Applied Surface Science 507 (2020) 145032

Contents lists available at ScienceDirect

Applied Surface Science

journal homepage: www.elsevier.com/locate/apsusc

Full Length Article

Copper nanoparticles obtained by laser ablation in liquids as bactericidal agent for dental applications

M. Fernández-Arias[a,*], M. Boutinguiza[a,e], J. Del Val[a], C. Covarrubias[b], F. Bastias[b], L. Gómez[c], M. Maureira[b], F. Arias-González[d], A. Riveiro[a,e], J. Pou[a,e]

[a] Applied Physics Dpt., University of Vigo, EEI, Lagoas-Marcosende, Vigo E-36310, Spain
[b] Laboratory of Nanobiomaterials, Institute for Research in Dental Sciences, Faculty of Dentistry, University of Chile, Independencia, Santiago, Chile
[c] Laboratory of Microbiology, Department of Patology, Faculty of Dentistry, University of Chile, Independencia, Santiago, Chile
[d] School of Dentistry, Universitat Internacional de Catalunya, Barcelona, Spain
[e] Galicia Sur Health Research Institute (IIS Galicia Sur), SERGAS-UVIGO, Vigo, Spain

ARTICLE INFO

Keywords:
Copper nanoparticles
Noble metal nanoparticles
Laser ablation
Antibacterial effect

ABSTRACT

The dramatic increase of antibiotic-resistant bacteria is considered one of the greatest threats to human health at global scale. The antibacterial activity of noble metal nanoparticles, could be the solution against bacterial infectious diseases which currently do not respond to conventional treatments.

In this work, copper nanoparticles were produced by laser ablation using two different lasers. A nanosecond laser operating at 532 nm and a picosecond laser at 1064 nm were used to ablate a copper target submerged in water and methyl alcohol. The obtained colloidal solutions consisted of copper oxide nanoparticles in suspension with diameters ranging from few nanometers to 45 nm. The nanoparticles formation process is highly influenced by laser parameters, but the solvent plays a crucial role on their characteristics. Cu oxide nanoparticles obtained in water present chain-like nanostructure, while those obtained in methyl alcohol are spherical with lower presence of oxide. All the obtained nanoparticles are crystalline and noticeably stable.

Microbiology tests confirm their strong activity against *Aggregatibacter actinomycetemcomitans*. Cytocompatibility with human periodontal ligament stem cells is also confirmed. The biological assays evidence that ions release is not the main parameter responsible for the bactericidal activity of copper nanoparticles. Other factors such as oxidation state, size and crystallographic structure, have a greater influence on the process.

1. Introduction

Nowadays, more and more infections caused by resistant microorganism, fail to conventional treatments. According to the Centre for Disease Control and Prevention (CDC), antibiotic resistant bacteria cause at least 2 million infections per year with 23,000 deaths in the U.S. and 25,000 deaths in Europe [1]. The excess and improper use of antibiotics, has made the treatment of infections more difficult and expensive; some voices in the health system claim we are facing a new global health crisis [2,3]. In this sense, Gram-negative bacteria are a huge threat, because of the rapid evolution of their resistance mechanisms what results in insusceptibility to nearly all available antibiotics [4].

In dentistry, some of the more extended diseases caused by bacterial infections are periodontitis and periimplantitis. In both cases, the inflammation and destruction of soft and hard tissues surrounding teeth or dental implants, ultimately leads to loss of teeth or dental implant failure as the most common consequences [5]. Although many risk factors are related to the origin of periimplantitis [6], pathogenic microflora are the main cause of this periodontal disease [5]. *Aggregatibacter actinomycetemcomitans* is a Gram-negative bacteria and commonly part of the normal flora of human mouths, especially in gingival and supragingival crevices [7].

In light of this situation, it is necessary to explore new alternatives in the treatment of diseases caused by infections such as periimplantitis. Nobel metal nanoparticles have become an attractive alternative source to fight against such resistant microorganisms. The antibacterial activity of noble metal nanoparticles have been extensively studied because of their high surface to volume ratio, that increases reactivity allowing to kill the pathogens efficiently [8]. Particularly, copper nanoparticles are of special interest because they are potentially effective against different bacterial pathogens [8,9], and are very attractive in

* Corresponding author.
E-mail address: monfernandez@uvigo.es (M. Fernández-Arias).

https://doi.org/10.1016/j.apsusc.2019.145032
Received 29 July 2019; Received in revised form 7 December 2019; Accepted 10 December 2019
Available online 16 December 2019
0169-4332/