COMPOSITE COATINGS OF POLYLACTIDE WITH GRAPHENE OXIDE AND HYDROXYAPATITE ON TITANIUM

MAIDER SAN TORCUATO[1,2], BARBARA SZARANIEC[1]*, SŁAWOMIR KĄC[3], JAN CHŁOPEK[1]

[1] DEPARTMENT OF BIOMATERIALS AND COMPOSITES, FACULTY OF MATERIALS SCIENCE AND CERAMICS, AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KRAKOW, POLAND
[2] INSTITUTE OF BIOMEDICAL ENGINEERING, FACULTY OF ENGINEERING, MONDRAGON UNIVERSITY, SPAIN
[3] FACULTY OF METALS ENGINEERING AND INDUSTRIAL COMPUTER SCIENCE, AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY, KRAKOW, POLAND
*E-MAIL: SZARAN@AGH.EDU.PL

[ENGINEERING OF BIOMATERIALS 148 (2018) 116]

Introduction

The surface is the most important part of an implant, due to the fact that it is the one that will always be in contact with the living tissues. Almost all of the interactions between cells and tissues with a material at the tissue implant interface refer to surface phenomena, thus a surface plays an important role in the integration of the implant with surrounding tissues. In order to improve the biological properties of titanium, multifunctional composite coatings are used to modify surface properties [1-3].

Materials and Methods

In this work, coatings were composed of polylactide (PLA, PL38 Purasorb, Purac), graphene oxide (GO, ITME) and hydroxyapatite (HAP, Chema Elektromet). Four compositions were prepared: PLA, PLA with 3wt% of GO, PLA with 1wt% of HAP and PLA with 3wt%of GO and 1wt% of HAP. Thin films were deposited on pre-etched [3] commercially available pure titanium Grade 2 plates (10x10mm) (Torresin Titanio SRL, Italy). Pure PLA (solution: 1g PLA / 10ml DCM) and PLA with additives (homogenized with sonicator, Vibra-Cell Sonics) were deposited by dip coating method with a speed of 50mm/min. The surface roughness (R_a, R_t, R_z) was measured using profilometer (Hommelwerke T 4000). For evaluating the quality of the coatings, scratch tests (NST 50-146 CSM Instruments) and microscopic observations (digital microscope VHX 5000, Keyence and scanning electron microscope FEI Nova NanoSEM 200) were carried out. Scratch tests were used for analysing the adhesion of the coatings to the titanium. Adhesion force was determined by generating a controlled scratch with a diamond tip on the sample under a progressive load perpendicular to the surface. The maximum load on the indenter was 100 mN.

Results and Discussion

As it is shown in FIG 1, the surface roughness was higher for composite coatings than for pure polymer layer. HAP powder presence had higher impact than GO. The highest R_a, R_t and R_z parameters values were for PLA-GO/HAP. Microscopic observations (FIG. 1b) did not show detachment of the composite coatings in a result of scratch test. The polymer modified with graphene and/or hydroxyapatite exhibited plastic deformation, it was pressed in and pulled with a movement of a scratch tester tip. It is clearly visible on the SEM images, eg. for a PLA-GO coating (FIG. 2). Similar behaviour was observed for other composite coatings. In the case of pure polymer coating, even with lower magnifications (200x), localized changes after scratch were visible. In FIG. 1a, arrows point to spots were film is no longer transparent and starts loosing contact with a titanium surface. It was confirmed with SEM observations that showed discontinuity of the polymer layer, its detachment and folding (FIG. 2a).

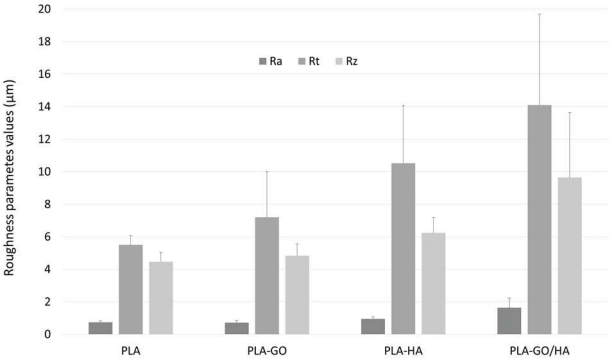

FIG. 1. The surface roughness of the titanium with coatings.

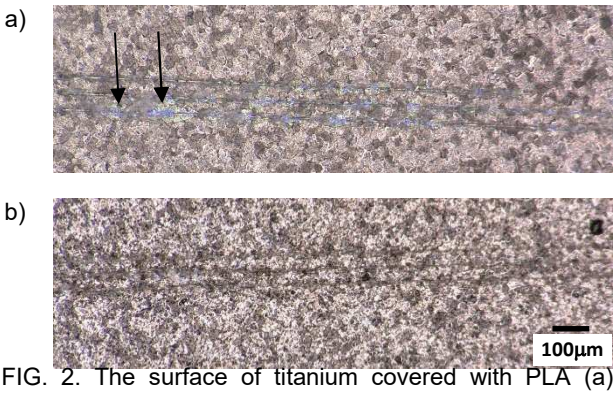

FIG. 2. The surface of titanium covered with PLA (a) and PLA-GO (b) after the scratch test (optical microscope).

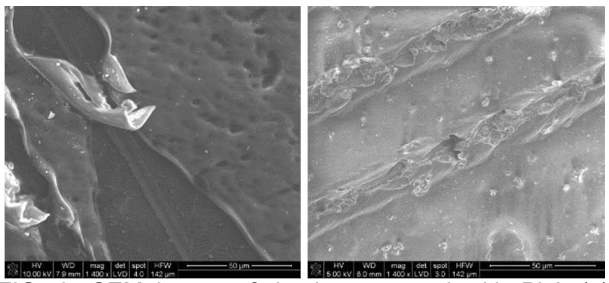

FIG. 3. SEM image of titanium covered with PLA (a) and PLA-GO (b) after the scratch test.

Conclusions

Dip coating method allowed obtaining continuous and good quality PLA and PLA with GO and/or HAP composite coatings. The adhesion of the composite films to titanium was better than that of pure polymer, what may be related to nanocomposites interactions with titanium surface or polymer plastification by additives [4].

Acknowledgments

The authors acknowledge financial support from AGH-UST project no 11.11.160.182.

References

[1] B. Szaraniec, K. Pielichowska, E. Pac *et al.,* *Mat. Sci. Eng. C* 93 (2018) 950-957.
[2] A. Bartkowiak, K. Suchanek, E. Menaszek *et al.,* *Mat. Sci. Eng. C* 92 (2018) 88-95.
[3] R. Pokrowiecki, T. Zaręba, B. Szaraniec, *et al.,* *Int. J. Nanomedicine* 12 (2017) 4285-4297.
[4] K. Gryń, B. Szaraniec, A. Morawska-Chochół *et al.* *Eng. Biomat.* 133 (2015) 22–33.