Bonelike Apatite Coating on Ti6Al4V: Novel Nucleation Process Using Sodium Silicate Solution

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Abstract. Despite the well known biocompatibility and bioactivity of synthetic hydroxyapatite (HA), its use, as structural biomaterial has been limited because of intrinsic low mechanical properties. In order to avoid this problem, metallic implants are commonly coated with a thin HA layers. Among the various techniques used to produce coatings on metals, the biomimetic process has gained increasing attention in the last years. In this work, a metallic substrate (Ti6Al4V) was coated using a variation of the traditional biomimetic method. The HA coatings were characterised by diffused reflectance spectroscopy (DRIFT) and scanning electron microscopy (SEM).

Introduction

Metals have gained special attention in the field of the implantology in last years because of their high mechanical resistance. However, metals are biotolerable materials not being able to bond to the living tissue. Bioactive materials, on the other hand, form chemical bonds with the living bone tissue, but do not exhibit suitable mechanical properties. Thus, the extensive use of HA as implants has been limited to non load-bearing sites and only on compression. The combination of mechanical strength with the bioactivity is possible through the surface coating of metallic substrates with HA [1].

Various methods can be employed for the application of coatings including ion sputtering, plasma spray, sol-gel, electro-deposition and biomimetic. Plasma spray is the only method used for commercial applications, however the high operating temperatures, ~10,000 °C, decompose HA into oxyapatite [Ca9(PO4)6O], α and β - tricalcium phosphate [α c β - Ca3(PO4)2], and a vitreous phase. This alters the biodegradation process and the nature of HA-metal bonding becomes purely mechanical, failing under tension [2,3].

In 1990 Abe and co-workers developed a procedure to coat almost any substrate with a uniform biological HA layer, up to 15 μm thick [4]. The method is based on immersion of the substrate into a synthetic solution that has similar ionic composition to that of blood plasma, simulated body fluid (SBF). A plate of bioactive glass (G glass) is also introduced in the system, at an approx. distance of 0.5 mm from the substrate. After 7 days at 36.5°C a continuous and homogeneous layer of biological HA with 1 μm thickness is formed. This layer is composed of very fine acicular crystals, elongated in the direction of c axis. The substrate re-immersion for 7 days in a more highly concentrated solution (1.5 SBF) allows the HA layer thickness to be increased up to 15 μm. Coating characterization revealed that the layer was composed of HA - CO3 of low crystallinity, similar to biological HA found in natural bone [4,5].