Inhibition Action of Corrosion on Ni- Ti Alloy with Artificial Saliva In the Presence of Three Different Tablets

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Abstract

Commonly orthodontic wires made of many metals and alloy. After dental treatment many food items such as fruit juice, buttermilk, glucose etc are taken orally. Many tablets are also orally taken. In the oral environment these orthodontic wires undergo many types of corrosion. g. The corrosion inhibition actions of Ni-Ti alloy with artificial saliva in presence of Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets has been evaluated by AC impedance spectra and polarization study Nyquist plots and Bode plots have been drawn. Charge transfer resistance (R_t), double layer capacitance (C_{dl}) and impedance values have been calculated. It is observed from the electrochemical studies, corrosion resistance increases for the Ni-Ti alloy electrode in the presence artificial saliva with Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets So, people having orthodontic wires made of Ni-Ti alloy need not hesitate to take Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets.

Keywords: Orthodontic wires, dentistry, Ni-Ti alloy, AC impedance spectra, polarization study, Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets.

Introduction

Corrosion process can be defined as destruction of certain substance, especially metal, in reaction with the environment. In dentistry, metallic materials are used as implants in reconstructive oral surgery to replace a single tooth or an array of teeth, or in the fabrication of dental prostheses such as metal plates for complete and partial dentures crowns, and bridges, essentially in patients requiring hypoallergenic materials. Corrosion of metallic implants is of vital importance, because it can adversely affect the bio-compatibility and mechanical integrity of implants. Many metals and alloys have been used in dentistry. The corrosion behavior in artificial saliva has been investigated. Rajendran et al., have been evaluated 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 [1]. The corrosion resistance of 18 ct gold in artificial saliva in the presence of Almox 250 DT has been investigated [2]. Madhumitha et al., have been investigated the corrosion resistance of 22 ct gold and Thermo active Super elastic shape memory alloy in presence of Syzygium cumin Fruit juice [3]. The effect of different concentrations of eugenol in artificial saliva on titanium corrosion has been investigated by Kinani and Chtaini [4]. The corrosion resistance of the commercial metallic orthodontic wires in a simulated intra-oral environment has been evaluated by Ziebowicz et.al., [5]. Saranya et al., have been investigated the corrosion resistance of 18 ct gold in artificial saliva in the absence and presence of D-Glucose [6]. Thakur Prasad Chaturvedi et al., observed that Corrosion behavior of titanium wires: An in vitro study. Component of liquid or solid is an important factor influencing the corrosion of metallic appliances placed in the oral cavity [7]. Anwar et. al., have studied that the effect of fluoride on the corrosion behavior of Ti and Ti6Al4V dental implants coupled with different superstructures. It was shown that increased fluoride concentration leads to a decrease in the corrosion resistance of all tested couples [8]. Dolo 650 mg is quinolone

antibiotic. It is used in the treatment of number of pain relief and fever. Glycomet 500 mg is non-steroidal anti-inflammatory drug. It is used to treat menstrual cycles more regulars and fertility. Zinetac 150 mg is quinolone antibiotic. It is used in the treatment of gastric ulcer and hypersecretory condition. Many researchers have been reported by using Ni-Ti alloy with different tablets. The present study leads to investigate the corrosion behavior of orthodontic wire made of Ni-Ti alloy in artificial saliva with Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets orally taken**.** Electrochemical studies such as polarization and AC impedance spectra have been used. The compositions of Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets are given in Table 1.

Table1: Composition of the tablets

Tablet	Composition
Dolo 650 mg	Paracetamol IP
Glycomet 500 mg	Metformin
Zinetac 150 mg	Ranitidine

Materials and Methods:

The composition of Ni –Ti alloy is Ni – 55.5 % and balanced Ti. The orthodontic wire was encapsulated in Teflon. The wire was polished to a mirror finish and degreased with trichloroethylene. The electrochemical studies were carried out in a three electrode cell assembly. The three electrodes were immersed in Fusayama Meyer artificial saliva (AS), whose composition is given in Table 2.

Table2: Composition of Artificial saliva

Name of salt	**Weight (g/lit)**
KCl	0.4
NaCl	0.4
$CaCl_2.2H_2O$	0.906
$NaH_2PO_4.2H_2O$	0.690
$Na_2S.9H_2O$	0.005
urea	1

The pH of the solution was 6.5. In electrochemical studies, the metal specimens were used as working electrodes. Artificial saliva (AS) was used as the electrolyte. The temperature was maintained at 37 ± 0.1°C.

Potentiodynamic Polarization

Polarization studies were carried out in a CHI-electrochemical workstation with impedance, Model 660A. A three-electrode cell assembly was used (Fig 1). The working electrode was Ni –Ti alloy. A saturated calomel electrode (SCE) was the reference electrode and 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 = ba and cathodic = bc) were calculated.

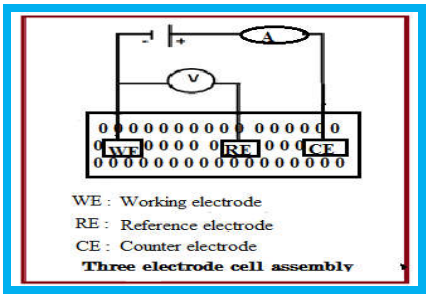

Figure 1: Three electrode cell assembly

AC Impedance Spectra

The instrument used for polarization study was also used to record AC impedance spectra. The cell setup was also the same. The real part (Z') and imaginary part (Z") of the cell impedance were measured in ohms at various frequencies. The values of the charge transfer resistance (R_t) and the double layer capacitance (C_{dl}) were calculated from Nyquist plot Impedance: log (z/ohm) value was calculated from Bode plots.

Results and Discussion

Analysis of potentiodynamic polarization studies

Electrochemical polarization studies have been used to confirm the formation of protective film formed on the metal surface during corrosion inhibition process [9-15]. If a protective film is formed on the metal surface, the corrosion current value (I_{corr}) decreases and corrosion potential value (E_{corr}) increases. The potentiodynamic polarization curves of Ni – Ti alloy immersed in Artificial Saliva (AS) in the absence and presence of Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets, obtained from polarization study are shown in Fig-2.The corrosion parameters, namely, corrosion potential (E_{corr} mV vs SCE), Tafel slopes (b_c mV/decade; b_amV/decade), linear polarization resistance (LPR ohm cm^2), and corrosion current (I_{corr} A/cm^2) values are given in Table 3.

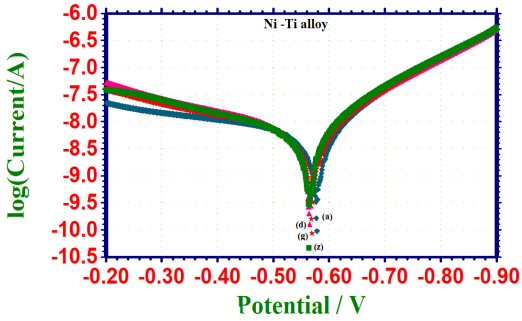

Figure 2: Polarization curves of Ni –Ti alloy immersed in Artificial Saliva (AS) in the absence and presence of Dolo650 mg, Glycomet 500 mg and Zinetac150 mg

(a) Artificial Saliva (AS) ; (d) AS + Dolo650 mg (100 ppm)
(g) AS + Glycomet 500 mg (100 ppm) ; (z) AS + Zinetac150 mg (100 ppm)

When Ni –Ti alloy is immersed in Artificial Saliva (AS), the corrosion potential is (-566 mV vs SCE).When Dolo 650 mg (100 ppm), Glycomet 500 mg (100 ppm) and Zinetac150 mg (100 ppm) are added to the above system the corrosion potential is shifted to (-578 mV vs SCE, -569 mV vs SCE and -568 mV vs SCE). The LPR value increases from 6579024.5 ohmcm^2 to 7109789.4 ohmcm^2, 6627975.2 ohmcm^2 and 7429656.4 ohmcm^2 and the corrosion current decreases

from 5.831x10^{-9}A/cm^2 to 5.640 x 10^{-9} A/cm^2, 5.825 x 10^{-9} A/cm^2 and 5.210 x 10^{-9}A/cm^2. All these observations lead to the conclusion that the corrosion resistance increases for the Ni – Ti alloy electrode in the presence of Dolo 650 mg (100 ppm), Glycomet 500 mg (100 ppm) and Zinetac150 mg (100 ppm). Hence polarization study leads to the conclusion that people having orthodontic wires made of Ni –Ti alloy need not hesitate to take Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets. The active ingredients of the Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets have not corroded wires.

Table3: Corrosion parameters of Ni-Ti immersed in Artificial Saliva (AS) in the absence and presence of Dolo 650 mg (100 ppm), Glycomet 500 mg (100 ppm) and Zinetac150 mg (100 ppm), obtained from polarization study

System	E_{corr} (mV vs SCE)	b_c (mV/ decade)	b_a (mV/ decade)	LPR (ohm cm^2)	I_{corr} (A/cm^2)
Artificial Saliva (AS)	-566	135	253	6579024.5	5.831 x 10^{-9}
AS + Dolo 650 mg (100 ppm)	-578	125	347	7109789.4	5.640 x 10^{-9}
AS + Glycomet 500 mg (100 ppm)	-569	127	294	6627975.2	5.825 x 10^{-9}
AS + Zinetac150 mg (100 ppm)	-568	129	285	7429656.4	5.210 x 10^{-9}

Analysis of AC Impedance spectra

AC impedance spectra (electro chemical impedance spectra) have been used to confirm the formation of protective film on the metal surface. If a protective film is formed on the metal surface, charge transfer resistance (R_t) increases; double layer capacitance value (C_{dl}) decreases. Impedance value increases. The AC impedance spectra of Ni –Ti alloy immersed in Artificial Saliva (AS) in the absence and presence of Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg, obtained from AC impedance spectra are shown in **Figs.3-7**. The AC impedance parameters namely charge transfer resistance (R_t) and double layer capacitance (C_{dl}) derived from Nyquist plots (Fig 3) are given in Table 4. The impedance value derived from Bode plots **(Figs 4, 5, 6 and 7)** are also given in this Table 4. It is observed that when Dolo 650 mg (100 ppm), Glycomet 500 mg (100 ppm) and Zinetac150 mg (100 ppm) are added to artificial saliva, the charge transfer resistance (R_t) increases from 2181.0 Ω cm^2 to 5752.0 Ω cm^2, 2669.0 Ω cm^2 and 3290.0 Ω cm^2. The C_{dl} value decreases from 7.536 x10^{-10} F/cm^2 to 2.857 x 10^{-10} F/cm^2, 6.158 x 10^{-10}F/cm^2 and 4.995 x 10^{-10} F/cm^2. The impedance value increases from 1.499 to 2.183, 2.179 and 1.518.

Table 4: AC impedance parameters of Ni – Ti alloy immersed in Artificial Saliva (AS) in the absence and presence of Dolo 650 mg (100 ppm), Glycomet 500 mg (100 ppm) and Zinetac150 mg (100 ppm)

System	R_t (ohm cm^2)	C_{dl} (F/ cm^2)	Impedance Log(z/ohm)
Artificial Saliva (AS)	2181.0	7.536 x10^{-10}	1.499
AS + Dolo 650 mg (100 ppm)	5752.0	2.857 x 10^{-10}	2.183
AS + Glycomet (100 ppm)	2669.0	6.158 x 10^{-10}	2.179
AS + Zinetac150 mg (100 ppm)	3290.0	4.995 x 10^{-10}	1.518

All these observation reveals that the corrosion resistance increases for the Ni – Ti alloy electrode in the presence of artificial saliva with Dolo 650 mg (100 ppm), Glycomet 500 mg (100 ppm) and Zinetac150 mg (100 ppm). Hence AC impedance spectra lead to the conclusion that people having orthodontic wires made of Ni- Ti alloy need not hesitate to take Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets. The active ingredients of the Dolo 650 mg, Glycomet 500 mg and Zinetac150 mg tablets have not corroded wires made of Ni –Ti alloy.

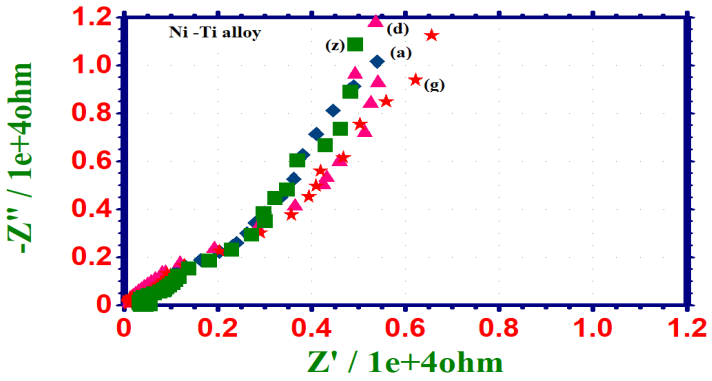

Figure 3: **AC impedance spectra (Nyquist Plots) of Ni –Ti alloy immersed in Artificial Saliva (AS) in the absence of Dolo650 mg, Glycomet 500 mg and Zinetac150 mg**

(a) Artificial Saliva (AS) ; (d) AS + Dolo650 mg (100 ppm)
(g) AS + Glycomet 500 mg (100 ppm) ; (z) AS + Zinetac150 mg (100 ppm)

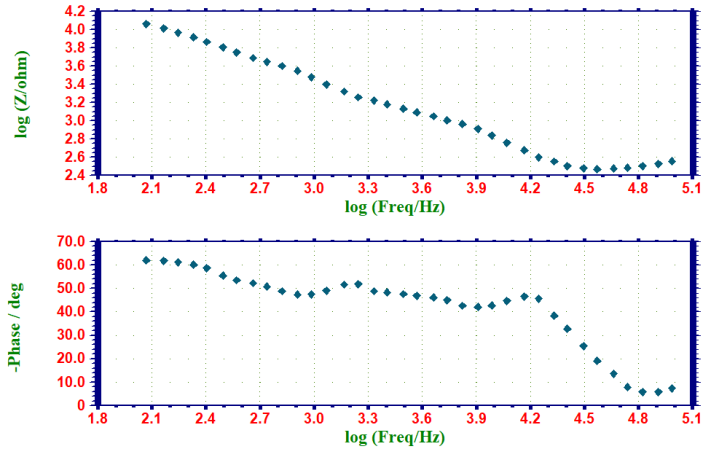

Figure 4: AC impedance spectra (Bode Plots) of Ni –Ti alloy immersed in Artificial Saliva (AS) in the absence of Dolo650 mg, Glycomet 500 mg and Zinetac150 mg

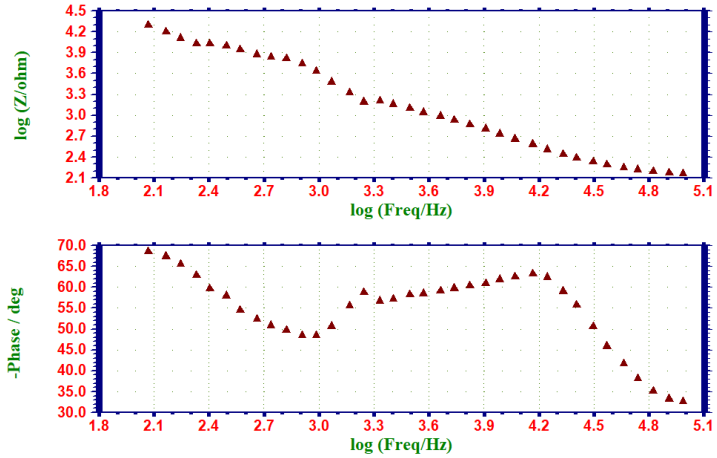

Figure 5: AC impedance spectra (Bode Plots) of Ni –Ti alloy immersed in Artificial Saliva (AS) in the presence of Dolo650 mg (100 ppm)

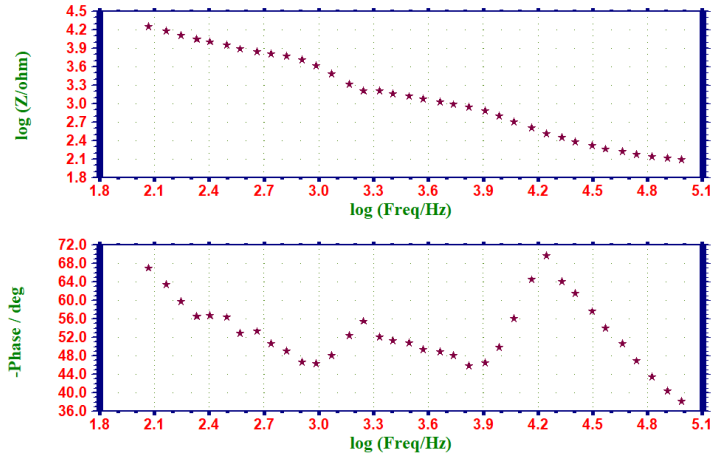

Figure 6: AC impedance spectra (Bode Plots) of Ni –Ti alloy immersed in Artificial Saliva (AS) in the presence of Glycomet 500 mg (100 ppm)

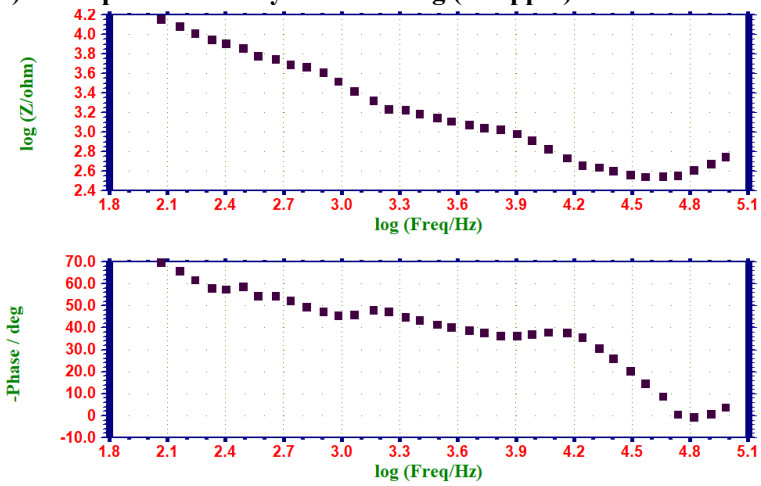

Figure 7: AC impedance spectra (Bode Plots) of Ni –Ti alloy immersed in Artificial Saliva (AS) in the presence of Zinetac150 mg (100 ppm)

Conclusion

Results of the electrochemical studies lead to the conclusion that the corrosion resistance increases for the Ni –Ti alloy electrode in the presence artificial saliva with Dolo 650 mg (100 ppm), Glycomet 500 mg (100 ppm) and Zinetac150 mg (100 ppm).

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