



CORROSION RESISTANCE OF ORTHODONTIC WIRES OF NI-CR AND NI-TI ALLOYS IN ARTIFICIAL SALIVA IN THE ABSENCE AND PRESENCE OF CIPROFLOXACIN HYDROCHLORIDE TABLET (500MG) ORALLY

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ABSTRACT

Corrosion resistance of orthodontic wires of Ni-Cr and Ni-Ti alloys in artificial saliva in the absence and presence of Ciprofloxacin Hydrochloride tablet 500mg has been evaluated by electrochemical study such as polarization study. Polarization study leads to the conclusion that corrosion resistance of Ni-Cr alloy decreases in the order: Artificial Saliva > Artificial Saliva + Ciprofloxacin Hydrochloride. Hence, people clipped with orthodontic wire made of Ni-Cr alloy, should avoid taking Ciprofloxacin Hydrochloride tablet orally. For Ni-Ti alloy, polarization study leads to the conclusion that corrosion resistance of Ni-Ti alloy decreases in the order: Artificial Saliva + Ciprofloxacin Hydrochloride > Artificial Saliva. So, people clipped with orthodontic wire made of Ni-Ti alloy can take

Ciprofloxacin tablet orally without any hesitation.

KEYWORD: Corrosion resistance, polarization, orthodontic wire, Ciprofloxacin Hydrochloride, Ni-Cr and Ni-Ti alloys.

Article Received on
05 October 2018,

Revised on 26 Oct. 2018,
Accepted on 16 Nov. 2018,

DOI: 10.20959/wjpps201812-12739

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1. INTRODUCTION

On the dental market there are a variety of dental alloys used in dentistry for manufacturing of fixed and removable prostheses. In the oral cavity, these structures are exposed to a chemically adverse environment, with saliva being the most corrosive agent, due to the high concentration of chloride ions that are causing localized corrosion. One of the most important factors determining the use of a metal alloy for making prosthesis is its resistance to corrosion.^[1,2] Non-precious metal alloys are being used due to their low cost and adequate mechanical properties. In the '60s, basic alloys such as nickel-chromium were developed. These alloys are basically composed of Ni (68% to 80%) and Cr (12% to 27%),^[3] Chromium enhances the resistance of nickel to oxidizing acids by encouraging the formation of passive films.^[4] Nitinol is regarded as alloy with excellent corrosion resistant, but its corrosion and electrochemical behaviour requires careful examination. The excellent corrosion of NiTi results from the formation resistance of very stable, continuous adherent and protective oxide film on its surface.^[5] As titanium has high affinity for oxygen, TiO₂ based oxides form spontaneously by exposing the fresh metal surface to the air or moisture. Various types of metal alloys are being used for the orthodontic treatment, which undergo chemical or electrochemical reaction with the oral environment. The oral environment is highly aggressive under several situations and leads to corrosion. various metals and alloys such as Ti-Co alloy,^[6] Ti30Ta alloy,^[7] Ti-6Al-4V alloy,^[8] Ti-6Al-7Nb alloy,^[9] Co-Cr alloy,^[10-14] CP-Ti and Ni-Cr-Ti alloy,^[15] Co-Cr-Mo alloy,^[16,17] Ni-Cr alloy,^[14,18,19] Ti- Cu,^[20] Ti-20Zr alloy,^[21] Ti12Mo and Ti60Ta,^[22] Ni-Ti shape memory alloy and stainless steel wire,^[23] and Ti-Mo^[24] were used for many studies. The present work is undertaken to study the Orthodontic wires of Ni-Cr and Ni-Ti alloys and its corrosion resistance in the absence and presence of ciprofloxacin Hydrochloride tablet 500mg in artificial saliva. 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

Orthodontic wire made of Ni-Cr and Ni-Ti alloys were chosen for present study. The composition Ni-Cr and Ni-Ti alloys are given below the table 1&2.

Table 1: Composition of Ni-Cr alloy.

Ni-Cr alloy	
Ni	75%
Fe	12%
Cr	11%
Mn	2%

Table 2: Composition of Ni-Ti alloy.

Ni-Ti alloy	
Nickel	49.16%
Titanium	50.84%

The metal specimens were immersed in Fusayama Meyer artificial saliva (AS)(Kinani,2007) containing Ciprofloxacin Hydrochloride tablet system, The composition of artificial saliva (AS) was KCl (0.4g/l), NaCl (0.4g/l), CaCl₂.2H₂O(0.906g/l), NaH₂PO₄.2H₂O (0.690g/l), Na₂S.9H₂O (0.005g/l) Urea(1g/l).

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 two metal (Ni-Cr and Ni-Ti) alloys. 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 Ni-Cr and Ni-Ti alloy immersed in various test solutions are given in Table 3. The potentiodynamic polarization curves are shown in Figure1 & 2. When corrosion resistance increases Linear Polarization Resistance (LPR) increases, Corrosion current (I_{corr}) decreases.

Table 3: Corrosion parameters of metals immersed in Artificial Saliva(AS) in the absence and presence of CiprofloxacinHydrochloride tablet 500 mg, Obtained by polarization study.

Metal	System	E_{corr} mV vs SCE	b_c mV/decade	b_a mV/decade	LPR Ohm cm^2	I_{corr} A/ cm^2
Ni-Cr	ArtificialSaliva(AS)	-393	0.187	0.235	1752108.9	2.586×10^{-8}
	AS + Ciprofloxacin Hydrochloride	-446	0.181	0.213	1200127.0	3.553×10^{-8}
Ni-Ti	ArtificialSaliva(AS)	-477	0.165	0.232	15381385.0	2.729×10^{-9}
	AS+ Ciprofloxacin Hydrochloride	-559	0.143	0.386	25910478.0	1.759×10^{-9}

Ni -Cr alloy

The polarization curve of Ni-Cr alloy immersed in various test solutions are shown in figure 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 3. It is observed from Table 3 that, when Ni-Cr alloy immersed in Artificial Saliva (AS), Linear Polarization Resistance (LPR) value is 1752108.9 ohm cm^2 . The Corrosion current (I_{corr}) is 2.586×10^{-8} A/ cm^2 . The Corrosion Potential (E_{corr}) is -393mV vs SCE. In presence of Ciprofloxacin Hydrochloride tablet system, Linear Polarization Resistance (LPR) value decreases from 1752108.9 to 1200127.0 ohm cm^2 . The Corrosion current (I_{corr}) increases from 2.586×10^{-8} to 3.553×10^{-8} A/ cm^2 . This indicates that Ni-Cr alloy is less corrosion resistance in Artificial Saliva containing Ciprofloxacin Hydrochloride tablet system than Artificial Saliva alone. Further the Corrosion Potential (E_{corr}) value shifts from -393 to -446mV vs SCE. These values indicate that, there is no effective protective film formed on the metal surface. Due to this, oxygen diffused to the metal surface and undergo further corrosion from spreading into the bulk of the metal. Hence corrosion resistance of Ni-Cr alloy is less in Artificial Saliva in presence of Ciprofloxacin Hydrochloride tablet than in Artificial Saliva (absence of Ciprofloxacin Hydrochloride tablet) alone. Thus the polarization study leads to the conclusion that when Ni-Cr alloy is immersed in various test solutions, the decreasing order of corrosion resistance is as follows:

Artificial Saliva > Artificial Saliva + Ciprofloxacin Hydrochloride

This study reveals that people should avoid taking Ciprofloxacin Hydrochloride tablet orally while clipping with orthodontic wires made of Ni-Cr alloy. Because its corrosion resistance is very less in the medium of Artificial Saliva + Ciprofloxacin Hydrochloride system.

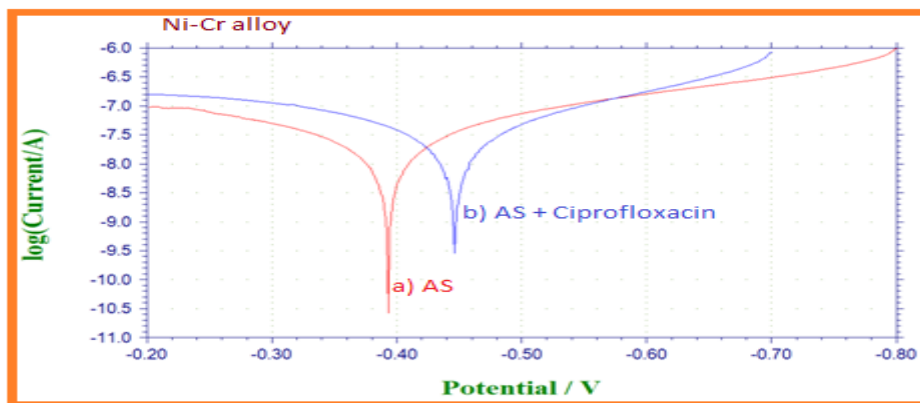


Figure 1: Polarization curves of Ni-Cr alloy immersed in various test solutions. a) Artificial Saliva (AS) b) AS + Ciprofloxacin Hydrochloride.

Ni-Ti alloy

The polarization curve of Ni-Ti alloy immersed in Artificial Saliva (AS) system are shown in Figure 2. Linear Polarization Resistance (LPR) value is $15381385.0 \text{ ohm cm}^2$. The Corrosion current (I_{corr}) value is $2.729 \times 10^{-9} \text{ A/cm}^2$. The Corrosion Potential (E_{corr}) is -477 mV vs SCE .

The polarization curve of Ni-Ti alloy immersed in Artificial Saliva (AS) containing Ciprofloxacin Hydrochloride tablet system is shown in Figure 2. Linear Polarization Resistance (LPR) value increases from 15381385.0 to $25910478.0 \text{ ohm cm}^2$. The Corrosion current (I_{corr}) decreases from 2.729×10^{-9} to $1.759 \times 10^{-9} \text{ A/cm}^2$. These values suggest that Ni-Ti alloy is more corrosion resistant in Artificial Saliva (AS) containing Ciprofloxacin Hydrochloride tablet system than in Artificial Saliva (AS) alone. Further the Corrosion Potential (E_{corr}) value shifts from -477 to -529 mV vs SCE . These values reveal that a protective film formed on the metal surface, which controlled the rate of corrosion of the metal alloy in Artificial Saliva in the presence of Ciprofloxacin Hydrochloride tablet. Thus the polarization study leads to the conclusion that when Ni-Ti alloy immersed in various test solutions, the decreasing order of corrosion resistance of Ni-Ti alloy is as follows:

Artificial Saliva + Ciprofloxacin Hydrochloride > Artificial Saliva

This study reveals that people clipped with orthodontic wires made of Ni-Ti alloy can take Ciprofloxacin Hydrochloride tablet orally without any hesitation. Because in this medium (Artificial Saliva + Ciprofloxacin Hydrochloride system) the corrosion resistance of Ni-Ti alloy is high.

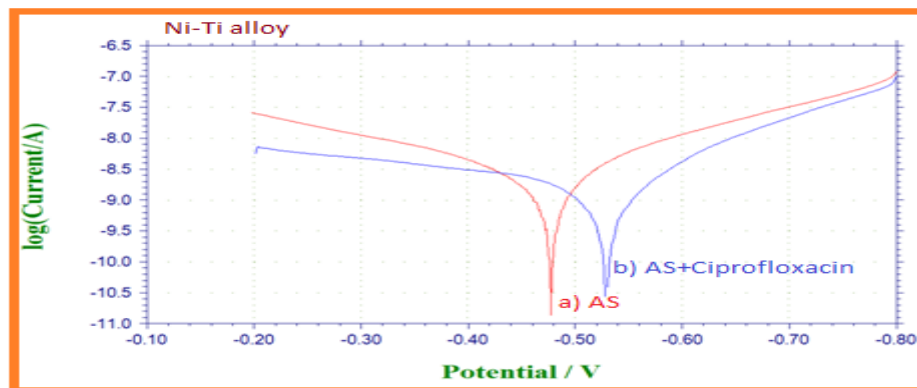


Figure 2: Polarization curves of Ni-Ti alloy immersed in various test solutions. a) Artificial Saliva (AS) b) AS + Ciprofloxacin Hydrochloride.

4. CONCLUSION

Orthodontic wires of Ni-Cr and Ni-Ti alloys and its corrosion resistance in the absence and presence of Ciprofloxacin Hydrochloride tablet 500mg in artificial saliva has been evaluated by electro chemical study such as polarization study. This study leads to the following conclusions.

Ni-Cr alloy

- The polarization study leads to the conclusion that when Ni-Cr alloy is immersed in various test solutions, the decreasing order of corrosion resistance is as follows:

Artificial Saliva > Artificial Saliva + Ciprofloxacin Hydrochloride

- This study reveals that people should avoid taking Ciprofloxacin Hydrochloride tablet orally while clipping with orthodontic wires made of Ni-Cr alloy. Because its corrosion resistant is very less in this medium of Artificial Saliva + Ciprofloxacin Hydrochloride system.

Ni-Ti alloy

- The polarization study leads to the conclusion that when Ni-Ti alloy is immersed in various test solutions, the decreasing order of corrosion resistance of Ni-Ti alloy is as follows:

Artificial Saliva + Ciprofloxacin Hydrochloride > Artificial Saliva

- This study reveals that people clipped with orthodontic wires made of Ni-Ti alloy can take Ciprofloxacin Hydrochloride tablet orally without any fear. Because in this medium

(Artificial Saliva + Ciprofloxacin Hydrochloride) the corrosion resistance of Ni-Ti alloy is high.

- Further this study reveals that Ni-Ti alloy is more corrosion resistant than Ni-Cr alloy. When compared to these two alloys, Ni-Ti alloy is the best candidate for clipping orthodontic wire while taking Ciprofloxacin Hydrochloride tablet orally. So, dentists can prescribed this tablet (Ciprofloxacin Hydrochloride 500 mg) to their patients while they are clipping with orthodontic wire made of Ni-Ti alloy on their teeth.

5. ACKNOWLEDGEMENT

The authors are thankful to their respective managements, for their constant help and encouragement and motivation.

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