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Corrosion resistance Performance of Domperidone and Perinorm tablets on orthodontic wire made up of Ni-Ti alloy in artificial saliva

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ABSTRACT:
People are implanted or clipped with orthodontic wires made of diverse materials in order to regulate the growth of teeth. When these orthodontic wires are exposed to the oral environment, by the influence of food intake, toothpaste, mouthwash and tablets, may undergo corrosion. The present study focus the evaluation of corrosion resistance action of orthodontic wires of Ni-Ti alloy immersed in artificial saliva in the absence and presence of Domperidone and Perinorm tablets. Polarization and AC impedance study reveals that the corrosion rate of the Ni-Ti alloy system in various solution decreases in the following order: Artificial Saliva > Artificial Saliva + Domperidone / Perinorm tablet. This is evidenced by gradual increase in Linear Polarization Resistance (LPR) and decrease in Corrosion Current (Icorr) by polarization studies then there is an increase in charge transfer resistance (Rct) and decrease in double layer Capacitance (Cdl) by AC impedance spectra. Scanning electron microscope imaging gave the morphological data for the sample; however using the Scanning electron microscope and Energy Dispersive Analysis of X-Rays the elemental composition was determined. Hence the present study concludes that people clip with orthodontic wire made of Ni-Ti alloy can take Domperidone / Perinorm tablets orally without any hesitation.

Keywords: Ni-Ti alloy, artificial saliva, Domperidone tablet, Polarization study, SEM, EDAX
1. INTRODUCTION:
Corrosion is defined as the process of interaction between a solid material and the chemical environment, which results in the loss of the structural integrity, change of the structural features, and loss of the substance from the material. Corrosion can also be defined as the degradation of material into its composing atoms due to the chemical reactions existed between the materials and its surrounding environments. In the oral cavity, the corrosion is induced by metal ions released, the subject that has been broadly estimated with regards to orthodontic brackets, fixed appliances, and other devices were employed in the oral cavity during the course of orthodontic treatment [1]. In order to regulate the growth of teeth, people are implanted or clipped with orthodontic wires made of different materials. When these orthodontic wires are exposed to the oral environment, by the influence of food intake, toothpastes, mouthwash and some tablets like vitamin, used as pain killer and antibiotics. These tablets that they use may corrode the orthodontic wires in the oral environment. Hence there is a need to investigate influence of various tablets on the corrosion resistance of orthodontic wires made of many metals and alloys. Ni-Ti wire with good corrosion resistance is crucial to dental prosthesis biocompatibility [2]. The electrochemical behavior of orthodontic wires in artificial saliva has been investigated by polarization study and AC impedance spectra. Dentists recommend the use of orthodontic wires to regulate the arrangement of teeth. After the regulation, people having these orthodontic wires, regulating the arrangement of teeth, have to take orally many tablets. These tablets may corrode the wires in the oral environment, especially saliva. Hence there is a need to investigate the influence of various tablets on the corrosion resistance of orthodontic wires made of many metals and alloys [3]

2. Materials and methods
2.1 Chemistry of Domperidone/Perinorm tablets:
- Molecular formula: \(\text{C}_{22}\text{H}_{24}\text{ClIN}_{5}\text{O}_{2}\) (Domperidone), \(\text{C}_{14}\text{H}_{22}\text{ClN}_{3}\text{O}_{2}\) (Perinorm)
- Molecular weight: 425.9 g/mol (Domperidone), 299.8 g/mol (Perinorm)

2.2 Composition of Artificial Saliva:
The composition of artificial saliva [2,7, 16-17] is given as:
- KCl - 0.4 g/L, NaCl - 0.4 g /L, CaCl\(_2\).2H\(_2\)O - 0.906 g/L, NaH\(_2\)PO\(_4\).2H\(_2\)O 0.690 g/L,
- Na\(_2\)S.9H\(_2\)O – 0.005 g/L, urea–1 g/L.

2.3 Medicinal uses of Domperidone / Perinorm tablets:
➢ Nausea
➢ Increase the movement of Gastrointestinal tract

3. Characterization Techniques
3.1 Electrochemical studies
3.1.1 Polarization study

The corrosion resistance of Ni-Ti alloy has been measured by electrochemical studies such as Polarization study and AC impedance spectra. A CHI electrochemical work station was used for this purpose. A three electrode cell assembly (Figure 1) was used in the present study Ni-Ti alloy was used as working electrode; saturated calomel electrode was used as reference electrode and Platinum electrode was used as counter electrode. From the Polarizations study corrosion parameters such as corrosion potential, corrosion current and Tafel slope values were calculated [4,6]. The AC impedance spectra charge transfer resistance and double layer capacitance values were calculated.

Figure: 1 Three Electrode Cell Assembly

3.1.2. AC Impedance measurements

The instrument used for the 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. Values of the charge transfer resistance ($R_t$) and double layer capacitance ($C_{dl}$) were calculated from the Nyquist plot and the impedance; log ($z$/Ohm) value was calculated from Bode plots [7].

3.2. Scanning Electron Microscope (SEM)
The Scanning Electron Microscope is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electron. By this Surface morphology measurements of the thin wire metal (Ni-Ti) specimen were examined [5].

3.3. Energy Dispersive Analysis of X-rays (EDAX)

Energy Dispersive Analysis of X-rays is an analytical technique used for the elemental analysis or chemical characterization of sample. The elements present in a material are determined by an EDAX spectrum. The surface morphology measurements of the Ni-Ti alloy were examined using Tescon, Vega 3, and USA computer controlled scanning electron microscope. The elemental analysis of the Ni-Ti alloy surface at the same condition was carried out using an Energy Dispersive Analysis of X-rays (edax), [Bucker, Nano, GMBH, Germany] unit attached to the SEM machine.

4. Result and discussion

4.1 Analysis of Electrochemical studies

4.1.1 Potentiodynamic polarization curves

Corrosion resistance of Ni-Ti alloy in various test solution has been evaluated by polarization study. When corrosion resistance increases, Linear Polarization Resistance (LPR) increases; Corrosion current (Icorr) decreases.

<table>
<thead>
<tr>
<th>System in Ni-Ti alloy</th>
<th>Ecorr V vs SCE</th>
<th>b_c v/decade</th>
<th>b_a v/decade</th>
<th>LPR Ohm cm^2</th>
<th>Icorr A/cm^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial Saliva(AS)</td>
<td>-0.3293</td>
<td>5.841</td>
<td>3.436</td>
<td>2137135</td>
<td>0.0219X10^-10</td>
</tr>
<tr>
<td>AS+ 100ppm Domperidone</td>
<td>-0.325</td>
<td>5.895</td>
<td>3.709</td>
<td>3349448</td>
<td>0.0135X10^-10</td>
</tr>
<tr>
<td>AS+ 100ppm Perinorm</td>
<td>-0.3938</td>
<td>4.422</td>
<td>5.284</td>
<td>2387576</td>
<td>0.02 X10^-10</td>
</tr>
</tbody>
</table>

When Ni-Ti alloy immersed in Artificial Saliva, LPR value is 2137135 ohm cm^2 and the Icorr is 0.0219X10^-10 A/cm^2. When Ni-Ti alloy immersed in 100ppm Domperidone / Perinorm tablets, LPR value increases from 2137135 to 3349448 Ohm cm^2 and for Perinorm tablet it value increases from 2137135 to 2387576 Ohm cm^2. The Icorr decreases from 0.0219 x10^-10 to 0.0135 x10^-10 A/ cm^2 for Domperidone and decreases to 0.02 x10^-10 A/ cm^2 for Perinorm tablet. This indicates that Ni-Ti alloy is more corrosion resistant for both the tablets taken in the present study. Thus the polarization study leads
to the conclusion that when Ni-Ti alloy is immersed in various test solution, the decreasing order of corrosion rate of Ni-Ti alloy is as follows: AS > AS + Domperidone tablet / Perinorm tablet.

![Figure: 2 Polarization curves of Ni-Ti alloy immersed in artificial saliva (AS)](image)

**Figure: 2 Polarization curves of Ni-Ti alloy immersed in artificial saliva (AS)**

![Figure: 3 Polarization curves of Ni-Ti alloy immersed in artificial saliva (AS) in the absence and presence of Domperidone/ Perinorm tablet](image)

**Figure: 3 Polarization curves of Ni-Ti alloy immersed in artificial saliva (AS) in the absence and presence of Domperidone/ Perinorm tablet**

### 4.1.2 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 (Rt) increases; double layer capacitance value (Cdl) decreases [8-15]. Impedance value increases. Thus from analysis of AC impedance parameters such as charge transfer Resistance (Rt), double layer Capacitance (Cdl) (derived from Nyquist plots), and impedance value log (z/ohm) (derived from Bode plots) of various alloys immersed in artificial saliva and artificial saliva containing Domperidone tablet are given in Table 2. Nyquist plots are shown in Figures 4 and 5, Bode plots in Figures 6 and 7. When corrosion resistance increases, the charge transfer resistance (Rt) value increases, impedance value increases and double layer capacitance value decreases.
Table 2. AC Impedance Spectral data of Ni-Ti immersed in artificial saliva (AS) in the presence and absence of Domperidone and Perinorm tablets obtained by polarization study

<table>
<thead>
<tr>
<th>System in Ni-Ti</th>
<th>Nyquist plot</th>
<th>Bode plot</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R&lt;sub&gt;t&lt;/sub&gt;</td>
<td>C&lt;sub&gt;dl&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>ohm cm&lt;sup&gt;2&lt;/sup&gt;</td>
<td>F/cm&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Artificial saliva</td>
<td>12342</td>
<td>4.05 x 10&lt;sup&gt;-10&lt;/sup&gt;</td>
</tr>
<tr>
<td>AS + 100ppm Domperidone</td>
<td>13446</td>
<td>3.718x 10&lt;sup&gt;-10&lt;/sup&gt;</td>
</tr>
<tr>
<td>AS + 100ppm Perinorm</td>
<td>18765</td>
<td>2.664 x 10&lt;sup&gt;-10&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Figure: 4 Nyquist Plots of Ni-Ti alloy immersed in artificial saliva (AS)

Figure: 5 Nyquist Plots of Ni-Ti alloy immersed in artificial saliva (AS) in the absence and presence of Domperidone/ Perinorm tablet

The AC impedance spectra of Ni-Ti alloy in various test solutions are shown in Figure 4 and 5. The corrosion parameters are given in table 2. It is observed from the table 2 that in presence of 100 ppm Domperidone/Perinorm tablets in artificial saliva the corrosion resistance of Ni-Ti alloy increases. This
is evident by increases of the charge transfer Resistance (Rt) from 12342 to 13446 for Domperidone and increases to 18765 for Perinorm tablet and further decrease of double layer Capacitance (Cd) observed from $4.05 \times 10^{-10}$ to $3.718 \times 10^{-10}$ F/cm$^2$ for Domperidone and decreases to $2.664 \times 10^{-10}$ for Perinorm tablet and increase in impedance value observed from 4.52 to 4.58 log(z/ohm) for Domperidone and increases to 4.85 log(z/ohm) for Perinorm tablet. These observations indicated that a protective film is formed on the metal surface when Ni-Ti alloy is immersed in artificial Saliva in presence of Domperidone/Perinorm tablets. The protective film prevents the transfer of electrons from the metal surface to the bulk of the solutions [5].

![Figure: 6 Bode plots of Ni-Ti alloy immersed in Artificial Saliva (AS)](image)

![Figure: 7 Bode plots of Ni-Ti alloy immersed in Artificial Saliva (AS) in the absence and presence of Domperidone/Perinorm tablet](image)

### 3.3 Analysis of scanning electron microscope (SEM)

SEM images of 100µm and 50µm for Ni-Ti alloy in absence and presence of the Domperidone/Perinorm tablet are shown in Fig8 (a, b, c and d). The surface is found to be smooth for pure polished metal.
Figure 8(b) is also smooth than pure polished metal. In the presence of Domperidone/Perinorm tablets the roughness of the metal surface is less Figure 8(c and d) than the artificial saliva. This is due to the presence of the productive film deposited on the metal surface [5] the active ingredient of the tablet forms the protective film on the metal surface.

![Figure 8 SEM Micrographs](image-url)

**Figure: 8 SEM Micrographs of**

(a) Ni-Ti alloy  
(b) Ni-Ti in Artificial Saliva  
(c) Ni-Ti in Artificial Saliva +Domeperidone  
(d) Ni-Ti in Artificial Saliva +Domeperidone

**Energy Dispersive Analysis of X –rays (EDAX)**
The EDAX are shown in Fig. 9 (a), (b) and (c). It is seen from the EDAX spectra that the presence of various elements present in the surface of Ni-Ti alloy in AS and both absence and presence of the Domeperidone and Perinorm tablets.

**Figure 9:** EDX spectra of (a) Ni-Ti alloy in AS (b) Ni-Ti alloy in AS + Domperidone (c) Ni-Ti alloy in AS + Perinorm

5. Conclusions

Corrosion resistance of Ni-Ti alloy in artificial saliva, in the absence and presence of a Tablets namely, Domperidone and Perinorm. It is observed that Domperidone/Perinorm is added to artificial saliva,
Charge transfer resistance Ni-Ti alloy increases, double layer capacitance value decreases and Impedance value increases. Further LPR increases and corrosion current decreases. In presence of Tablets Domperidone /Perinorm smoothness in surface is observed through SEM. Hence it is concluded that people clipped with orthodontic wires made of Nickel-Titanium alloy, can take the Domperidone/Perinorm tablets without any hesitation.

6. References


[19]. Sathish, T., OPTIMISATION OF SURFACE ROUGHNESS IN CNC MILLING PROCESS USING RSM.


