# INFLUENCE OF THERMO-CHEMICAL TREATMENT METHODS ON PITTING CORROSION RESISTANCE OF Ti6Al4V ALLOY

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**Introduction**

Thermo-chemical treatments such as oxidation, carburization or nitriding are used in order to improve the mechanical properties of materials, especially the tribological superficial one. This parameter is particularly important for metallic biomaterials, which are used for implants production. Biomaterials working in a pair, such as endoprosthesis in a hip-joint, are particularly exposed to wear friction, so they should have a very high tribological strength. Additionally, the body fluids consist very harsh environment for biomaterials and can reduce the corrosion resistance of implants. That leads to a pitting corrosion. When it develops implant must be removed from the body, because the products of corrosion can damage the surrounding tissues. An important aspect for this is therefore to keep balance between the thermo-chemical treatment and corrosion resistance of the material. The results present in this work show the influence of thermo-chemical treatments on the corrosion potential and pitting corrosion of the Ti6Al4V alloy.

**Materials and Methods**

Samples made of Ti6Al4V alloy were superficially diffusive strengthen through the following thermo-chemical treatments: oxidation, carburization and nitriding. The processes were carried out in a wide temperature range from 650ºC do 950ºC. Next the samples were investigated towards corrosion properties. Corrosion tests were done in deoxygenated PBS solution (pH 7.4) using potentiostat/galvanostat AUTOLAB 302N (Metrohm Autolab B.V.) controlled by NOVA 1.11 software. Saturated calomel electrode was used as reference, while a platinum wire served as the auxiliary electrode. The corrosion potential was measured in open circuit potential for 1800s. The resistance to pitting corrosion was evaluated by anodic polarization up to potential value of 4V (the scan rate was 1.0 mV/s). After polarization tests the samples were photographed and their surfaces were examined using metallographic microscope.

**Results and Discussion**

The corrosion resistance of materials strongly depends on their surface chemistry which is correlated with the corrosion potential ($E_{cor}$) value. Therefore some initial information about corrosion properties of investigated materials may be extracted from the comparison of $E_{cor}$ values determined before and after applied surface treatments. In this study all applied thermo-chemical treatments resulted in higher value of corrosion potential ($E_{cor}$). The highest $E_{cor}$ value was determined for Ti6Al4V alloy sample carburization at temperature of 850ºC.

The effect of thermo-chemical surface treatments on pitting corrosion resistance of titanium alloy was estimated on the basis of potentiodynamic characteristics gathered in a wide range of anodic polarization. Such characteristics representative for each type of investigated samples are shown in FIG. 1. These characteristics allowed to determine the pitting potential ($E_{pit}$), which was taken as the potential value, where an abrupt increase in the anodic current density was observed. From FIG. 1 it is evident that titanium alloy without surface treatment, as well as alloy samples oxidized and gas nitrided at lower temperature are pitting resistant. In the case of these samples no pitting corrosion could be detected. While for the other samples the pitting occurred, and $E_{pit}$ potential was detected in the range of 2.0-2.5V. The changes in surface morphology caused by anodic polarization were different depending on type of sample. The photographs of the investigated samples taken after anodic polarization are presented in FIG. 2.

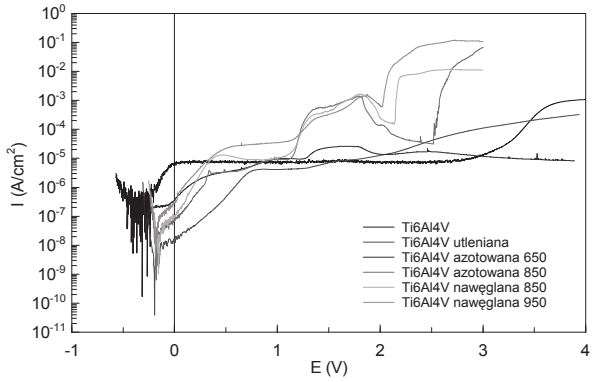


FIG. 1. The anodic polarization curves for thermo-chemical treated Ti6Al4V alloy samples.

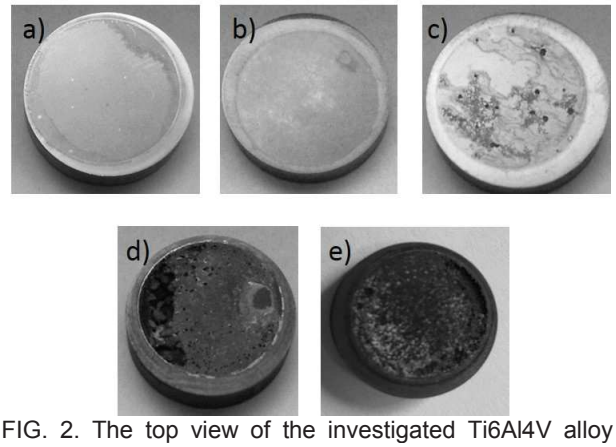


FIG. 2. The top view of the investigated Ti6Al4V alloy samples after anodic polarization a) oxidized, b) gas nitrided 650ºC, c) gas nitrided 850ºC, d) gas carbourized 850ºC, e) gas carbourized 950ºC.

**Conclusions**

Taking into consideration the obtained results it can be pointed that all the applied surface treatment processes alter the corrosion properties of Ti6Al4V alloy. Gas nitriding at higher temperature, as well as gas carburizing regardless on process temperature increase the pitting sensitivity of titanium alloy. Nevertheless the pitting corrosion resistance of such samples is still sufficient for biomedical application since pitting potentials are very high (above 2V).

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