Ti-6Al-4V (ELI) wettability modification via adsorption of polyether-silicone compound.

Katarzyna Wojdat [1], Joanna Krawczyk [1], Joanna Karasiewicz [2]

[1] Department of Interfacial Phenomena, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Skłodowska University
[2] Department of Chemistry and Technology of Silicon Compounds, Faculty of Chemistry, Adam Mickiewicz University

katarzyna.wojdat@mail.umcs.pl

The Ti-6Al-4V (ELI) alloy is one of the most commonly used metallic biomaterials in medicine. This is due to its large biocompatibility, which is caused by the ability of titanium and its alloys to passivate spontaneously in contact with oxygen. The passivation layer provides corrosion resistance and biocompatibility of metallic biomaterials. The properties of this layer (hydrophilicity, composition, thickness, homogeneity and stability) depend mainly on the titanium and titanium surface preparation and decide about its practical application. For example, its wettability and roughness play a crucial role in medicine in the context of microbial adhesion to metallic biomaterial surfaces. High implant surface roughness is advantageous for osseointegration, as it provides a larger contact area and facilitates the adhesion and ingrowth of bone cells into the implant structure. On the other hand, excessive roughness can be detrimental, as it increases the risk of bacterial proliferation and accelerates peri-implant bone loss. Consequently, the focus has shifted to the creation of micro- and nanostructures.
Adhesion of microorganisms can be inhibited by changes in biomaterial surface roughness and/or its hydrophilic–hydrophobic balance. The surface hydrophilic–hydrophobic properties depend mainly on the conditions of the material and its surface preparation or adsorption of different substances, for example, bacteriostatic compounds. One of the methods to change the biomaterial surface properties is controlled passivation. The other one is connected with using compounds that are able to adsorb at the biomaterial-liquid interface. Consequently, this adsorption modifies the wettability process in the biomaterial-liquid-air system. For this purpose, the silicone compounds can be used. They influence the wettability of biomaterials while also preventing the formation of bacterial biofilm, thus reducing the risk of biocorrosion. Therefore, the aim of this study was to evaluate the effect of polyether trisiloxane surfactant (HOL 12) on the wettability of Ti-6Al-4V (ELI) as well as to analyse the correlation between wetting and adsorption properties of HOL12. On the basis of the obtained results, it was deduced that the addition of HOL12 to water causes the complete wetting of the Ti-6Al-4V (ELI) surface in the range of surfactant critical micelle concentration (CMC). This is strictly connected with the presence of the hydroxyl groups on the Ti-6Al-4V (ELI) surface and their interactions with the oxygen atoms that are present in the trisiloxane chain as well as the specific structure of the HOL12 molecule.

References:

[1] Choi, J. Kwon, K. Suk, H. Kim, S. Moon, S. Park, B.H. Lee, The Clinical Use of Osteobiologic and Metallic Biomaterials in Orthopedic Surgery: The Present and the Future, Materials, 16 (2023) 3633.
[2] Y.W. Cui, L. Wang, L. Zhang, Towards load-bearing biomedical titanium-based alloys: From essential requirements to future developments, Progress in Materials Science, 144 (2024) 101277.
[3] K. Shukla, R. Balasubramaniam, S. Bhargava, Properties of passive film formed on CP titanium, Ti–6Al–4V and Ti–13,4Al–29Nb alloys in simulated human body conditions, Intermetallics, 13 (2005) 631.
[4] J. Karasiewicz, R.M. Olszyński, P. Nowicka Krawczyk, J. Krawczyk, Ł. Majchrzycki, Containing Polyether Groups—Synthesis and Use as an AntiBiocorrosion Coating, International Journal of Molecular Science, 25 (2024) 6801.
[5] S. Kar, A. Arora, J. Marwaha, P. Bansal, N. Sathish, S. Gupta, Comparative analysis of bacterial adhesion on titanium implants treated with plasma electrolytic oxidation, Journal of Pharmacy and Bioallied Science, 17 (2025) S1610-2.
[6] J. Yu, M. Zhou; L. Zhang, H. Wei, Antibacterial Adhesion Strategy for Dental Titanium Implant Surfaces: From Mechanisms to Application, Journal of Functional Biomaterial 13 (2022) 169.