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Corrosion resistance of Ni-Ti alloy, SS18/8 alloy and thermoactive alloy in artificial saliva in the absence and presence of tea

ABSTRACT

Corrosion resistance of Ni-Ti alloy, SS18/8 alloy and thermoactive alloy in artificial saliva (AS) in the absence and presence of tea has been evaluated by such as polarization study. For Ni-Ti alloy, SS18/8 alloy and thermoactive alloy, polarization study lead to the conclusion that corrosion resistance of Ni-Ti alloy and thermoactive alloy decreases in the order

AS + Tea > Tea > AS

Hence, people implanted with orthodontic wire, made of Ni-Ti alloy and thermoactive alloy can take tea orally without any hesitation.

For SS18/8 alloy, polarization study lead to the conclusion that corrosion resistance of SS18/8 alloy decreases in the order

AS > AS + Tea >Tea

So, people implanted with orthodontic wire, made of SS18/8 alloy should avoid taking tea.

Keywords: *corrosion resistance, orthodontic wires, artificial saliva, extract tea, Ni-Ti alloy, SS18/8 alloy, thermoactive alloy, polarization study.*

1. INTRODUCTION

Corrosion is the one of the most common process. It is a natural, spontaneous and thermo-dynamically favorable process. This problem caused by the defects in the components of the implants. Corrosion is destruction of materials when they interact with the the environment. The teeth could be regularized and by using orthodontic wires. Orthodontic wires can be made of many metals and alloys. After implantation many food items, many tablets are also orally taken. In the oral environment these orthodontic wires undergo many types of corrosion. In dentistry, metallic materials are used as implants in reconstructive oral surgery to replace a single tooth or an array of teeth [1]. Many metals and alloys have been used in dentistry. The corrosion behavior in artificial saliva has been investigated. The effect of different concentrations of eugenol in artificial saliva on titanium corrosion has been investigated by Kinani and Chtaini [2]. Corrosion resistance tests of the CrNi, NiTi, and CuNiTi wires showed comparable data of parameters obtained in artificial saliva. The effects of multilayered Ti/TiN or single-layered TiN films deposited by pulse-biased arc ion plating (PBAIP) on the corrosion behavior of NiTi orthodontic brackets in artificial saliva have been investigated by Liu et al. [3]. The corrosion resistance of stainless steel 316L, mild steel (MS), and mild steel coated with zinc (MS-Zn) has been evaluated in artificial saliva in the absence and presence of spirulina, D-Glucose and electrol[4]. Five non-precious Ni-Co based alloys have been analyzed with respect to their corrosion behavior in artificial saliva [5]. The corrosion resistance of orthodontic wire made of 18 carat gold, in artificial saliva in presence of a tablet Brufen 400 mg has been investigated by MohamedKasim sheit et al., The corrosion behavior of palladium silver binary alloy, TiCrNi, NiTi, CuNiTi, dental amalgam [6-11], in artificial saliva has been investigated. Corrosion resistance of two orthodontic wires made of thermoactive superelastic shape memory alloy and 22 K gold in artificial saliva in the absence and presence of syzygium cumini extract has been evaluated by Madhumitha et al.[12]. Corrosion resistance of Super Elastic Nickel-Titanium alloy in

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artificial saliva, in the absence and presence of a tablet namely, Almox 250mg has been evaluated by Rajendran et al. [13 - 20]. Various metals and alloys have been used as biomaterials whose corrosion resistance has been investigated in artificial body fluids; various metals and alloys such as Ni-Al-Fe intermetallic alloys [21], titanium alloy [22], NiTi alloy [23], CoCrMo alloys [24,25], magnesium alloy [26,27], Cr-Ni stainless steel, Cr-Ni-Mo stainless steel [28], 316L stainless steel [29-31]. Corrosion inhibiting properties of some crown ethers on corrosion of stainless steel (types 304 and 316) in hydrochloric acid has been evaluated by Abdallah et al.,[32]. Corrosion behaviour of SS 316 L in artificial saliva in presence of electoral has been studied by Rajendran et al. [33]. Christy et al., have studied that the Influence of corrosion resistance of orthodontic wires in artificial saliva in the absence and presence of coffee [34].

2. EXPERIMENTAL

Orthodontic wires made of Ni/Ti, SS 18/8 and thermoactive alloys were used in the present study. The alloys were used as working electrode. Corrosion behavior of Ni/Ti, SS 18/8 and thermoactive alloys have been investigated in various test solution such as Artificial Saliva, Tea, Artificial Saliva +Tea. Orthodontic wires immersed in Fusayamma Meyer artificial saliva whose composition is

Table 1: Composition of Artificial Saliva

Tabela 1. Sastav veštačke pljuvačke

S.No	Name of the chemicals	Weight/lt
1	KCl	0.4g/l
2	NaCl	0.4g/l
3	$NaH_2PO_4.2H_2O$	0.690g/l
4	Urea	1g/l
5	$CaCl_2.H_2O$	0.906g/l
6	$Na_2S.9H_2O$	0.005g/l

3. RESULT AND DISCUSSION

3.1. Potentiodynamic Polarization study

Polarization analysis has been used for detection of the protective film formation on the metal surface during corrosion inhibition process. Polarization studies were carried out in a CHI-Electrochemical workstation with impedance, Model 660A. A three-electrode cell assembly was used. The working electrode was one of the three alloys. A saturated calomel electrode (SCE) was the reference electrode while platinum was the counter electrode. From the polarization study, corrosion parameters such as corrosion potential (E_{corr}), corrosion current (I_{corr}), and Tafel Slopes (anodic = b_a and cathodic = b_c) were calculated.

3.2. Analysis of Polarization curves

Corrosion resistance of Ni-Ti alloy, SS18/8 alloy and thermoactive alloy in various test solutions has been evaluated by polarization study. When corrosion resistance increases Linear Polarization Resistance (LPR) increases; corrosion current(I_{corr}) decreases [33-41].

Ni – Ti alloy

The polarization curves of Ni-Ti alloy immersed in various test solutions are shown in Fig 1. The corrosion parameters namely Corrosion Potential (E_{corr}), Tafel slopes ((b_c= cathodic; (b_a=anodic)), Linear Polarization Resistance (LPR) and Corrosion current(I_{corr}) are given in Table 2.

When Ni-Ti alloy is immersed in Artificial Saliva (AS), Linear Polarization Resistance (LPR) value is 3277970 ohm cm^2. The Corrosion current (I_{corr}) is $1.488x10^{-8}$ A/ cm^2 . The Corrosion Potential (E_{corr}) is -375 mV vs SCE. When Ni-Ti alloy immersed in Tea, Linear Polarization Resistance (LPR) value increases from 3277970 to 3422320 ohm cm^2. The Corrosion current (I_{corr}) decreases from $1.488x10^{-8}$ to $1.300\ x10^{-7}$ A/ cm^2 . This indicates that Ni-Ti alloy is more corrosion resistant in Tea. Further, the Corrosion Potential (E_{corr}) value shifts from -375 to -553 mV vs SCE. A protective film is forms on the metal surface. When Ni-Ti alloy immersed in the system consisting of AS and Tea, the LPR value further increases to 4697814 ohm cm^2. The Corrosion Current decreases to $8.420\ x10^{-9}$ A/ cm^2. This indicates that Ni-Ti alloy is more corrosion resistant in AS + Tea system than in Tea system or AS system. Further, the Corrosion Potential shifts to -638 mV vs SCE. Thus the polarization study leads to the conclusion that when Ni-Ti alloy is immersed in various test solution, the decreasing order of corrosion resistance of Ni-Ti alloy is as follows:

AS + Tea > Tea > AS

This study reveals that people having orthodontic wires made of Ni-Ti alloy should not hesitate to take Tea. The reason for it is because in this medium the corrosion resistance of Ni-Ti alloy increases.

Table 2: Corrosion parameters of alloys immersed in Artificial Saliva (AS) in the presence and absence of Tea, obtained by Polarization study

Tabela 2. Parametri korozije legura uronjenih u veštačku pluvačku (AS) u prisustvu i odsustvu čaja, dobijeni polarizacionim ispitivanjima

Metal	System	E_{corr} mVvs SCE	b_c mV/decade	b_a mV/decade	LPR Ohm cm^2	I_{corr} A/cm^2
Ni-Ti alloy	AS	-375	178	302	3277970	1.488x10^{-8}
	Tea	-553	143	359	342232	1.300x10^{-7}
	AS+ Tea	-638	129	310	4697814	8.420x10^{-9}
SS 18/8	AS	-343	193	302	2638460	1.942x10^{-8}
	Tea	-391	176	273	2101240	2.210x10^{-8}
	AS+ Tea	-657	162	296	964243	4.717x10^{-8}
Thermoactive	AS	-501	158	315	7636745	5.775x10^{-9}
	Tea	-466	171	212	14251401	2.767x10^{-9}
	AS+ Tea	-622	142	280	8369940	4.890x10^{-9}

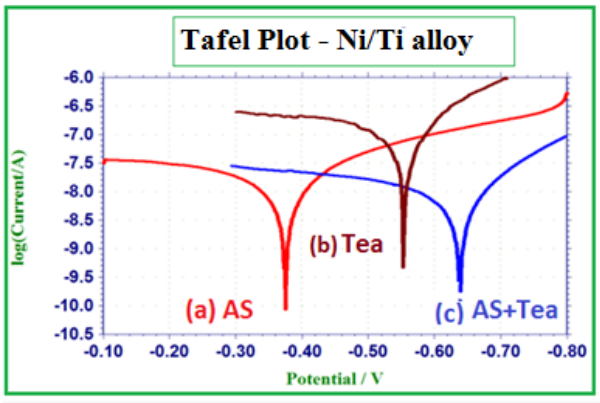

Figure 1. Polarization curve of Ni-Ti alloy immersed in various test solution: (a) AS (b) Tea (c) AS + Tea

Slika 1. Polarizacione krive legure Ni-Ti uronjene u različite ispitivane rastvore: (a) AS (b) Čaj (c) AS + Čaj

3.3. SS18/8 alloy

The polarization curves of SS18/8L alloy immersed in various test solutions are shown in Fig 2. The corrosion parameters namely Corrosion Potential (E_{corr}), Tafel slopes ((b_c= cathodic; (b_a=anodic)), Linear Polarization Resistance (LPR) and Corrosion current(I_{corr}) are given in Table 2. When SS18/8 alloy immersed in Artificial Saliva (AS), Linear Polarization Resistance (LPR) value is 2638460 ohm cm^2. The Corrosion current (I_{corr}) is 1.942 x10^{-8} A/ cm^2 . The Corrosion Potential (E_{corr}) is -343 mV vs SCE. When SS18/8 alloy immersed in Tea, Linear Polarization Resistance (LPR) value decreases to 2101240 ohm cm^2. The Corrosion Current (I_{corr}) increases to 2.210 x10^{-8}A/ cm^2. This indicates that corrosion resistant of SS18/8 alloy decreases in Tea, when compare to the one in saliva system. When SS18/8 alloy is immersed in AS and Tea system, the LPR value further decreases (964243 ohm cm^2) while the corrosion current value (4.717 x10^{-8}A/ cm^2) further increases. This indicates the corrosion resistance of SS18/8 alloy decreases in AS + Tea system. Thus the polarization study leads to the conclusion that when SS18/8 alloy is immersed in various test solutions, the decreasing order of corrosion resistance of SS18/8 is as follows:

AS > Tea >AS + Tea

This study suggests that people having orthodontic wires made of SS18/8 alloy should avoid taking Tea. The reason for it is because in this medium the corrosion resistance of SS18/8 alloy decreases.

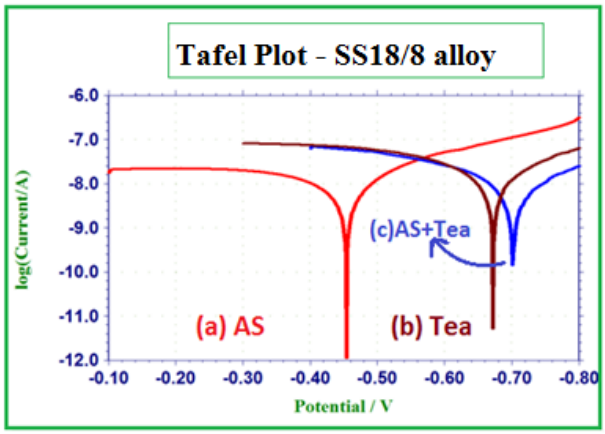

Figure 2. Polarization curve of SS18/8 alloy immersed in various test solution: (a) AS (b) Tea (c) AS + Tea

Slika 2. Polarizacione krive legure SS18/8 uronjene u različite ispitivane rastvore: (a) AS (b) Čaj (c) AS + Čaj

3.4. Thermoactive alloy

The polarization curves of Thermoactive alloy immersed in various test solutions are shown in Fig 3. The corrosion parameters namely Corrosion Potential (E_{corr}), Tafel slopes ((b_c = cathodic; (b_a=anodic)), Linear Polarization Resistance (LPR) and Corrosion current(I_{corr}) are given in Table 2.

When Thermoactive alloy immersed in Artificial Saliva (AS), Linear Polarization Resistance (LPR) value is 7936745 ohm cm^2. The Corrosion current (I_{corr}) is 5.775x10^{-9} A/ cm^2 . The Corrosion Potential (E_{corr}) is -501 mV vs SCE. When Thermoactive alloy immersed in Tea, Linear Polarization Resistance (LPR) value increases from 7936745 to 14251401 ohm cm^2. The Corrosion current (I_{corr}) decreases to 2.767 x10^{-9} A/ cm^2 . This indicates that Thermoactive alloy is more corrosion resistant in Tea. Further the Corrosion Potential (E_{corr}) value is -466 mV vs SCE. A protective film forms on the metal surface. When Thermoactive alloy immersed in the system consisting of AS and Tea, the LPR value further increases to 8369940 ohm cm^2. The corrosion current decreases to 4.890 x10^{-9} A/ cm^2 than in AS system. This indicates that Thermo-active alloy is more corrosion resistant in AS + Tea system than in Tea system or AS system. Further, the corrosion potential shifts to -622 mV vs SCE. Thus, the polarization study leads to the conclusion that when Thermoactive alloy is immersed in various test solutions, the decreasing order of corrosion resistance of Thermoactive alloy is as follows:

AS + Tea > Tea > AS

This study reveals that people having orthodontic wires made of Thermoactive alloy should not hesitate to take Tea. The reason for it is because in this medium the corrosion resistance of Thermoactive alloy increases.

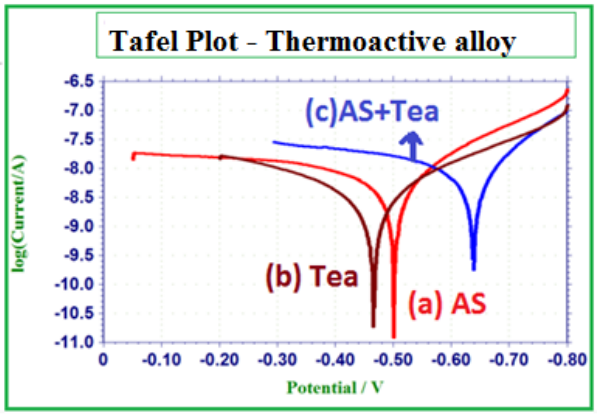

Figure 3. Polarization curve of Thermoactive alloy immersed in various test solution: (a) AS (b) Tea (c) AS + Tea

Slika 3. Polarizacione krive Termoaktivne legure uronjene u različite ispitivane rastvore: (a) AS (b) Čaj (c) AS + Čaj

4. CONCLUSION

- Corrosion resistance of Ni-Ti alloy, SS18/8 alloy and Thermoactive alloy in artificial saliva (AS) in the absence and presence of Tea has been evaluated by polarization study.
- For Ni-Ti alloy and Thermoactive alloy polarization study leads to the conclusion that corrosion resistance of Ni-Ti alloy and Thermoactive alloy decreases in the order
- AS + Tea > Tea > AS
- For SS316L alloy polarization study leads to the conclusion that corrosion resistance of SS18/8 alloy decreases in the order
- AS >Tea >AS + Tea
- People implanted with orthodontic wire, made of Ni-Ti alloy and Thermoactive alloy can take Tea orally without any hesitation.
- People implanted with orthodontic wire, made of SS18/8 alloy should avoid taking Tea orally.

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IZVOD

OTPORNOST NA KOROZIJU LEGURE Ni-Ti, LEGURE SS18 / 8 I TERMOAKTIVNE LEGURE U VEŠTAČKOJ PLJUVAČCI U ODSUSTVU I PRISUSTVU ČAJA

Otpornost na koroziju legure Ni-Ti, legure SS18 / 8 i termoaktivne legure u veštačkoj pljuvačci (AS) u odsustvu i prisustvu čaja procenjena je polarizacijom. Za legure Ni-Ti, legure SS18 / 8 i termoaktivne legure, polarizaciono ispitivanje dovodi do zaključka da se otpornost na koroziju legure Ni-Ti i termoaktivne legure smanjuje u redosledu

AS + Tea > Tea > AS

Stoga, ljudi implantirani sa ortodontskom žicom, napravljenom od legure Ni-Ti legure i termoaktivne legure mogu uzimati čaj oralno bez ikakvih oklevanja.

Za leguru SS18/8, studija polarizacije dovodi do zaključka da se otpornost na koroziju legure SS18 / 8 smanjuje u redosledu

AS > AS + Tea >Tea

Dakle, ljudi implantirani sa ortodontskom žicom, napravljenom od legure SS18/8 trebalo bi izbegavati uzimanje čaja.

Ključne reči: *otpornost na koroziju, ortodontska žica, veštačka pljuva, ekstrakt čaja, Ni-Ti legura, legura SS18/8, termoaktivna legura, polarizacija.*

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