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Epoxy resin and hydroxyapatite based ink for coating the surface of metal implants

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Abstract – Plasma-spraying is the most commercially used process for hydroxyapatite deposition on metal implants. In addition to high costs, it changes the physical, chemical and crystallographic properties of hydroxyapatite, increasing fragility and the coating dissolution rate. This study proposes a new coating technique based on the development of a composite ink hydroxyapatite/epoxy resin. Potential clinical applications for this ink include medical prostheses and dental implants coatings, improving bioactive bonding and load transfer between implant and bone.

In orthopedic and dental implants, the implant-bone interface is of great importance to ensure its functionality. This bonding promotes a good junction between the surface of the implant and bone without any fibrous tissue interface between them.

The inorganic part of the bone consists of mainly of apatite nanocrystals and the most similar structure is hydroxyapatite. Besides being part of bone constituents, hydroxyapatite allows the activation of proteins and cells signals to initiate the cascade of events that result in bone formation. The mechanical properties of bioceramics - including hydroxyapatite - are limited, not allowing it to be used as an anchor for implants subjected to loads. Therefore, the implants are not made with bioceramic materials, but with bioceramics coated metal. Titanium, niobium, tantalum and their alloys have been successfully used as biomaterials due to their chemical and mechanical properties, excellent corrosion resistance and biocompatibility.

The process of plasma spraying is the more established and widely used commercially method for coating implants. The technique of plasma spraying consists of spraying powder material on the metallic substrate, where a torch is used to accelerate the particles toward the target. In coatings with hydroxyapatite by plasma spraying, the particles are 100% crystal in the range of 20-40μm. However, when colliding with the substrate, they are deformed in a characteristic shape called splats, consisting of spread particles on the surface [1]. This layer usually contains considerable amounts of amorphous calcium phosphates, that makes it more soluble, and a fraction of crystalline phases resulting from the decomposition of hydroxyapatite. The reversal of this framework can be by heat treatment, but this procedure has disadvantages such as adverse effects on the substrate, the process costs and the possibility of decomposition of hydroxyapatite into other calcium phosphates. These other phases may be undesirable because of possible cytotoxicity of other phases such as calcium oxide.

This study aims to produce a composite ink composed by resin-based and stoichiometric, nano-sized and crystalline hydroxyapatite. The composite will be applied to the metal surface as an ink. The application, at room temperature, does not generate changes in crystallinity or composition of the inorganic phase. The epoxy resin is the matrix of the composite and promotes a good adhesion to the metal and the nanoparticles, similar to pigments, provide bioactivity. This technique also proposes to mimic tooth periodontal ligament absorbing the load of the masticatory movements.

The purpose of this study is a new coating technique will improve the bond to bone, promotes the kinetics of the osteogenesis process, obtain bioactive bond and absorb the load transfer between implant and bone.

References

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