Investigation of the growth kinetics of *streptococcus mutans* bacteria on zr-c coating surfaces deposited on 316l steel substrates

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Abstract

Statement of the Problem: The aim of the conducted research is to describe the kinetics of Staphylococcus mutans bacteria growth on the surface of Zr-C coatings with varying carbon content, deposited on 316L medical grade stainless steel substrates. The coatings were deposited using the MS PVD (Magnetron Sputtering Physical Vapour Deposition) technique at a constant temperature of 400°C. Varying carbon contents in the coatings were achieved by changing the flow rate of acetylene during the process. The dynamics of bacteria growth cultivated at 37°C were examined on the surface of the coatings, for incubation times ranging from 0 to 144 hours. Generalized logistic functions were utilized for mathematical description of the obtained results. The produced coatings exhibited varying carbon content, determining the structural composition ranging from a mixture of metallic Zr and ZrC, through stoichiometric zirconium carbide, to nanocrystalline grains of ZrC in an amorphous carbon matrix. The obtained results unequivocally demonstrate that in the case of ZrC coatings, the carbon content influences both the rate of bacterial growth during the proliferation phase and the final population of bacteria. In the conducted research on bacterial population dynamics, only a single strain of Staphylococcus mutans was considered, and the mathematical description was limited to reaching a pseudo-steady-state by the population.

Conclusion & Significance: The proposed model can successfully be adapted to describe the dynamics of other individual strains of bacteria dwelling on metallic surfaces as well as coatings. The proposed model can serve as a tool for studying, among other things, inflection points of logistic curves, which are considered as the boundary between the dominance of anabolic and catabolic processes in the bacterial population.

Image

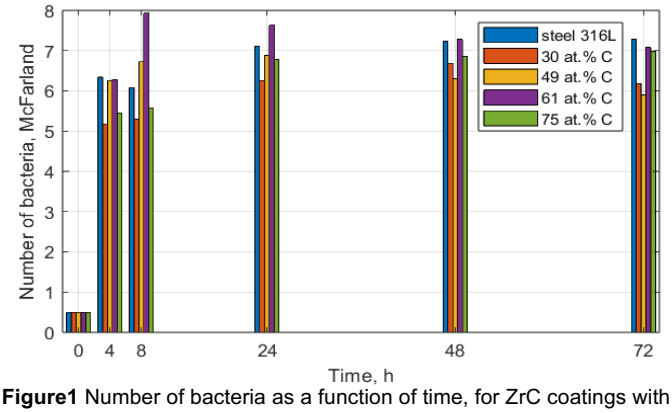
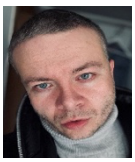


Figure1 Number of bacteria as a function of time, for ZrC coatings with different carbon content.

Recent publications

1. Szparaga Ł, Bartosik P, Gilewicz A, Mydłowska K, Ratajski J (2021) Optimisation of mechanical properties of gradient Zr–C coatings. Materials 14(2): 296.
2. Ratajski J, Gilewicz A, Mydłowska K, Szparaga Ł (2020) Inter-Relationship between Coating Micro/Nanostructure and the Tribological Performance of Zr–C Gradient Coatings. Coatings 10(11): 1121.
3. Gilewicz A, Mydłowska K, Ratajski J, Szparaga Ł, Bartosik P, Kochmański P, Jędrzejewski R (2019) Structural, mechanical and tribological properties of ZrC thin films deposited by magnetron sputtering. Vacuum 169: 108909.
4. Mydłowska K, Czerwińska E, Gilewicz A, Dobruchowska E, Jakubczyk E, Szparaga Ł, Ceynowa P, Ratajski J (2020) Evolution of Phase Composition and Antibacterial Activity of Zr–C Thin Films. Processes 8(3): 260.
5. Ratajski J, Szparaga Ł, Mydłowska K, Dobruchowska E, Czerwińska E, Gilewicz A (2018) Investigation on the influence of ZrC coatings structure on their resistance to corrosion and antimicrobial properties. Engineering of Biomaterials 21: 148.

Photograph



Biography

Dr Łukasz Szparaga is an Assistant Professor of the Department of Biomedical Engineering at the Faculty of Mechanical Engineering and Energy at KUT. His main research interests focus on the use of mathematical and computer methods in the description and design of protective coating deposition processes using PVD techniques. In addition, he deals with the theory and techniques of multi-criteria optimization, in particular research on methods of classification, analysis and selection of optimal sets of solutions, in the field of materials and biomedical engineering.

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