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Synthesis and deposition of silver nanoparticles on cp Ti by laser ablation in open air for antibacterial effect in dental implants

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ABSTRACT

Silver nanoparticles have been synthetized and deposited on cp Ti substrates in one-step process by the use of laser ablation in open air. The nanoparticles are produced by ablating Ag foil using two different lasers and an inert gas jet oriented into the interaction zone to prevent oxidation and to direct the ablated material to the substrate. The HRTEM images and FFT confirmed the crystalline nature of the obtained silver nanoparticles with the presence of oxidized ones, while FE-SEM revealed that the nanoparticles were uniformly distributed on Ti substrates. The Ag-containing Ti substrates showed good antibacterial activity against *Lactobacillus salivarius*.

1. Introduction

Silver nanoparticles have been recently used in many applications such as photocatalysis, water purification, antifungal and antimicrobial compounds, plasmonic enhancement, etc. [1–6]. Their antibacterial, antifungal and antiviral activities make them scientifically interesting as object of research besides their use in commercial products [7].

The fundamental properties of silver nanoparticles strongly depend on their size, crystalline structure as well as their morphology, which are consequently related to the synthesis process. There is a broad variety of methods and techniques for producing silver nanoparticles, including chemical, physical and biological processes [8–11]. Each one presents advantages and disadvantages. The nanoparticles obtained by most of these methods are associated to the presence of impurities due to the use of chemical solvents, most of them are not scalable and in some cases a post-treatment to deposit or anchor the nanoparticles on substrates is required. Among the mentioned methods, laser ablation, has gathered attention as physical method for fabrication method of nanoparticles in different media. Laser ablation process to synthesis nanoparticles is generally performed in both gas and liquid media. Although silver nanoparticles have been widely synthetized using laser ablation in gas and liquids [12–15], to best of our knowledge there are very limited works on obtaining silver nanoparticles by laser ablation in open air [16]. In a previous work we have obtained Ag nanoparticles by laser ablation in open air [17]. On the other hand Ti claimed as biocompatible material is widely used in implants and dentistry [18]. In this paper we report the results of synthesising and depositing silver nanoparticles by laser ablation in open air on cp Ti, the "gold standard" material in dental implantology [18]. The antibacterial capacity of the Ag-containing Ti substrates against the growth of *Lactobacillus salivarius*, which plays an important role in biofilm formation [19] is also studied, as preliminary step to their use in dental implants.

2. Experimental

Foils of Ag with 99.99% of purity were used as targets to be ablated by two different laser sources in open air atmosphere. The laser beam was focused on the target to give a spot size about 0.15 mm diameter. The first source consisted of a pulsed Nd:YAG laser operating at 1064 nm, 10 Hz, 3.2 ms of pulse width, and pulse energy of 12 J. The second source was a diode-pumped Nd:YVO_4 laser, providing 10 ns pulses at 532 nm, 20 kHz, and 0.30 mJ of pulse energy. Commercial pure (cp) titanium (grade 2) discs with a 6.0 mm diameter and about 50 nm of average surface roughness

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