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Influence of digene tablet juice orally taken in on the corrosion resistance of orthodontic wire made of SS 18/8 in presence of artificial saliva

ABSTRACT

Dentists make use of orthodontic wires such as SS 18/8, SS 316, Ni-Cr etc., to regulate the growth of teeth. In the saliva environment these wires undergo corrosion. Aside from this, they undergo corrosion by the food items , juices and Tablets orally in taken. Corrosion resistance of SS 18/8 alloy in artificial saliva (AS) , in the absence and presence of Digene Tablet juice, has been investigated by polarization and AC impendance techniques. It is inferred that corrosion resistance of SS 18/8 alloy in artificial saliva decreases in presence of Digene Tablet. This is exposed by decrease in Linear Polarization Resistance (LPR) value, Charge transfer resistance (R_t) value, in impedance value, and increase in corrosion current and double layer capacitance value(C_{dl}). In presence of Digene Tablet, the LPR value decreases from 3488228 to 1629535 Ohmcm^2. The corrosion current value increases from 1.447 x10^{-8} to 2.637x10^{-8}A/cm^2 . The Charge transfer resistance (R_t) value decreases from 37796 to 10481Ohmcm^2. The double layer capacitance value increases from 1.349x10^{-10} F/cm^2 to 4.866x10^{-10}F/cm^2. The impedance value decreases from 4.857 to 4.428. Hence it implies that people with orthodontic wire made of SS 18/8 alloy should avoid taking Digene Tablet juice orally.

Keywords: *orthodontic wires, SS18/8, corrosion resistance, Digene Tablet juice, artificial saliva.*

1. INTRODUCTION

It is interesting to note that for some people the arrangement of teeth are not in a regular manner by God's greatness . To regulate the growth of teeth Dentist make use of orthodontic wire made of various types of alloys such as SS 18/8, Ni-Cr, SS 316, Thermoactive super elastic alloy, Gold 18 K, Gold 20 K etc., After having clipped with orthodontic wires people take many food items, tablets, juice etc., orally. Apart from saliva, these food items, may corrode the orthodontic wires. Therefore a study on this aspect is necessary, to know how far these wires are affected and corroded. More research papers have been available in this regard [1-24].

The consequence of glow discharge nitriding on the corrosion resistance of stainless steel orthodontic arches in artificial saliva solution has been studied by Kamiński et al. [1].

Kamiński et al. have carried out a relative study on orthodontic arch-wires AISI304 steel before and after low temperature plasma nitriding. Polarisation and AC impedance techniques have been employed for this reason. Microhardness was calculated before and after treatment. Erwansyah and Susilowati [2] have investigated the influence of snake fruit extract (*Salacca zalacca*) in inhibiting the release of chromium (Cr) and nickel (Ni) ion from stainless steel orthodontic wire to saliva [2]. Cr and Ni ion discharge was calculated using Atomic Absorption Spectrophotometry. The exploration was made on control group and treatment groups. Pre-tests and post-tests were conducted. It is understandable from this learning that Snake fruit seeds extract effectively inhibits the Ni ions let go from stainless steel orthodontic wire at a concentration of 300 ppm [2].

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The influence of probiotic supplements, recommended for use in orthodontic patients, on the corrosion stability of stainless steel and three types of NiTi orthodontic wires have been examined by Musa Trolic et al [3]. The corrosion resistance was calculated by polarization study and AC impedance spectra. It was observed that probiotic bacteria L. reuteri and probiotic supplement power on a general corrosion rate as well as on likelihood of pitting corrosion incidence. It was in addition noticed that their effect is dependent on the kind of alloy and coating.

316L Stainless steels are widely used in biomedical applications with respect to their outstanding corrosion resistance, nonmagnetic properties, lofty ductility and acceptable biocompatibility. Electrochemical studies have been carried out in-vitro in order to determine the corrosion reactions, which are necessary for foreseeing the behavior of the materials used in orthodontic uses. The ruin of metals and alloys in the human body is a blend of effects due to corrosion and mechanical activities. In dentistry, 316L stainless steels are used in a variety of applications: clean instruments, endodontic files in root canal therapy, metal posts in root canal treated teeth, temporary crowns, arch wires and brackets in orthodontics, a necessary condition for these applications must to resist to pitting corrosion [4]. Effects of some Tablets on orthodontic wire made of SS 316L Alloy in Artificial Saliva have been investigated by Agnes Brigitta et al. [5,6].

Influence of some tablets on corrosion resistance of orthodontic wires made of SS 316L alloy in artificial saliva has been studied by Anandan et al. by means of electrochemical studies such as polarization study and AC impedance specta [7]. Renita D'souza et al. have measured corrosion resistance of SS 316L alloy in artificial saliva in presence of Sparkle fresh Toothpaste (Medline Industries, Inc.)

By electrochemical studies [8]. Agnes Brigitta et al. have investigated corrosion resistance of SS18/8,Gold18 carat, Gold 22 carat and SS 316L alloy in artificial saliva in the absence and presence of Vitavion Fort Tablet 500mg [9]. Influence of D-glucose on corrosion resistance of SS 316 L in presence of artificial saliva has been studied by Saranya and Rajendran by means of electrochemical studies [10]. Zhang et al. have investigated the effect of the heat treatment on corrosion and mechanical properties of CoCrMo alloys manufactured by selective laser melting [12]. Corrosion resistance of Co-Cr dental alloys processed by alternative CAD/CAM technologies in artificial saliva solutions has been investigated by Savencu et al. [13]. The present work is undertaken to study the corrosion resistance of orthodontic wire made of SS 18/8 alloy in artificial saliva in the presence of Digene Tablet (Abbott India Limited) juice, by electrochemical studies such as polarisation study and AC impedance spectra.

2. MATERIALS AND METHODS

Preparation of the metal specimens

A thin wire of SS 18/8 alloy is used as test material for this work. The chemical composition of the alloy is as follows: 18% Cr, 8% Ni, and balance is Fe. The orthodontic wire was encapsulated in Teflon rod (Invento). It was polished to mirror finish and used for electrochemical studies.

Preparation of artificial saliva

The preparation of artificial saliva was done using the composition of Fusayama Meyer artificial saliva (AS). Artificial saliva was prepared in laboratory and the composition of artificial saliva was as follows: KCl - 0.4 g/L, NaCl - 0.4 g/L, $CaCl_2.2H_2O$ - 0.906 g/L, $NaH_2PO_4.2H_2O$ - 0.690 g/L, $Na_2S.9H_2O$ - 0.005 g/L, urea – 1 g/L.

Digene Tablet

Digene Tablet (Abbott India Limited) is a medicine that reduces the amount of acid produced in your stomach. It is used for treating acid-related diseases of the stomach and intestine such as heartburn, acid reflux, peptic ulcer disease, and some other stomach conditions associated with excessive acid production

Compositions

Digene Tablet contains: Sodium Bicarbonate IP 44.03%, Sodium Citrate Anhydrous USP 15.75%, Tartaric Acid IP 22.25%, Citric Acid Anhydrous IP 17.88%, Flavoured excipients q.s. also contains Saccharin Sodium IP as sweetener [14].

Potentiodynamic polarization technique

A CHI 660 A workstation model was used in the electrochemical studies. Polarization study was carried out using a three electrodes cell assembly, Figure 1. SS 18/8 was used as working electrode, platinum as counter electrode and saturated calomel electrode (SCE) as reference electrode. After having done iR compensation, polarization study was carried out at a sweep rate of 0.01 V/Sec. The corrosion parameters such as linear polarization resistance (LPR), corrosion potential $E_{corr,}$ corrosion current I_{corr} and Tafel slopes (b_a and b_c) were measured.

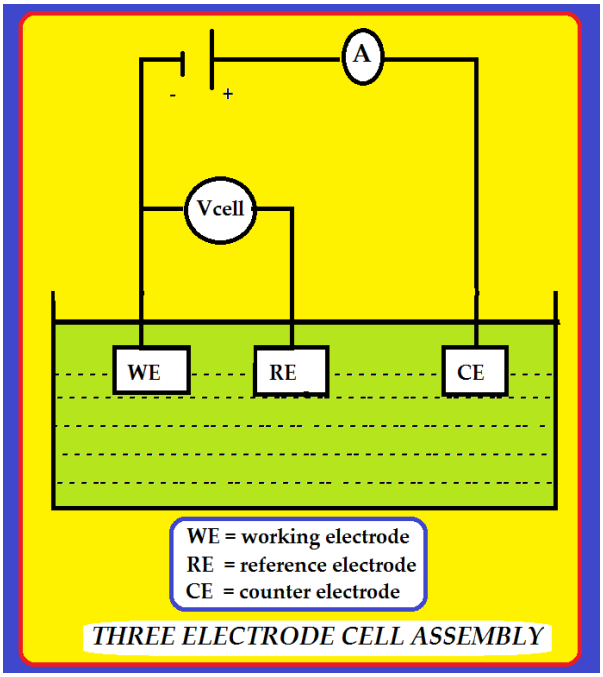

Figure 1. Three electrode cell assembly

Slika 1. Sklop ćelija sa tri elektrode

Alternating current impedance spectra

AC impedance spectra were recorded in the same instrument used for polarization study, using the same type of three electrode cell assembly. The real part (Z') and imaginary part (-Z") of the cell impedance were measured in Ohms for various frequencies. The charge transfer resistance (R_t) and double layer capacitance (C_{dl}) values were calculated.

3. RESULTS AND DISCUSSION

Influence of Digene Tablet on corrosion resistance of SS 18/8 alloy in artificial saliva

The influence of Digene Tablet (powder juice) on corrosion resistance of SS 18/8 alloy in artificial saliva (AS), has been investigated by polarization and AC impendance techniques.

Polarization technique

In the present investigation Tafel plots were carried out in a CHI Electrochemical work station/ analyzer, model 660A. It was provided with automatic *iR* compensation facility. A three electrode cell assembly was used, Figure 1.

The working electrode was SS 18/8 alloy. A SCE was the reference electrode. Platinum was the counter electrode. A time interval of 5 to 10 min was given for the system to attain a steady state open circuit potential. The electrodes were immersed in artificial saliva (AS) , in the absence and presence of Digene Tablet. From polarization study, corrosion parameters such as corrosion potential (Ecorr), corrosion current (Icorr), Tafel slopes anodic = ba and cathodic = bc and LPR (linear polarisation resistance) value were calculated. The scan rate (V/S) was 0.01. Hold time at (Efcs) was zero and quiet time (s) was two.

In polarization technique, when corrosion resistance and LPR decrease corrosion current increases, Figure 2.

The Polarization curves of SS18/8 alloy in AS in the absence and presence of 500 ppm of Digene Tablet are shown in Figure 3. The corrosion parameters are given in Table1.

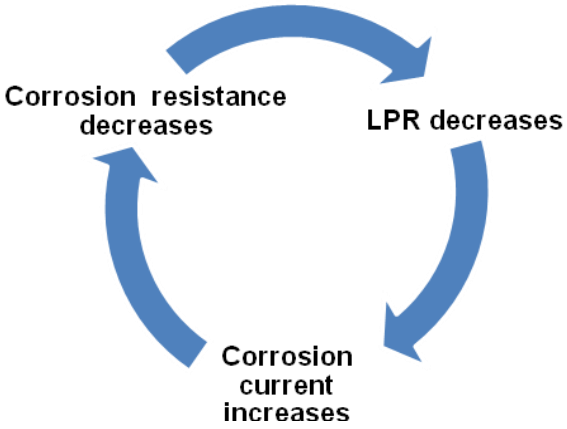

Figure 2. Correlation among corrosion parameters in polarization study

Slika 2. Korelacija među parametrima korozije u polarizacionoj studiji

Table1. Corrosion parameters of SS 18/8 immersed in Artificial Saliva (AS) in presence of Digene (500 ppm) obtained from polarization study

Tabela 1. Parametri korozije SS 18/8 uronjene u veštačku pljuvačku (AS) u prisustvu Digena (500ppm) dobijeni ispitivanjem polarizacije

System	E_{corr} mV vs SCE	b_c mV/ decade	b_a mV/decade	LPR Ohmcm^2	I_{corr} A/cm^2
AS	-276	169	388	3488228	1.447 x10^{-8}
AS+ Digene	-351	182	216	1629535	2.637 x10^{-8}

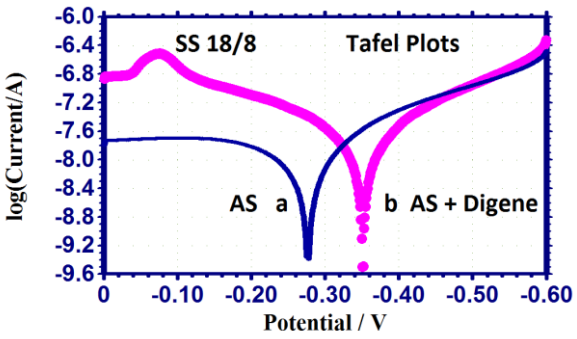

Figure 3. Polarisation curves of SS18/8 alloy immersed in various test solutions

Slika 3. Krive polarizacije legure SS18/8 uronjene u različitim ispitivanim rastvorima

It is observed from Table 1, that in presence of Digene, the corrosion resistance of SS 18/8 in AS decreases. This is revealed by the fact that, in presence of Digene LPR value of SS 18/8 decreases, Figure 4 and corrosion current increases.

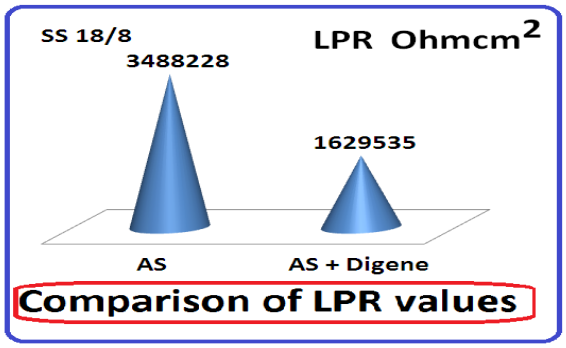

Figure 4. Comparison of LPR values

Slika 4. Poređenje LPR vrednosti

It is also observed that in presence of Digene the corrosion potential shifts from -276 to -351 mv VS SCE. It is inferred that in presence of Digene the cathodic reaction in controlled predominantly.

Implication

Corrosion resistance of SS 18/8 alloy in artificial saliva decreases in presence of Digene. Hence people clipped with orthodontic wire made of SS 18/8 alloy should avoid taking Digene orally.

AC Impedance spectra

In the present investigation the same instrument set-up used for polarization study was also used to record AC impedance spectra . A time interval of 5 to 10 min was given for the system to attain a steady state open circuit potential. The real part (Z') and imaginary part (-Z'') of the cell impedance were measured in ohms at various frequencies. AC impedance spectra were recorded with initial E (v) = 0, high frequency (Hz = 1x10^5), low frequency (Hz = 1), amplitude (V) = 0.005 and quiet time (s) = 2. From Nyquist plot the Values of charge transfer resistance (R_t) and the double layer capacitance (C_{dl}) were calculated.

$$R_t = (R_s + R_t) - R_s$$

Where R_s = solution resistance.

C_{dl} values were calculated using the relationship

$$C_{dl} = 1/2 \times 3.14 \times R_t \times f_{max}$$

Where f_{max} = frequency at maximum imaginary impedance.

When corrosion resistance decreases, R_t values and impedance values decrease whereas C_{dl} values increases, Figure 5.

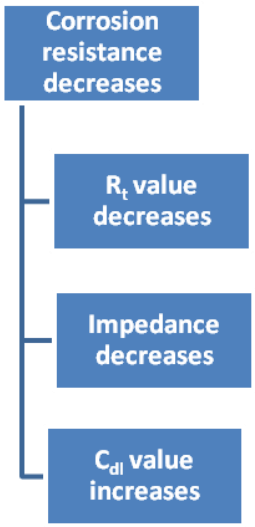

Figure 5. Correlation among corrosion parameters in AC impedance spectra

Slika 5. Korelacija među parametrima korozije u spektrima impedanse naizmenične struje

The AC impedance spectra of SS 18/8 alloy in AS in the absence and presence of 500 ppm of Digene are shown in Figure 6, 7, 8 and 9. The Nyguist plots are shown in Figures 6 and 7. The Bode plots are shown in Figures 8 and 9.

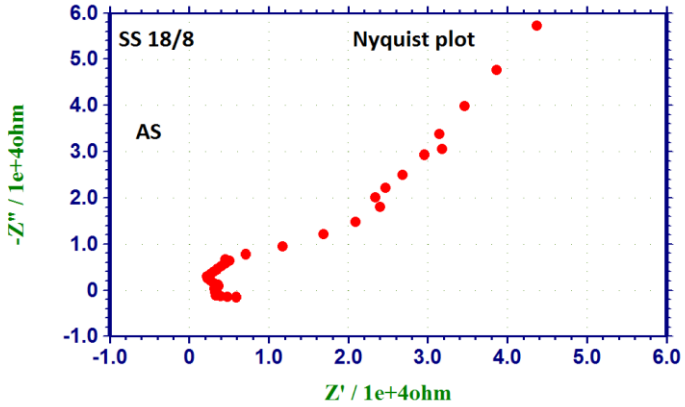

Figure 6. AC impedance spectrum of SS 18/8 immersed in Artificial Saliva (Nyquist plot)

Slika 6. Spektar impedanse naizmenične struje SS 18/8 uronjene u veštačku pljuvačku (Nyquist plot)

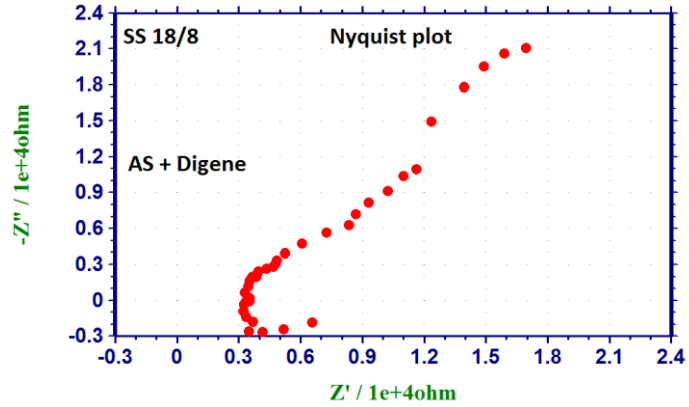

Figure 7. AC impedance spectrum of SS 18/8 immersed in Artificial Saliva + Digene (500 ppm) (Nyquist plot)

Slika 7. Spektar impedanse naizmenične struje SS 18/8 uronjene u veštačku pljuvačku + Digen (500 ppm) (Nyquist plot)

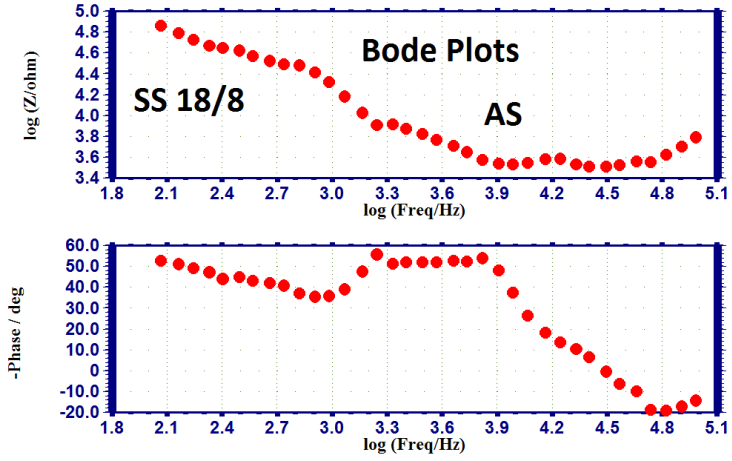

Figure 8. AC impedance spectrum of SS 18/8 immersed in Artificial Saliva (Bode plots)

Slika 8. Spektar impedanse naizmenične struje SS 18/8 uronjene u veštačku pljuvačku (Bode plots)

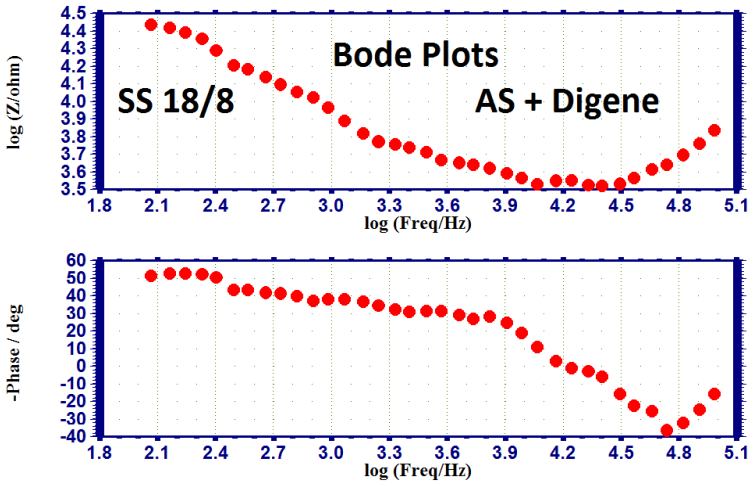

*Figure 9. AC impedance spectrum of SS 18/8 immersed in Artificial Saliva + Digene **(500 ppm)** (Bode plots)*

*Slika 9. Spektar impedanse naizmenične struje SS 18/8 uronjen u veštačku pljuvačku + Digen **(500 ppm)** (Bode plots)*

The corrosion parameters such as change transfer resistance (Rt), impedance value and double layer capacitance (C_{dl}) values are given in Table 2.

Table 2. Corrosion parameters of SS 18/8 immersed in Artificial Saliva (AS) in presence of Digene (500 ppm) obtained from AC impedance spectra

Tabela 2. Parametri korozije SS 18/8 uronjene u veštačku pljuvačku (AS) u prisustvu Digen (500 ppm) dobijenog iz spektra impedanse naizmenične struje

System	R_t, Ohmcm^2	Impedance, log (z/ohm)	C_{dl}, F/cm^2
AS	37796	4.857	1.349×10^{-10}
AS + Digene	10481	4.428	4.866×10^{-10}

It is observed from Table 2, that is in presence of Digene, the corrosion resistance of SS 18/8 in AS decreases. This is revealed by the fact that in presence of Digene, R_t value decreases, Figure 8, impedance value increases and C_{dl} value increases.

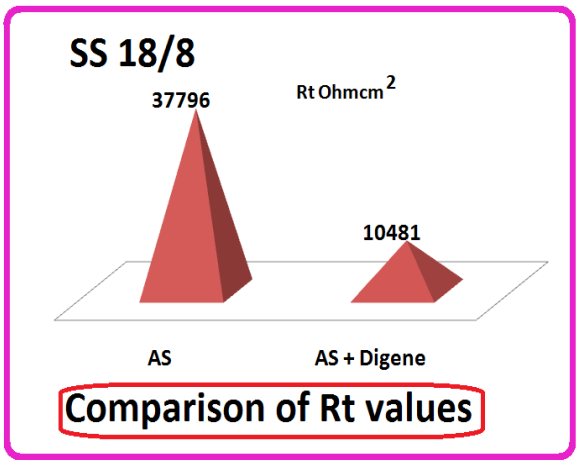

Figure 10. Comparison of Rt values

Slika 10. Poređenje vrednosti Rt

Implication

Corrosion resistance of SS 18/8 alloy in artificial saliva decreases in presence of Digene. Hence people clipped with orthodontic wire made of SS 18/8 alloy should avoid taking Digene orally.

Various corrosion parameters are compared in Table 3 and Figure 11.

Table 3. Comparison of corrosion parameters of SS 18/8 in various test solutions

Tabela 3. Poređenje parametara korozije SS 18/8 u različitim ispitivanim rastvorima

Corrosion parameters	Artificial Saliva (AS)	AS + Digene 500 ppm
LPR, Ohm.cm^2	3488228	1629535
Rt , Ohm.cm^2	37796	10481
impedance, log(Z/ohm)	4.857	4.428
corrosion current, A/ cm^2	1.447×10^{-8}	2.637×10^{-8}
double layer capacitance, F/ cm^2	1.349×10^{-10}	4.866×10^{-10}

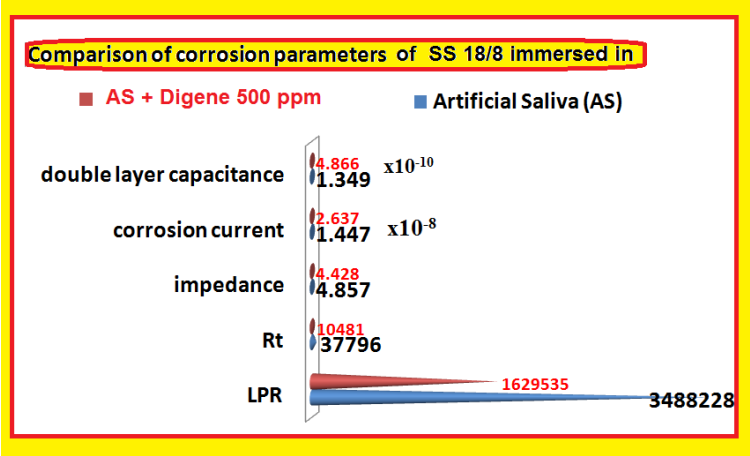

Figure 11. Graphical representation of corrosion parameters of SS 18/8 in various test solutions

Slika 11. Grafički prikaz parametara korozije SS 18/8 u različitim ispitivanim rastvorima

4. CONCLUSIONS

Corrosion resistance of SS 18/8 alloy in artificial saliva (AS) , in the absence and presence of Digene Tablet has been investigated by polarization and AC impedance techniques. It is inferred that corrosion resistance of SS 18/8 alloy in artificial saliva decreases in presence of Digene. This is revealed by decrease in LPR value, Rt value, impedance value, and an increase in corrosion current and increase in double layer capacitance value. Hence it implies that people clipped with orthodontic wire made of SS 18/8 alloy should avoid taking Digene Tablet orally, Table 3 and Figure11.

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IZVOD

UTICAJ ORALNO UZETOG SOKA TABLETA DIGENE NA OTPORNOST NA KOROZIJU ORTODONTSKE ŽICE OD SS 18/8 U PRISUSTVU VEŠTAČKE PLJUVAČKE

Stomatolozi koriste ortodontske žice kao što su SS 18/8, SS 316, Ni-Cr itd. za regulaciju rasta zuba. U okruženju pljuvačke ove žice podležu koroziji. Osim toga, podvrgavaju se koroziji usled uzimanja hrane, sokova i tableta. Otpornost na koroziju legure SS 18/8 u veštačkoj pljuvački (AS), u odsustvu i prisustvu soka Digene tablete, ispitana je tehnikama polarizacije i impedanse naizmenične struje. Zaključuje se da se otpornost legure SS 18/8 na koroziju u veštačkoj pljuvački smanjuje u prisustvu Digene tablete. Ovo je izloženo smanjenjem vrednosti otpora linearne polarizacije (LPR), vrednosti otpora prenošenja naboja (Rt), vrednosti impedanse i povećanjem korozione struje i vrednosti dvoslojne kapacitivnosti (Cdl). U prisustvu tablete Digene, vrednost LPR se smanjuje sa 3488228 na 1629535 Ohmcm^2. Vrednost struje korozije se povećava sa 1,447 k10^{-8} na 2,637k10^{-8} A/cm^2. Vrednost otpora prenosu naboja (Rt) opada sa 37796 na 10481 Ohmcm^2. Vrednost kapaciteta dvostrukog sloja povećava se sa 1.349k10^{-10} F/cm^2 na 4.866k10^{-10}F/cm^2. Vrednost impedanse se smanjuje sa 4,857 na 4,428. Stoga implicira da bi ljudi sa ortodontskom žicom od legure SS 18/8 trebali izbegavati oralno uzimanje soka Digene tablete.

Ključne reči: *ortodontske žice, SS18/8, otpornost na koroziju, sok tablete Digene, veštačka pljuvačka.*

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