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Effect of potassium fluoride on the structure and corrosion properties of anodic coatings on Ti6Al4V alloy

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Abstract – In this study, KF film was obtained by anodization method on Ti6Al4V material, which is preferred to be used in many areas such as the defense industry, biomedical field and aviation sector. The aim of this study is to compare the corrosion resistance of untreated Ti6Al4V, TiO_2 coated Ti6Al4V and KF (potassium fluoride) coated Ti6Al4V samples. XRD and SEM were used for the structural characterization of the samples. Corrosion experiments were performed in simulated body fluid (SBF). According to the results, the highest corrosion resistance was obtained in the new morphological structure obtained by KF coating of the volcano-type structures.

Keywords – KF, Corrosion, Anodization, Ti6Al4V.

I. INTRODUCTION

Today, titanium and its alloys are used in many applications in areas such as aerospace, biomedical field and defense industry due to their high strength, good fatigue strength, biocompatible structure and many other superior properties [1]. Among titanium and its alloys, one of the most preferred materials for use in applications is Ti6Al4V alloy [2].

However, as in every material, there are some disadvantages in Ti6Al4V alloy. These disadvantages limit the lifetime of applications produced using Ti6Al4V material. One of the most important of these disadvantages is that the corrosion resistance is insufficient under certain conditions due to the effect of environmental factors (high temperature, exposure to abrasion) [3]. It has been emphasized in the literature that the corrosion resistance of the Ti6Al4V alloy is insufficient under the influence of some environmental conditions and environmental factors. When the studies to eliminate this disadvantage in the literature are examined, it has been seen that most of the studies have tried to make the Ti6Al4V material more resistant to corrosion by applying protective coatings [4-6].

One of the methods used to produce a protective coating is the anodization method. Because the anodization method has some advantages over other methods. The most important of these is that the protective coating thickness can be obtained at the desired thickness and its applicability is easy [7]. In addition, by producing protective coatings in different chemical compositions with the anodization method, the desired physical, chemical and mechanical strengths can be developed, depending on the area of use.

In this study, TiO_2 and KF coatings were produced on the Ti6Al4V sample by anodization method. The purpose of this study is to determine the corrosion behavior of untreated Ti6Al4V, TiO_2 coated Ti6Al4V and KF coated Ti6Al4V samples. XRD and SEM were used for the structural characterization of the samples. Electrochemical properties were investigated using potentiodynamic polarization and open circuit potential (OCP) approaches.

II. MATERIALS AND METHOD

In this study, Ti6Al4V samples whose chemical composition was given in another study were used

[8]. All Ti6Al4V samples were polished with 80-1200 SiC abrasive papers and then ultrasonically cleaned in acetone and ethanol. The samples were again ultrasonically cleaned with distilled water and dried.

The stainless-steel container's wall and a sample of the Ti6Al4V alloy were employed as the anode and cathode, respectively. The electrolytic solutions contained distilled water, 2.0 g/l KOH, and 20.0 g/l Na_2SiO_3 with or without the addition of 16.0 g/l KF. Using a Cu-K (=1.54059) source at 40 kV and 30 mA with an XRD-GNR-Explorer X-Ray diffraction equipment, the phase of Ti6Al4V samples was calculated using a 2 scale between 10° and 90°. By comparing them to the International Diffraction Data Center (ICDD) standard cards, all phases could be identified. Using the FEI QUANTA 250 Scanning Electron Microscope, pictures of the top and cross-section were captured.

In electrochemical studies using the GAMRY series G750TM (Gamry Instruments, Warminster, USA) in SBF solution, potentiodynamic polarization was used. The three-electrode technique was used for the electrochemical tests. The counter electrode was made of graphite, and the reference electrode was made of Ag/AgCl [9].

III. Results

XRD plots of untreated Ti6Al4V, TiO_2 and KF coated Ti6Al4V samples are shown in Fig. 1. When the XRD graphics are examined, it is seen that the Ti6Al4V sample has an α-Ti and β-Ti structure. When the XRD graph of the film obtained after the anodization surface treatment was examined, it was confirmed in the XRD graphs that the TiO_2 and KF structure was formed on the Ti6Al4V surface [10].

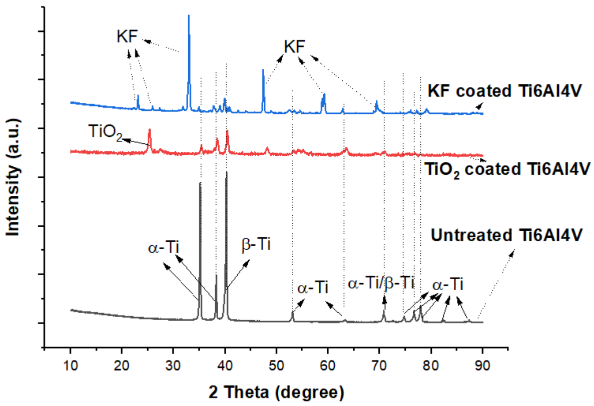

Fig. 1 XRD graphs of untreated Ti6Al4V, TiO_2 caoted Ti6Al4V, and KF coated Ti6Al4V.

Fig. 2 shows top view SEM images of untreated Ti6Al4V, TiO_2 and KF coated Ti6Al4V samples. It is observed that volcano-type TiO_2 structures are formed after the anodization process. As can be seen from the surface roughness values of volcano-type TiO_2 structures given in Fig. 3, it was observed that the surface roughness increased compared to the untreated sample. Afterward, it is understood from both SEM images and surface roughness images that the surface roughness decreases with the acquisition of the KF structure [10].

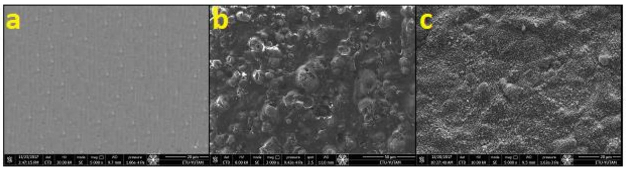

Fig. 2 SEM images of (a) untreated Ti6Al4V, (b) TiO2 caoted Ti6Al4V, (c) KF coated Ti6Al4V.

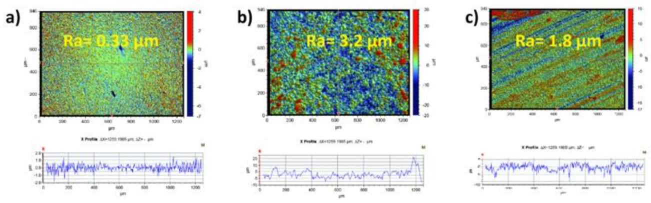

Fig. 3. Surface roughness images of (a) untreated Ti6Al4V, (b) TiO2 caoted Ti6Al4V, (c) KF coated Ti6Al4V.

Open circuit potentials and potentiodynamic polarization curve graphs of coated and untreated Ti6Al4V samples are shown in Figs. 4 and 5, respectively. When the graphics are examined, it is seen that the corrosion resistance increases because of the anodic film formed on Ti6Al4V. When the OCP graphs are examined, the positive way shift of the graph after the anodization surface treatment shows that the corrosion resistance increases [11]. In this way, the highest corrosion resistance was obtained from the KF-coated sample. In addition, when the potentiodynamic polarization curve graphs are examined, it is seen that the highest corrosion resistance is obtained from the KF-coated sample. As can be seen from the SEM images, covering the volcano-type structures after KF coating reduced the contact of the SBF liquid with the substrate, resulting in an increase in corrosion resistance [10].

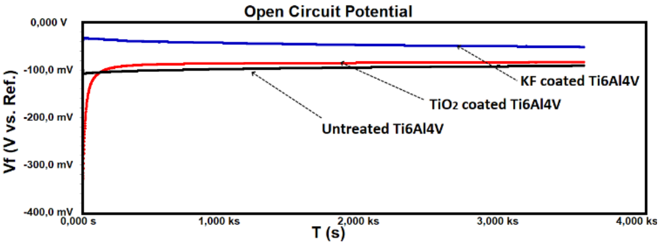

Fig. 4. Open circuit potential graphs of untreated Ti6Al4V, TiO2 caoted Ti6Al4V, and KF coated Ti6Al4V.

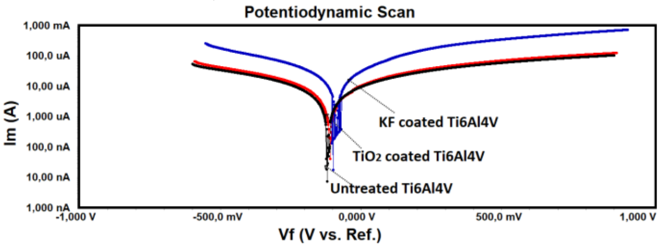

Fig. 5. Potentiodynamic polarization curves of untreated Ti6Al4V, TiO2 caoted Ti6Al4V, and KF coated Ti6Al4V.

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IV. DISCUSSION

In this study, untreated Ti6Al4V, TiO_2 coated Ti6Al4V and KF coated Ti6Al4V samples were used and corrosion performance was evaluated after structural analysis. The presence of TiO_2 and KF was confirmed by XRD analyses. After SEM analysis, it is seen that the morphological structure of the surface has changed. The highest surface roughness was obtained from volcano type structures. Also, it was observed that the surface roughness decreased with the KF coating. According to the results obtained from the electrochemical experiments, the highest corrosion resistance was obtained with the reduction of the contact between the SBF liquid and Ti6Al4V by the KF structures covering the volcano-type structures.

V. CONCLUSION

As a result, volcano-type structures obtained by anodization method on Ti6Al4V changed the surface morphology. Covering of volcano type structures by KF structures caused an increase in corrosion resistance.

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REFERENCES

[1] X. Liu, P.K. Chu, C. Ding, Surface modification of titanium, titanium alloys, and related materials for biomedical applications, Mater. Sci. Eng. R Rep. 47 (2004) 49–121.

[2] A. Çelik, M.T. Acar, T. Yetim, H. Kovacı, A.F. Yetim, Improving structural, tribological and electrochemical properties of Ti6Al4V alloy with B-doped TiO2 thin films, Tribol. Int. 146 (2020) 106210.

[3] C. Xu, L.-Y. Chen, C.-B. Zheng, H.-Y. Zhang, C.-H. Zhao, Z.-X. Wang, S. Lu, J.-W. Zhang, L.-C. Zhang, Improved wear and corrosion resistance of microarc oxidation coatings on Ti–6Al–4V alloy with ultrasonic assistance for potential biomedical applications, Adv. Eng. Mater. 23 (2021) 2001433.

[4] M.T. Acar, H. Kovacı, A. Çelik, Enhancement of the tribological performance and surface wettability of Ti6Al4V biomedical alloy with boric/sulfuric acid anodic film, Surf. Topogr. Metrol. Prop. 9 (2021) 035024.

[5] C.T. Kwok, P.K. Wong, F.T. Cheng, H.C. Man, Characterization and corrosion behavior of hydroxyapatite coatings on Ti6Al4V fabricated by electrophoretic deposition, Appl. Surf. Sci. 255 (2009) 6736–6744.

[6] M.F.M. Yusoff, M.R.A. Kadir, N. Iqbal, M.A. Hassan, R. Hussain, Dipcoating of poly (ε-caprolactone)/hydroxyapatite composite coating on Ti6Al4V for enhanced corrosion protection, Surf. Coat. Technol. 245 (2014) 102–107.

[7] M.T. Acar, H. Kovacı, A. Çelik, Improving the wettability and corrosion behavior of Cp-Ti by applying anodization surface treatment with the addition of boric acid, graphene oxide and hydroxyapatite, Mater. Today Commun. 31 (2022) 103683.

[8] M.T. Acar, H. Kovacı, A. Çelik, Comparison of the structural properties, surface wettability and corrosion resistance of TiO2 nanotubes fabricated on Cp-Ti, Ti6Al4V and Ti45Nb, Mater. Today Commun. 33 (2022) 104396.

[9] M.T. Acar, H. Kovacı, A. Çelik, Investigation of corrosion and tribocorrosion behavior of boron doped and graphene oxide doped TiO2 nanotubes produced on Cp-Ti, Mater. Today Commun. 32 (2022) 104182.

[10] J. Liang, B. Guo, J. Tian, H. Liu, J. Zhou, T. Xu, Effect of potassium fluoride in electrolytic solution on the structure and properties of microarc oxidation coatings on magnesium alloy, Appl. Surf. Sci. 252 (2005) 345–351.

[11] O. Çomakli, M. Yazici, T. Yetim, A.F. Yetim, A. Çelik, The effects of aging time on the structural and electrochemical properties of composite coatings on CP-Ti substrate, J. Bionic Eng. 14 (2017) 532–539.