12TH WORKSHOP ON SURFACE ENGINEERING

28.06.2023 to 30.06.2023, J. Selye University, Slovakia

Formation of ceramic- polymer coatings on titanium implants and their stability

Maciak W., Kazek-Kęsik A. Jaśko W., Simka W. , Faculty of Chemistry, Silesian University of Technology, Poland

SUMMARY

The aim of the study was to develop a method for obtaining ceramic-polymer coatings on titanium implants and to analyze the stability of these coatings.

INTRODUCTION

Titanium implants have a long history of applications in medicine. Now increasingly used in veterinary medicine as well. In the case of implants for animals, special surface preparation is required so that they can be left in the patient's body until the end of their life.

The bioactivity of titanium implants can be increased by using the electrochemical plasma oxidation process to incorporate calcium and phosphorus compounds from the electrolyte into the forming oxide layer. Such an action has a positive effect on the integration of bone tissue into the implant.

METHODOLOGY

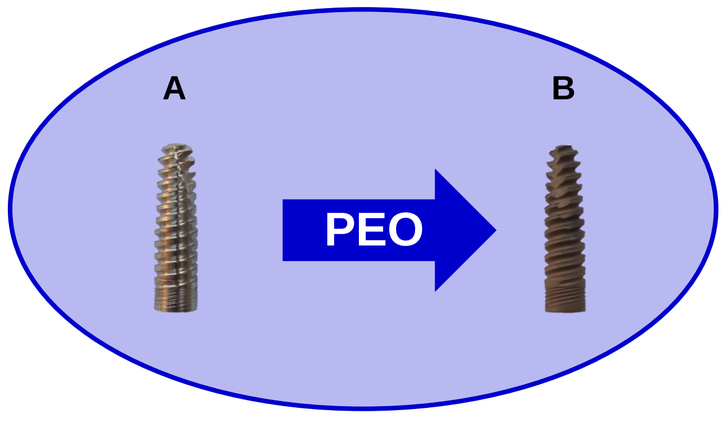
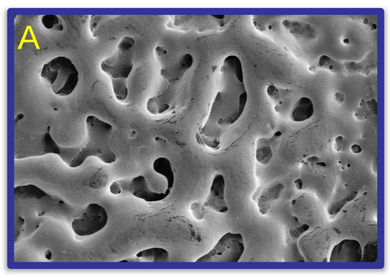


Fig. 1. Image of (A) animal titanium dental implant, and (B) dental implant after plasma electrolytic oxidation treatment (PEO)

RESULTS

The porous oxide layer thus formed was then applied to the polymer poly(lactide-co-glycolide) with the drug clindamycin using an immersion method (2% by weight PLGA + 0.5% by weight clindamycin).



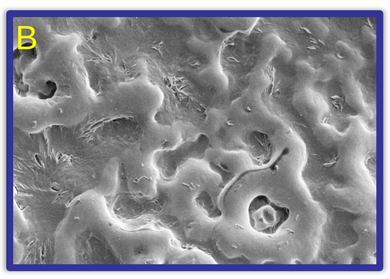


Fig. 2. Example of (A) SEM image of the PEO layer formed on implant and (B) SEM image of a polymer-oxide hybrid layer containing with antibiotic

Under the degradation of the polymer matrix, the antibiotic is released into the patient's body to inhibit bacterial growth.

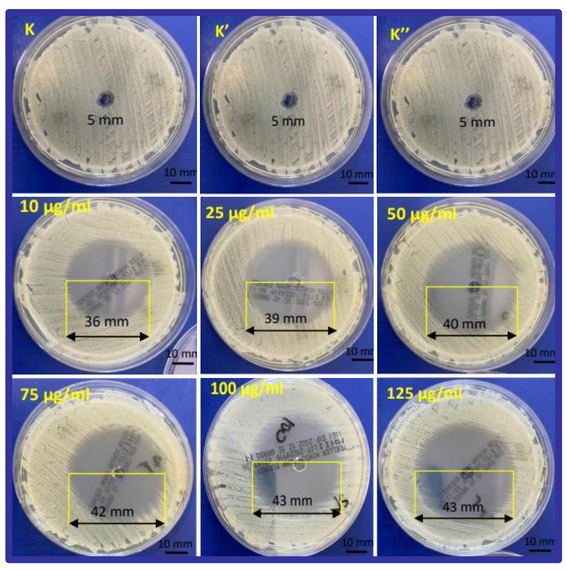


Fig. 3. Photos of zones growth inhibition for *Staphylococcus aureus* bacteria depending on the clindamycin various concentration (K, K', K'' - control sample)

The stability and concentration of clindamycin released from the polymer matrix were determined and analyzed using high-performance liquid chromatography (HPLC) techniques.

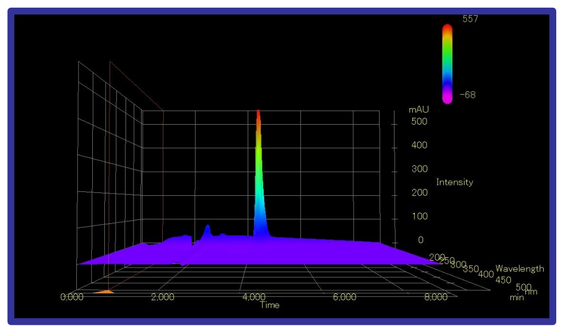


Fig. 4. Representative chromatogram of clindamycin released from the hybrid coating formed on animal dental implants after 1 hour of their immersion in PBS solution. Signals present before amoxicillin signals (tr=4.4 min) from Ringer's solution

The effect of the amount of drug released on inhibiting bacterial growth on the surface of the implant has a direct impact on its stability in the tissues in which it is embedded.

Analyses after 24h incubation implants

Tabele 1. Minimum inhibitory concentration test for bacteria *Staphylococcus aureus* (ATCC 25923) after 24h of drug release from the polymer matrix

		S. aureus ATCC 25923	
		O.D after 18 h of incubation	Average O.D.
ID-PLGA-CLINDAMYCIN	1	0	0
	2	0	
	3	0	
Control	1	7,7	7,37±0,42
	2	6,9	
	3	7,5	

Analyses after 12 weeks incubation implants

Tabele 2. Minimum inhibitory concentration test for bacteria *Staphylococcus aureus* (ATCC 25923) after 12 weeks of drug release from the polymer matrix

		S. aureus ATCC 25923	
		O.D after 18 h of incubation	Average O.D.
ID-PLGA-CLINDAMYCIN	1	0	0
	2	0	
	3	0	
Control	1	5,6	5,63±0,06
	2	5,6	
	3	5,7	

Researches were also conducted for *E. coli* bacteria (ATCC 25922). However, better results were obtained for S. aureus bacteria, indicating that the released drug is more effective against gram-positive bacteria.

CONCLUSION

The results of microbiological experiments confirmed that the released concentration of clindamycin from the polymer matrix was sufficient to completely inhibit the growth of the tested Staphylococcus aureus bacteria. These results further confirmed that the modified implant coatings exhibit bacteriostatic properties.

In addition, long-term studies have confirmed the stability of clindamycin. The results of the study may find application in researching the use of such layers in dental implantology for animals, and potentially in the development of dental implantology in humans.

ACKNOWLEDGMENTS

This work was supported by the National Centre for Research and Development, Poland, according to the LIDER XI programme. Project "Technology of hybrid coatings formation on titanium implants for animals" no. LIDER/12/0048/L-11/19/NCBR/2020.