Bactericide Action of a Titanium Surface Biofunctionalized with a Novel Bioactive Glass

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Statement of Purpose: The revision surgery of a failed implant always brings serious risk for patients[1]. Less than 10% of such failures occur in implants due to bacterial infections[2], however this kind of failures is the most serious and difficult to treat[3]. Attached and growing bacterial colonies rapidly produce an extracellular polysaccharide matrix – biofilms, which protect them against antibiotics and the host body's innate defense system. An important strategy for reducing such a problem is to prevent the initial attachment of bacteria to implants and device surfaces. The objective of this research was to produce a titanium surface with antibacterial property by biofunctionalizing it with a novel bioactive glass.

Methods: The bioactive glass (BG) composition (patent BR10 20130209619) from the SiO_2-Na_2O-K_2O-MgO-CaO-P_2O_5 system was obtained by melting using a Pt crucible. A composition containing 1wt% silver was also tested (BG+Ag). The surfaces biofunctionalization was done using a proprietary method (patent BR10 2014 003817 5) to attach the glass particles to the surfaces. The antibacterial activity was evaluated by (1) the plate count method according to JIS standard − Z 2801:2010 "Antibacterial products - Test for antibacterial activity and efficacy" and (2) the spread plate method to evaluate the adhered viable cells (biofilm) in a sequence as follow: (a) cultivation; (b) incubation; (c) ultrasonic detachment; (d) dilution and (e) spread plate method for counting the final CFU. The first method tested the (a) Staphylococcus aureus, (b) Staphylococcus epidermidis, (c) Escherichia coli and (d) Pseudomona aeruginosa. The second method tested the Staphylococcus aureus. For SEM analysis the samples, after the incubation period, were immediately fixed in 2.5% glutaraldehyde for 15 minutes and gradually dehydrated in ascending series of alcohol (15, 30, 50, 70, 90, 80 and 100%).

Results: All biofunctionalized surfaces showed a strong bactericide action for all bacteria with at least 5 log reduction in the colony-forming unit (CFU) – Figure 1. Because of that the BG+Ag was not tested. For adhered viable cells evaluation (biofilm) the reduction was approximately 3 log – Figure 2, for the BG+Ag. The basic BG composition had a better result than the gold standard, i.e. the bioglass 45S5. The SEM analysis – Figure 2, confirm these results.

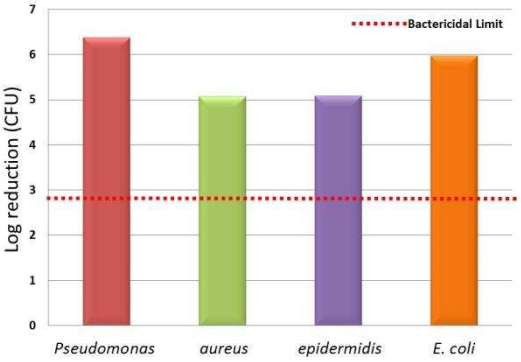

Figure 1 – The bioactive glass bactericidal effect

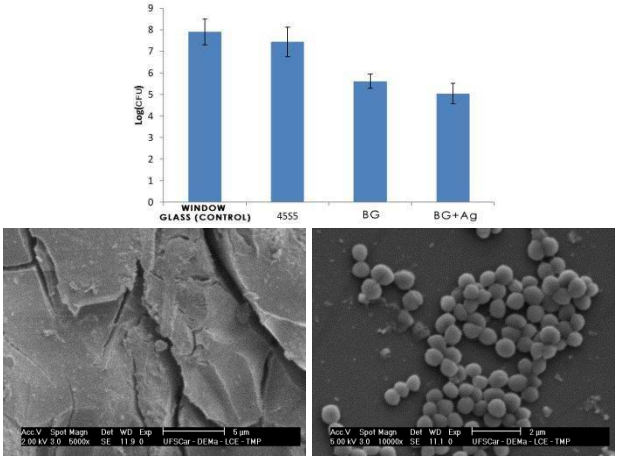

Figure 2 − Adhered viable cells (biofilm) results. TOP: Log CFU. Botton: SEM (left - BG+Ag / Right – Control)

Conclusions: The surfaces biofunctionalized with the novel bioactive glass composition are highly bactericide and has a good potential to avoid biofilm formation. The addition of silver enhances this potential.

References:

1 – SUNDFELDT, M. et al. Aseptic loosening, not only a question of wear. A review of different theories. **Acta Orthopaedica**, 77 (2), 2006. 177–197.

2 – RATH, L. Metal Hips Fail Faster, Raise Other Health Concerns. **Arthritis Today**, Março 2012. Availabe on: <http://www.arthritistoday.org/news/hip-replacement-failure-rate187.php>. Acesso em: Fevereiro 2013.

3 – XIANG, Z.; SPECTOR, M. Biocompatibility of Materials. In: WEBSTER, J. G. **Encyclopedia of Medical Devices and Instrumentation**. 2. ed. [S.l.]: John Wiley & Sons, Inc, v. 1, 2006, p.113. p. 655.