EFFECT OF AMORPHOUS AND CRYSTALLINE TITANIUM DIOXIDE NANO-MATERIAL ON *BACILLUS SUBTILIS* BIOFILM DEVELOPMENT

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Abstract

This study aims to compare the anti-biofilm activity between amorphous titanium oxide nano-powder and crystalline (anatase) titanium oxide nanoparticles. Both titanium oxide forms were prepared by sol-gel method and tested against fluorescently labelled *Bacillus subtilis*. Here, surface coated by amorphous titanium oxide and anatase titanium oxide nanoparticles showed reduced biovolume of attached cells to almost negligible to $5x10^{-2}$ $\mu m^3/\mu m^2$ and $0.01x10^{-2}$ $\mu m^3/\mu m^2$; respectively, in comparison to the biovolume attached to the uncoated slide glass control samples $155x10^{-2}$ $\mu m^3/\mu m^2$. However the lower cost, amorphous titanium oxide nano-powder show lower anti-biofilm efficiently than its crystalline form.

Keywords: Bacteria, South-Central Mediterranean, Biotechnologies

Introduction

Microbes often form surface attached micro-communities called biofilms mainly to get protected against antimicrobials and other environmental stresses [1]. This is a major problem in medical, environmental and industrial settings as getting rid of these biofilms is not always easy. Coating surfaces with titanium oxide nanoparticles can be one of the ways to achieve this anti-bioflm property [2]. However its promising properties, researchers tend to use its amorphous form to overcome cost of thermal treatment for crystallization.

Methods

Glass slides were coated by nanoparticles to create an anti-adhesive surface against bacteria as a route for preventing bacterial-surface attachment and successive biofilm development. Nanoparticles were synthesized by sol-gel and used as amorphous (a-TiO_2) and crystalline (TiO_2 anatase) forms. Briefly, titanium isopropoxide as titanium precursor was added to isopropanol and then isopropanol was supplied drop by drop during continuous stirring at room temperature. The turbid solution containing the isopropoxide hydrolysate was dried at 100°C to obtain a-TiO_2. Thermal calcination process for dried powder was performed at 450°C for 2 h to prepare TiO_2 anatase [3]. For prepared powdered, the crystal phase were estimated by X-ray diffractometer. The morphology of the prepared nanomaterials was determined by Philips 200 transmission electron microscope. The hydrodynamic diameter and zeta potential of the prepared metal oxides were identified by dynamic light scattering. Cleaned glass slides were dipped in nano-suspensions then allowed to be dried. The anti-adhesive properties of the treated slides were tested by studying the attachment of *B. subtilis* strains after 24 hours of inoculation using confocal laser scanning microscope.

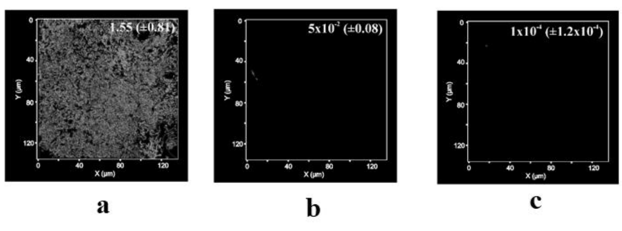

Fig. 1. Biofilm development on glass surfaces that were uncoated (A) or coated with amorphous titanium dioxide (B), crystalline titanium dioxide (C).

Results

Here, surface coated by a-TiO_2, TiO_2 anatase NPs showed reduced biovolume of attached cells to almost negligible to $5x10^{-2}$ $\mu m^3/\mu m^2$ and $0.01x10^{-2}$ $\mu m^3/\mu m^2$; respectively, in comparison to the biovolume attached to the uncoated slide glass control samples $155x10^{-2}$ $\mu m^3/\mu m^2$.

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References

1 - Abee, T., Kovács, Á.T., Kuipers, O.P. and van der Veen, S. (2011) Biofilm formation and dispersal in Gram-positive bacteria. *Curr Opin Biotechnol* **22,** 172-179.

2 - Vargas-Reus, M.A., Memarzadeh, K., Huang, J., Ren, G.G. and Allaker, R.P. (2012) Antimicrobial activity of nanoparticulate metal oxides against peri-implantitis pathogens. *Int J Antimicrob Agents* **40,** 135-139.

3 - El-Shafei, A. et al. (2015) Eco-friendly finishing agent for cotton fabrics to improve flame retardant and antibacterial properties. *Carbohydr Polym* **118,** 83-90.