Wettability of a Novel Biofilm-Resistant Surface Modification Process for Metallic Implants

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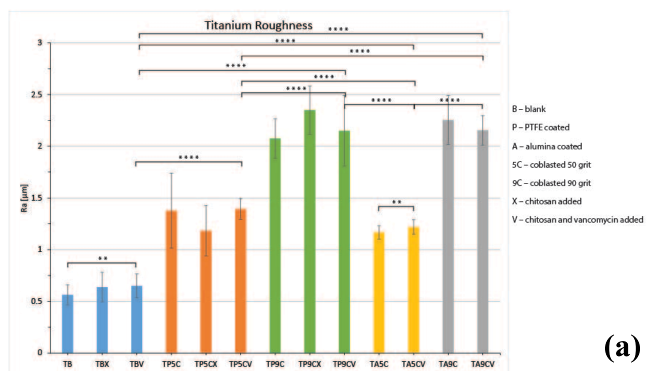
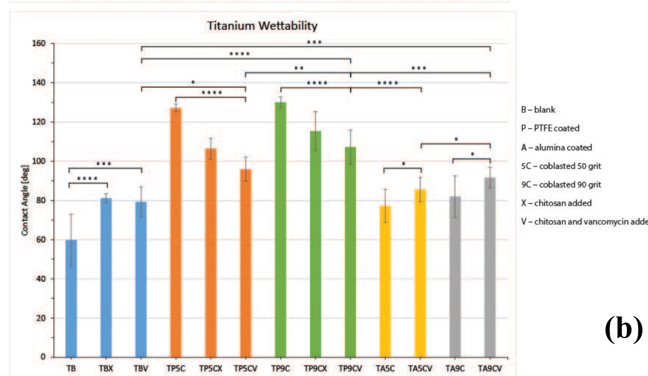
Introduction: The accumulation of proteins and bacteria on implant surfaces is a critical concern in the biomedical field, especially with respect to the potential of biofilm formation on implant surfaces. Material surface wettability is often used as a predictor of surface interactions between a material and the surrounding environment, and is often used as a predictor of potential colonization of specific bacterial strains. Surface roughness has also been shown to have a strong relationship with biofilm formation, as rougher surfaces tend to have a stronger affinity to harbor bacterial colonies. The modification of implant surfaces to impart a biofilm resistant layer can come at the expense of increasing surface roughness however, and it is therefore important to determine how the variables of wettability and roughness are affected by any new surface coating technologies. In the current work, a novel CoBlast (C) process that impregnates alumina (A) at 50 µm grit (5) or 90 µm grit (9) sizes, with the possible addition of polytetrafluoroethylene (P) onto titanium surfaces, combined with a plasma coating process called BioDep, that coats the surface with chitosan (X) with the possible addition of vancomycin (V), were evaluated for wettability and surface roughness to determine their potential as biofilm resistant treatments on implants.

Materials and Methods: N=65 titanium alloy samples (n=5 for 13 sample modification types as described above and in the figure legends below) were analyzed for surface roughness and wettability. Following cleaning in ethanol, roughness testing (for measures of Ra, Rq, Rt and Rz) was performed using a Wyko NT-2000 optical profilometer (28.7x magnification, FOV of 164x215 µm) at 5 different locations on the surface of each specimen, and contact angle analysis was performed using a KRUSS EasyDrop instrument. The KRUSS Drop Shape Analysis software was used to analyze each of the 2 µL drops of water to determine their contact angle with the surface. Statistical differences between groups was determined using ANOVA.

Results and Discussion: Figure 1a summarizes the roughness results, with significant roughening being observed with between surface blanks and all surface modification techniques, especially the CoBlasted 90 µm grit treatments. As expected, wettability (shown in Figure 1b) was significantly affected by PTFE modifications and also by the introduction chitosan and vancomycin.



(a)



(b)

***Figure 1: (a)** Average surface roughness and **(b)** average wettability form samples of Ti-6Al-4V*

Conclusions: As can be seen from these results, changing the coating of a material can change the surface topography and the wettability of the surface, which can be beneficial for different applications. The results from this work show that the CoBlast and BioDep processes significantly affect both wettability and roughness, and that the benefits and potential drawbacks of each must be considered when assessing their potential for biofilm resistance. PTFE-coated samples would be best used when wanting to prevent a hydrophobic substance from binding to the material, while the alumina-coated or blank samples would be best used to prevent a hydrophilic substance from binding. In the future, nonpolar liquid wettability will be assessed to better mimic in-vivo conditions and to determine surface energy to be able to make better conclusions about the relationship between surface roughness and wettability.

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