradation of zirconia ceramics and improving their functional properties will be realized by controlling the grain size of inorganic fillers, controlling sintering conditions, and adding a second phase. In particular, the inclusion of a second phase. The light-curing resins will also include monomers that polymerize according to a hybrid mechanism, combining radical and cationic pathways. This hybrid approach aims to achieve increased reactivity, better resolution of 3D printing while maintaining favorable mechanical properties. The resulting polymer networks allow the photopolymerization rate and crosslinking density to be adjusted, thereby regulating the final properties of resins for 3D printing. An innovation in the proposed project will also be the introduction of dispersants and surfactants, which is expected to contribute to better blending of the organic and inorganic phases, which will ensure adequate homogeneity and viscosity to enable 3D printing.

Obtaining a new type of photo-curable bioceramic materials, and finally dental implants, requires acquiring comprehensive information on the kinetics and reaction mechanism of their formation, as well as their rheological and mechanical properties, their structure and porosity extended by aspects related to biological studies determining their applicability for dental applications. All these issues will be addressed in the project. In particular, an analysis of the mechanisms of interaction of the organic matrix - photoinitiator - inorganic filler doped with another component, dispersant, surfactant - 3D printing parameters - printing and burning process on the final properties of the prints will be carried out. Photocurable bioceramic materials with optimized composition will be tested in 3D printing for dental applications, followed by post-processing. **It is expected that the selection of an appropriate composition, 3D printing parameters and post-processing will lead to prints with favorable mechanical properties and high osteointegration, which are essential properties for photo-cured bioceramic materials for modern implantology applications.** The research proposed under the project is novel, and its implementation will significantly enrich the available knowledge in both photochemistry, materials engineering and bioceramic materials.

