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Corrosion resistance of SS18/8 alloy, SS316L alloy, Gold18carat and Gold 22 carat in artificial saliva in the absence and presence of erythromycin tablet 500mg

ABSTRACT

Corrosion resistance of SS18/8 alloy, SS316L alloy, Gold18carat and Gold 22 carat in artificial saliva in the absence and presence of Erythromycin tablet 500mg has been evaluated by electrochemical study such as polarization study. For SS316L alloy, Gold 18 carat and Gold 22 carat, Polarization study leads to the conclusion that corrosion resistance of SS316L alloy, Gold 18 carat and Gold 22 carat decreases in the order : AS + Erythromycin > AS. Hence, people clipped with an orthodontic wire made of SS316 alloy, Gold 18 carat and Gold 22 carat can take Erythromycin tablet orally without any hesitation. For SS18/8 alloy, polarization study leads to the conclusion that corrosion resistance of SS18/8 alloy decreases in the order: AS > AS + Erythromycin. So, people clipped with an orthodontic wire made of SS18/8, should avoid taking Erythromycin tablet orally.

Keyword: corrosion resistance, polarization study, orthodontic wire, SS18/8 alloy, SS316L alloy, Gold 18carat and Gold 22 carat, Erythromycin.

1. INTRODUCTON

Orthodontic treatment is vital for improving and maintaining good oral and dental health, as well as creating an attractive smile that contributes to the development of self –esteem. Saul M Castro et el [1]. Model wires should be designed to move teeth with continuous forces and should remain elastic [2]. Different wire alloys are available for orthodontic treatment. However, no wire is optimal for orthodontic applications during all the different stages of treatment [3]. The properties required for orthodontic wires depend on their application, Until the 1930s, the available orthodontic wires were made of gold. Austenitic SS was introduced as an orthodontic wire in 1929, and because of its superior strength, higher modulus of elasticity, good resistance to corrosion, and moderate costs, SS promptly gained acceptance and preference over gold [4].

The alloy of SS most frequently used for orthodontic materials is the American Iron and Steel Institute type 304, containing 18-20% of chromium and 8-10% of nickel[3,5]. SS wires have good biocompatibility, good corrosion resistance, excellent formability, high yield strength, and high modulus of elasticity [4,6].The corrosion is one of the most important problems which lead to the rejection of the implants or their components, the corrosion process can be accelerated by the defects appeared on the surface of the implants, during their manufacturing process. corrosion can be defined as the destruction of a certain substances, especially metal, in reaction with an environment [7]. The issue of corrosion has began to attract attention since the presence of a scientific research about the galvanic corrosion of dental compound about 40 years before [8]. Many metals and alloy have been used in dentistry. The corrosion behavior in artificial saliva has been investigated. Corrosion resistant of 18 Carat Gold in artificial saliva in presence of D-Glucose has been investigated by Saranya et al [9]. Corrosion resistance of SS316Lalloy in artificial saliva in presence of a sparkle Tooth paste has been

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investigated by Renita D' Souza et al [10]. Electrochemical corrosion behavior of Dental/ Implant alloy in artificial saliva has been investigated by Mohit Sharma et al [11].

Corrosion behavior of Metals in Artificial saliva in presence of D-Glucose , Spirulina powder and electrol have been investigated by Rajendran et al [9,12,13]. The corrosion resistance of orthodontic wire made of 18 Carat Gold , in artificial saliva in presence of a tablet Brufen 400mg has been investigated by MohamedKasim Shiet et al [14]. Corrosion resistance of two orthodontic wires made of thermoactive super elastic shape memory alloy and 22k gold in artificial saliva in the absence and presence of syzygium cumini extract has been evaluated by Madhumitha et al [15]. Corrosion resistance of super Elastic Nickel-Titanium alloy in artificial saliva in the absence and presence of tablets namely, Almox 250mg has been evaluated by Rajendran et al [16-23]. Influence of Corrosion resistance of orthodontic wires in artificial saliva in the absence and presence of coffee has been investigated by Christy et al [24]. Corrosion inhibition By an aqueous extract of Aleovera, Henna leaves have been investigated by Sribharathi and Rajendran et al [25,26]. Corrosion Inhibition of Titanium in Artificial Saliva Containing Fluoride and Orthodontic Brackets have been investigated by Kinani et al [27,28]. Corrosion resistance of SS316L immersed in artificial saliva in presence of Ciprofloxacin tablet, Coca –Cola, Maaza, Sparkle Fresh have been evaluated by Mohamed Kasim,Devlin, Sangeetha, Renita et al. [29-31]. The present work was undertaken to study the Corrosion resistance of SS18/8 alloy, SS316L alloy, Gold 18carat and Gold 22 carat in artificial saliva in the absence and presence of Erythromycin tablet 500mg. By a polarization study, corrosion parameters such as Corrosion potential $E_{(Corr)}$, Linear polarization Resistance(LPR), Corrosion current(I_{Corr}) and Tafel slopes (anodic= b_a and cathodic= b_c) were calculated.

2. MATERIALS AND METHODS

Four metal/alloy specimen, namely, Stainless Steel18/8 (SS18/8), Gold18carat, Gold 22 carat, Stainless Steel 316L (SS316L) and were chosen for present study. The composition (SS18/8), Gold 18 carat, Gold 22 carat, and (SS316L) are given below the tables 1&2.

The metal specimens were immersed in Fusayama Meyer artificial saliva (AS) (Kinani,2007) containing Erythromycin tablet system, The composition of artificial saliva (AS) is given in Table 3.

Table 1. Composition of SS316L and SS18/8 alloys

Tabela 1. Sastav legura SS316L i SS18 / 8

Composition of SS316L		Composition of SS18/8
Carbon	0.3%	.08%
Manganese	2%	2%
Chromium	16-8%	18-20%
Molybdenum	2-3	-
Nickel	10-14%	8-10.5%
Iron	Bal	Bal
Silicon	1%	1%
Phosphorous	.045%	.045%
Sulfur	.03%	.03%
others	-	

Table 2. Composition of Gold22 carat and Gold18 carat

Tabela 2. Sastav legura zlato 22 karaka i zlato 18 karata

Metals	Gold 22carat	Gold 18carat
Gold	91.6%	75%
Silver	5%	10-205
Copper	2%	5-15%
Zinc	1.33%	----

Table 3. Composition of Artificial Saliva

Tabela 3. Sastav veštačke pljuvačke

S.No	Name of the chemicals	Weight/lit
1.	NaCl	0.4 g
2.	Urea	1 g
3.	KCl	0.4 g
4.	CaCl ₂ H ₂ O	0.906 g
5.	NaH ₂ PO ₄ .2H ₂ O	0.690 g
6.	Na ₂ S.9H ₂ O	0.005 g

2.1. Polarization Study

Polarization Studies were carried out in a CHI-Electrochemical work station with impedance. A three electrode cell assemblies were used. The working electrode was one of the four metals. A saturated Calomel electrode [SCE] was the reference electrode and platinum electrode was the counter electrode. From the polarization study corrosion parameters such as Corrosion Potential (E_{Corr}), Linear polarization Resistance(LPR), Corrosion Current(I_{Corr}) and Tafel slopes (anodic= b_a and cathodic= b_c) were calculated.

3. RESULT AND DISCUSSION

3.1. Analysis of Potentiodynamic polarization curves

Corrosion resistance of SS18/8 alloy, Gold18carat, Gold 22 carat and SS316L alloy

immersed in various test solutions are given in Table 4. The potentiodynamic polarization curves are shown in Figure1-4. When corrosion resistance increases Linear Polarization Resistance (LPR) increases; Corrosion current (I_{corr}) decreases.

Table 4. Corrosion parameters of metals immersed in Artificial Saliva(AS) in the absence and presence of Erythromycin tablets, Obtained by polarization study

Tabela 4. Parametri korozije metala uronjenih u veštačku pljuvačku (AS) u odsustvu i prisustvu tableta Eritromicin, dobiveni polarizacijom

Metal	System	E _{corr} mV vs SCE	b _c mV/ decade	b _a mV/decade	LPR Ohmcm ²	I _{corr} A/ cm ²
SS18/8	AS	-501	0.182	0.245	1604576.8	2.834X10 ⁻⁸
	AS+Erythromycin	-481	0.209	0.204	1259706.8	3.574X10 ⁻⁸
Gold 18 carat	AS	-113	0.160	0.215	2118899	1.889X10 ⁻⁸
	AS+Erythromycin	-102	0.139	0.185	3916073.3	8.838X10 ⁻⁸
Gold 22 carat	AS	-057	0.103	0.287	5935387	5.594X10 ⁻⁸
	AS+Erythromycin	-106	0.134	0.37	5964082	7.217X10 ⁻⁸
SS316L	AS	-544	0.174	0.255	777108.8	5.809X10 ⁻⁸
	AS+Erythromycin	-434	0.175	0.232	1284415.5	3.385X10 ⁻⁸

SS18/8 alloy

Polarisation curves of SS18/8 alloy immersed in various test solutions are shown in figure1. The corrosion parameters namely Corrosion Potential (E_{corr}), Tafel slopes (b_c = cathodic; b_a =anodi) Linear Polarization Resistance (LPR) and Corrosion current (I_{corr}) are shown in table 4.

When SS18/8 immersed in Artificial Saliva (AS), Linear Polarization Resistance (LPR) value is 1604576.8ohm cm². The Corrosion current (I_{corr}) is 2.834X10⁻⁸A/ cm². The Corrosion Potential (E_{corr}) is - 501 mV vs SCE.

When SS18/8 is immersed in AS containing Erythromycin tablet system, Linear Polarization Resistance (LPR) value decreases from 1604576.8 to 1259706.8 ohm cm². The Corrosion current (I_{corr}) increases from 2.834X10⁻⁸ to 3.574X10⁻⁸A/ cm².

This indicates that SS18/8 alloy is less corrosion resistance in AS containing Erythromycin tablet system. Further the Corrosion Potential (E_{corr}) value shifts from -501mV to -481mV vs SCE. The corrosion resistance of SS18/8 alloy is less in AS in presence of Erythromycin tablet than AS (absence of Erythromycin tablet) alone. 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 is as follows:

$$AS > AS + Erythromycin$$

This study reveals that people should avoid taking Erythromycin tablet orally while clipping of an orthodontic wires made of SS18/8 alloy, for its corrosion resistant is very less in this medium of AS + Erythromycin system.

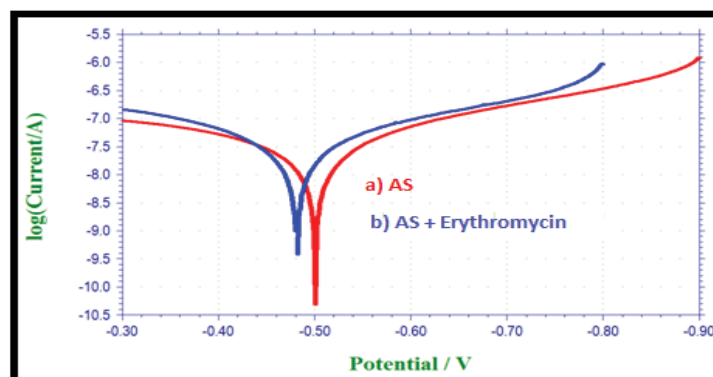


Figure 1. Polarization curves of SS18/8alloy immersed in various test solutions, a) AS, b) AS + Erythromycin

Slika 1. Polarizacijske krive legure SS 18 / 8 uronjene u različite testne rastvore, a) AS b) AS + Eritromicin

Gold 18 carat

When Gold 18 carat immersed in Artificial Saliva (AS), polarisation curves are shown in Figure 2. Linear Polarization Resistance (LPR) value is 2118899 ohm cm^2 . The Corrosion current (I_{corr}) value is $1.889 \times 10^{-8} \text{ A/cm}^2$. The Corrosion Potential (E_{corr}) is -113 mV vs SCE .

When Gold 18 carat immersed in AS containing Erythromycin tablet system polarisation curves are shown in Figure 2. Linear Polarization Resistance (LPR) value increases from 2118899 to $3916073.3 \text{ ohm cm}^2$. The Corrosion current (I_{corr}) decreases from 3.574×10^{-8} to $8.838 \times 10^{-9} \text{ A/cm}^2$. This values suggest that Gold 18 carat in AS presence of Erythromycin tablet is more corrosion resistant than AS alone. Further the Corrosion Potential (E_{corr}) value shifts from -113 mV to $-$

102 mV vs SCE . This value reveals that a protective film formed on the metal surface, which controlled the rate of corrosion of the metal alloy in AS in the presence of Erythromycin tablet. The nature of the protective film has to be analyzed in a future study. Thus the polarization study leads to the conclusion that when Gold18 carat is immersed in various test solutions, the decreasing order of corrosion resistance of Gold18 carat is as follows:

$$\text{AS} + \text{Erythromycin} > \text{AS}$$

This study reveals that people clipped with an orthodontic wires made of Gold18 carat can take Erythromycin tablet orally without any hesitation, because in this medium (AS + Erythromycin system) the corrosion resistance of Gold18 carat is higher.

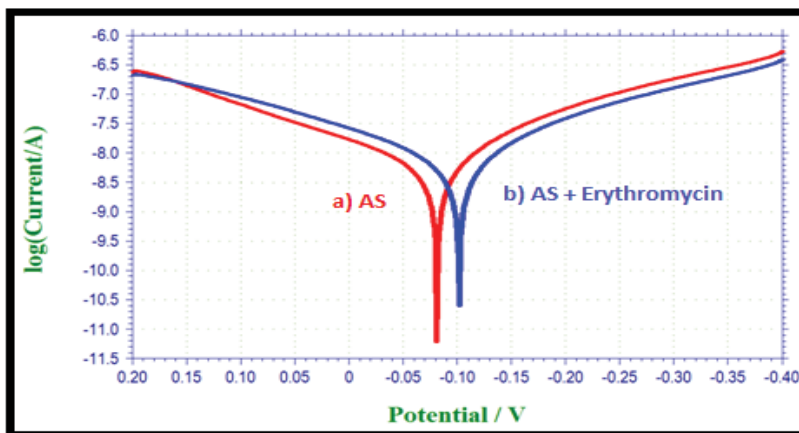


Figure 2. Polarization curves of Gold18 carat immersed in various test solutions
a) AS, b) AS + Erythromycin

Slika 2. Polarizacijske krive zlata 18 karata uronjenog u različite testne rastvore
a) AS, b) AS + Eritromicin

Gold 22 carat

When Gold 22 carat immersed in Artificial Saliva (AS) the polarisation curves are shown in Figure 3. Linear Polarization Resistance (LPR) value is 5935387 ohm cm^2 . The Corrosion current (I_{corr}) $5.594 \times 10^{-9} \text{ A/cm}^2$. The Corrosion Potential (E_{corr}) is -057 mV vs SCE .

When Gold 22 carat immersed in AS in the presence of Erythromycin tablet the polarisation curves are shown in Figure 3. The Linear Polarization Resistance (LPR) values increases a little more from 5935387 to 5964082 ohm cm^2 . The Corrosion current (I_{corr}) decreases from 5.594×10^{-9} to $7.217 \times 10^{-9} \text{ A/cm}^2$. These values suggest that Gold 22 carat is more corrosion resistant in AS in presence of Erythromycin tablet than in the absence of Erythromycin tablet in AS.

Further the Corrosion Potential (E_{corr}) value shifts from -057 mV vs SCE to -106 mV vs SCE . A protective film forms on the metal surface. Due to the formation of the protective film, corrosion resistance of Gold 22 carat increases in the presence of Erythromycin tablet in AS. Thus the polarization study leads to the conclusion that when Gold 22 carat is immersed in various test solutions, the decreasing order of corrosion resistance of Gold18 carat is as follows:

$$\text{AS} + \text{Erythromycin} > \text{AS}$$

This study reveals that the people clipped with an orthodontic wires made of Gold 22 carat can also take Erythromycin tablet orally without any fear, because in this medium of AS + Erythromycin the corrosion resistance of Gold 22 carat is higher.

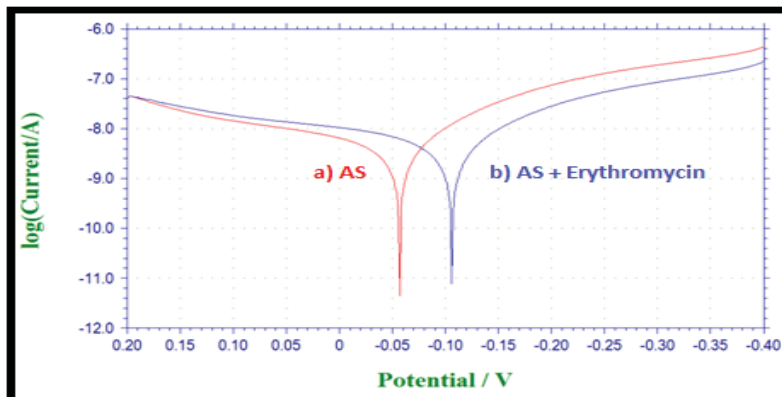


Figure 3. Polarization curves of Gold 22 carat immersed in various test solutions, a) AS, b) AS + Erythromycin

Slika 3. Polarizacijske krive zlata 22 karata uronjenog u različite testne rastvore, a) AS, b) AS + Eritromicin

SS316L alloy

When SS316L immersed in Artificial Saliva (AS) the polarisation curves are shown in Figure 4. Linear Polarization Resistance (LPR) value is $777108.8 \text{ ohm cm}^2$. The Corrosion current (I_{corr}) is $5.809 \times 10^{-8} \text{ A/cm}^2$. The Corrosion Potential (E_{corr}) is -544 mV vs SCE .

When SS316L immersed in AS containing Erythromycin tablet as shown in Figure 4, it is interesting to note that the Linear Polarization Resistance (LPR) value increases to a greater extent from 777108.8 to $1284415.5 \text{ ohm cm}^2$ and also the Corrosion current (I_{corr}) decreases from 5.809×10^{-8} to $3.385 \times 10^{-8} \text{ A/cm}^2$. This indicates that SS316L is more corrosion resistant in presence of Erythromycin tablet in AS than AS alone. Further the Corrosion Potential (E_{corr}) value shifts from -544 mV vs SCE to -434 mV vs SCE . This is due to

the formation of an effective protective film formed on the metal surface. This protective film controls the rate of corrosion of the SS316L alloy. Hence, the corrosion resistance of SS316L increases in the presence of Erythromycin tablet in AS than AS alone. Thus the polarization study leads to the conclusion that when SS316L alloy is immersed in various test solutions, the decreasing order of corrosion resistance of SS316L alloy is as follows:

$$\text{AS + Erythromycin} > \text{AS}$$

This study suggests that the people clipped with an orthodontic wires made of SS316L alloy, there is no problem in taking Erythromycin tablet orally, because, in this medium (AS + Erythromycin) the corrosion resistance of SS316L alloy is higher.

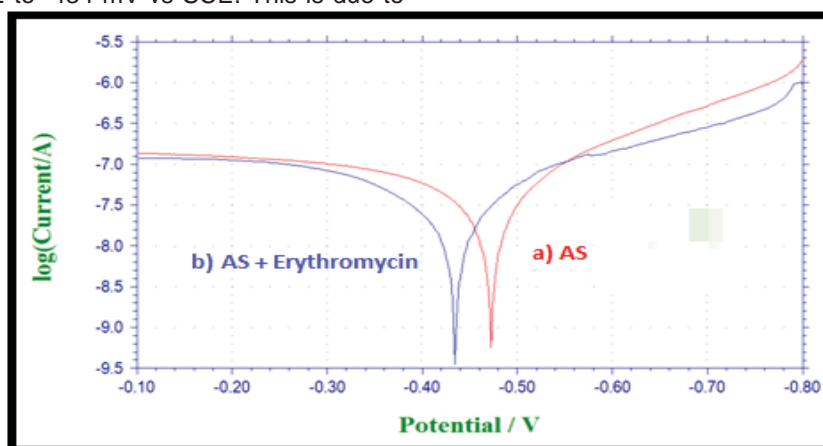


Figure 4. Polarization curves of SS316L alloy immersed in various test solutions a) AS, b) AS + Erythromycin

Slika 4. Polarizacijske krive legure SS316L uronjene u različite testne rastvore a) AS, b) AS + Eritromicin

4. CONCLUSION

1. For SS18/8 alloy, the polarization study leads to the conclusion that when SS18/8 alloy is immersed in various test solutions, the decreasing order of corrosion resistance is as follows:

AS > AS + Erythromycin

2. This study reveals that people should avoid taking Erythromycin tablet orally while clipping of an orthodontic wires made of SS18/8 alloy, for its corrosion resistant is very less in this medium of AS + Erythromycin system.

3. For Gold 18 carat, the polarization study leads to the conclusion that when Gold18 carat is immersed in various test solutions, the decreasing order of corrosion resistance of Gold18 carat is as follows:

AS + Erythromycin > AS

4. This study reveals that people clipped with an orthodontic wires made of Gold18 carat can take Erythromycin tablet orally without any hesitation, because in this medium (AS + Erythromycin system) the corrosion resistance of Gold18 carat increases.

5. For Gold 22 carat, the polarization study leads to the conclusion that when Gold 22 carat is immersed in various test solutions, the decreasing order of corrosion resistance of Gold18 carat is as follows:

AS + Erythromycin > AS

6. This study reveals that the people clipped with an orthodontic wires made of Gold 22 carat can also take Erythromycin tablet orally without any fear, because in this medium of AS + Erythromycin the corrosion resistance of Gold 22 carat increases.

7. For SS18/8 alloy, the polarization study leads to the conclusion that when SS316L alloy is immersed in various test solutions, the decreasing order of corrosion resistance of SS316L alloy is as follows:

AS + Erythromycin > AS

8. This study suggests that the people clipped with an orthodontic wires made of SS316L alloy, There is no problem to take Erythromycin tablet orally, because in this medium (AS + Erythromycin) the corrosion resistance of SS316L alloy increases.

Further, the study reveals the following facts

1. In AS system Gold 18 carat is more corrosion resistant than SS18/8 alloy.

2. In AS system, Gold 22 carat is more corrosion resistant than Gold 18 carat.

3. In AS system, Gold 22carat is more corrosion resistant than SS316L alloy.

4. In AS system SS18/8 is more corrosion resistant than SS316L.

5. In AS Containing Erythromycin tablet system, Gold 18 carat is more corrosion resistant than SS18/8 alloy.

6. In AS Containing Erythromycin tablet system, Gold 22 carat is more corrosion resistant than Gold 18 carat.

7. In AS Containing Erythromycin tablet system Gold22carat is more corrosion resistant than SS316L alloy.

8. In AS Containing Erythromycin tablet system SS316L alloy is more corrosion resistant than SS18/8.

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IZVOD

KOROZIJSKA OTPORNOST LEGURE SS 18/8, LEGURE SS316L, ZLATA 18 KARATA I ZLATA 22 KARATA U VEŠTAČKOJ PLJUVAČKI U ODSUSTVU I PRISUSTVU TABLETA ERITROMICINA 500mg

Otpornost na koroziju legure SS 18/8, legure SS316L, zlata 18 karata i zlata 22 karata u veštačkoj pljuvački u odsustvu i prisustvu tablete Eritromicin 500 mg je procenjena elektrohemijским ispitivanjem, kao što je ispitivanje polarizacije. Za leguru SS316L, zlato 18 karata i zlato 22 karata, studija polarizacije dovodi do zaključka da se otpornost na koroziju legure SS316L, Gold 18 karata i Gold 22 karata smanjuje u redosledu: AS + Eritromicin > AS. Stoga, ljudi koji u sebi imaju ortodontsku žicu izrađenu od legure SS316, zlato 18 karata i zlato 22 karata, mogu uzimati Eritromicin tablete oralno bez ikakvih oklevanja. Za leguru SS 18/8, studija polarizacije dovodi do zaključka da se otpornost na koroziju legure SS 18/8 smanjuje u redosledu: AS > AS + Eritromicin. Dakle, ljudi koji u imaju u sebi ortodontsku žicu izrađenu od legure SS 18/8, treba izbegavati uzimanje Eritromicin tablete oralno.

Ključne reči: otpornost na koroziju, ispitivanje polarizacije, ortodontska žica, legure SS18/8, legure SS316L, zlato 18 karata, zlato 22 karata, eritromicin.

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