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STUDIES AND RESEARCH ON ADDICTION CORROSION RATE OF TI_6AL_4V, FOR MEDICAL IMPLANTS, DEPENDING ON THE NATURE AND TEMPERATURE OF THE CORROSIVE AGENT

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Abstract

Some new sandblasted and acid etched (SLA) surface methods have been used on Ti_6Al_4V surface. Contact angle test showed that surface hydrophilicity was significantly increased after modified SLA surface modification. The roughness of a metal implant surface was established between, R_a:1.494-2.524 µm. The highest corrosion rate was obtained using $H_2SO_4$1m and HCl1m mixture, 1: 1 as corrosive agent, at 20 °C. Maximum penetration index was obtained under the same conditions.

Key words: Titanium, Sandblasted and acid etched (SLA), roughness surface modification

1. Introduction

This paper aims at addressing a topic of great interest to study the dependence of corrosion titanium used for medical implants both the strength and corrosive agents to temperature.

The main objective of the work is the change of the contact surface of the metal with the biological environment.

Focussing on this aim, we will prepare various type of titanium surfaces by chemical treatment acid etched (SLA) [1], [2].

Unchanged titanium surface used for medical implants is hydrophobic thus preventing proper adhesion with the biological environment [3]. Our study highlights the transformation of the surface into a hydrophilic one and changing the roughness of the contact surface of the titanium [4], [5], thereby changing the substantial adhesion with the biological environment, thus improving the life of the implant [6].

2. Theoretical Considerations

The main parameters that emphasize the success rate of oseointegration titanium implants and ensure long-term stability of these implants consist of optimizing metal surface topography [7], [8]. This can be achieved through several methods. One of those methods is corrosion of the metal surface with various acids to create a desired surface roughness. Another method used is the creation of nanotubes of titanium oxide on the metal surface.

Optimal roughness of the metal surface used for implants must be contained: R = 0.5-2µm [9]. This range of surface roughness is described in literature as the most frequently used model to study the influence of topographic changes in the oseointegration and bone healing. Histological analysis of the healing stages microrough surface locations associated with titanium implants shows that the initial bone formation occurs not only around the nearly walls in the vicinity but also along an area "osteophilice" implant surface [10].

Abrahmasson et al. [11] compared the healing time associated with rough surfaces oseointegration, demonstrating by histological evidence that early healing is associated with implant surfaces microrugnees.

Recently, it has been demonstrated that a chemically modified microrough surface, leading to a hydrophilic surface with fewer contaminants, promoted enhanced bone apposition during the early stages of osseointegration [12].

Chen et all [13] reported that a decrease in a surface roughness of Ti resulted in an increase in its corrosion resistance and a decrease of ion release. The roughness of a metallic implant surface and its uniformity in the horizontal or vertical direction influence its favorable mechanical locking to tissues.

Sandblasted and acid etched (SLA) titanium surface is a popular surface, which has application in clinical usage for many years [14].

Even if the SLA dental implants are today the most used in clinical practice, there is a lack of description in the manufacturing process.[15]. They showed that corrosion rate for Ti_6Al_4V alloy in single acid/mixture of acids bath (hydrochloric acid, sulphuric acid) at room temperature is extremely low. At high temperatures (60˚C), corrosion rate is higher in all acid uses. The most effective is the mixture of sulphuric acid and hydrochloric acid.

3. Experimental part

All samples subjected to corrosion were first blasted with $Si0_2$.

Then, were subjected to corrosion with various mixtures of acids:

• samples 81, 82 and 83: sulfuric acid and hydrochloric acid

•sample 84: mixture of hydrofluoric acid and phosphoric acid.

- Sample 82 was maintained at 60 ° C in an oven for 24 hours
- The other samples were etched at 20 ° C for 24 hours, thus the sample 83 was kept 48 hours.

We used analytical balance for weighing Adams type

All purity acids were used p.a.

For the temperature of 60˚C the Humboldt type oven was used.

The corrosion rate was calculated by the relationship given by:

$$V_c = k_g = \frac{\Delta m}{S \cdot t} \text{ [g/m}^2\text{·h]} \qquad (1)$$

where:

Δm - is the amount (g) of metal that passes in corrosive solution after anodic dissolution process,

t - duration of exposure of the sample in corrosive environment (h)

S – surface of titanium (m^2)

Penetration index expressed in [mm/year], was calculated using the formula:

$$I_p = \frac{k_g \cdot 24 \cdot 365}{1000\, d} \text{ [mm/an]} \qquad (2)$$

where:

d- is the density of the metallic material.

4. Results and discussion

Experimental results obtained are listed in tables 1,2,3.

Sample Nr.	Corrosive environment	Corrosion time [h] / Temperature [˚C]	Mass of the sample before corrosion [g]	Mass of the sample after corrosion [g]
81	HCl 1m, H_2SO_4 1m 1:1	24 20	2,7536	2,7534
82	HCl 1m, H_2SO_4 1m 1:1	24 60	2,7523	2,7182
83	HCl 1m, H_2SO_4 1m 1:1	24 20	5,8212	5,8204
83	HCl 1m, H_2SO_4 1m 1:1	48 20	5,8212	5,8105
84	HF 0.5%, H_3PO_4 1m 1:1	24 20	5,7922	5,7331

Table 1: Corrosive environment used, time of corrosion weight samples before and after corrosion.

Sample Nr	Δm	S [m^2]	V_c [g/m^2h]	I_p [mm/an]
81	0,0002	0,0003 56704	0,0233	0,0452
82	0,0341	0,0003 53225	4,022	7,79
83	0,0008	0,0009 68436	0,034	0,065
83	0,0107	0,0009 68436	0,23	0,446
84	0,0591	0,0009	2,547	4,94

Table 2: The corrosion rate and penetration index

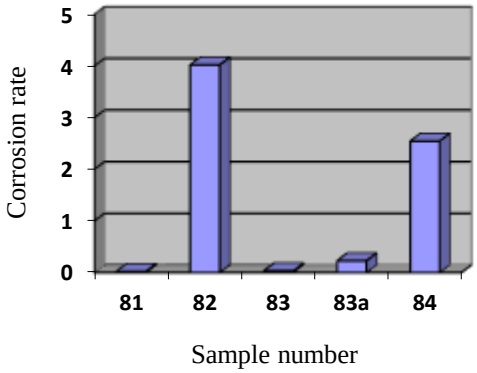


Fig.1.: Dependence of corrosion rate of environmental corrosive nature

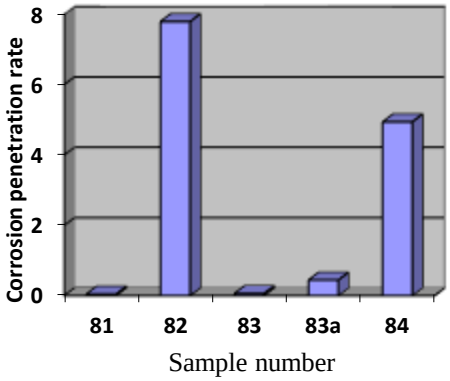


Fig.2: Dependence Ip of the nature of corrosive agent

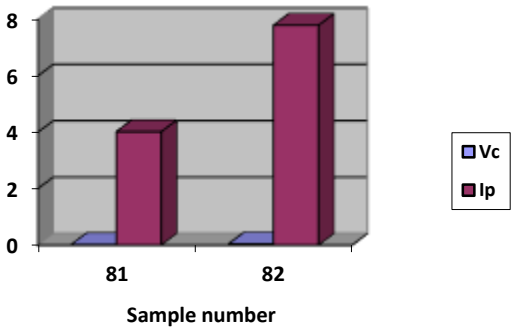


Figure 3: Dependence of the corrosion rate and penetration index by temperature

Sample number	Corrosive agent	Corrosion time [h] Temperature [˚C]	Ra [µm]	Rz [µm]
81	HCl 1m, H_2SO_4 1m 1:1	24 20	2,213	14,477
82	HCl 1m, H_2SO_4 1m 1:1	24 60	2,012	12,134
83	HCl 1m, H_2SO_4 1m 1:1	24 20	1,494	14,34
84	HF 0.5%, H_3PO_4 1m 1:1	24 20	2,524	14,34

Table 3: Roughness determination

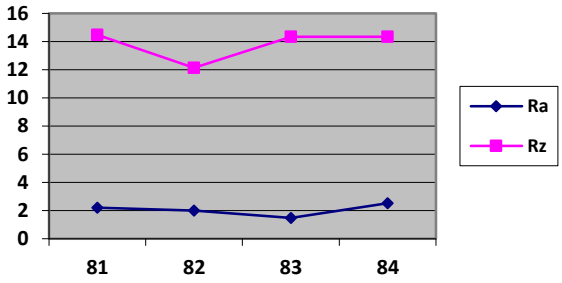


Figure 4: Results of the measurements of the roughness surface

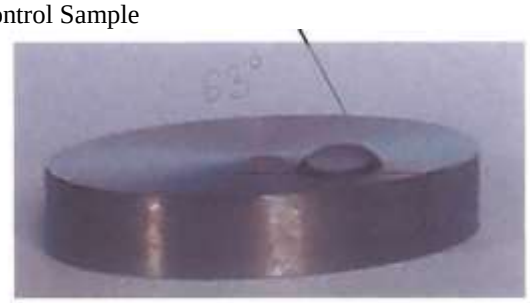
In order to estimate the transformation of the samples surfaces from hydrophobic in hidrophilic we droplet pure water on the samples into surface. The contact angle formed between liquid/vapor interfaces and the solid surface is much lower. The results are shown in figure number 5.

5. Conclusions

In this experiment we emphasized:

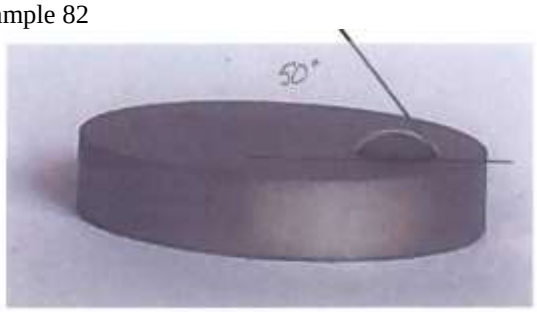
- The nature of corrosive agent has a big influence in corrosion rate and penetration rate.
- Through this process we can transform the surface of titanium from hydrophob into hydrophil.

Control Sample



Sample 81

Sample 82



Sample 83

Figure 5: Contact angle between dripping pure water and metallic surface

- Surface roughness is also influenced by the corrosion process, being able to obtain the desired roughness.
- In our experiment the sample that is the most suitable for testing the implants is sample number 83.

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