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# Influence of Gelusil Tablet on the Corrosion Behaviour of 18 K Gold in Artificial Saliva Investigated by Electrochemical Studies

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## Abstract

The corrosion resistance of 18 K Gold in artificial saliva (AS), in the absence and presence of Gelusil Tablet has been evaluated by polarization study and AC impedance spectra. Polarisation study reveals that in the presence of Gelusil, LPR value increases and corrosion current decreases. That is in presence of Gelusil, the corrosion resistance of 18 K Gold in artificial saliva increases. AC impedance study reveals that in the presence of Gelusil, $R_t$ value increases and $C_{dl}$ decreases. When Gelusil is added to AS, The LPR value increases from 1746281 Ohmcm$^2$ to 2869661Ohmcm$^2$. The corrosion current decreases from 2.166 x $10^{-8}$ to 1.263 x $10^{-8}$A/cm$^2$. Further, when Gelusil is added to AS, the Rt Value increases from 113500 to 253200 Ohmcm$^2$.Double layer capacitance decreases from 4.493 x$10^{-11}$ to 2.014 x$10^{-11}$F/ cm$^2$. The impedance value increases from 5.368 to 5.669 . That is in the presence of Gelusil the corrosion resistance of 18 K Gold in AS increases. It is concluded that people clipped with orthodontic wire made of 18 K Gold need not hesitate to take Gelusil orally.

**Keywords:** Electrochemical studies; Gelusil; artificial saliva; orthodontic wire; 18K Gold;

## Introduction

To regulate the growth of teeth, Dentists make use of various types of alloys such as SS 18/8, 316 L, Thermo active etc., After clipping with the wires people orally take so many food items such as milk, soft drinks, juices and tablets. During these intake the orthodontic wires may undergo corrosion apart from the corrosion due to oral environment, namely saliva. Many research scholars are doing research work in this line, measuring the corrosion resistance of wires in saliva and also in presence of food additives and tablets orally taken.

Zhang et al. have investigated the effect of the heat treatment on corrosion and mechanical properties of CoCrMo alloys manufactured by selective laser melting. Their work presents the adhesion properties of Streptococcus mutans on the surface of CoCrMo alloys manufactured by selective laser melting (SLM) and proposes how to regulate the effect of the heat treatment on the corrosion resistance and mechanical properties of CoCrMo alloys manufactured by SLM [1].

The effect of fluoride on the corrosion behavior of nanostructured Ti-24Nb-4Zr-8Sn alloy in acidulated artificial saliva has been investigated by Li et al., Electrochemical studies, such as potentiodynamic polarization and electrochemical impedance spectroscopy (EIS) have been used to evaluate the corrosion resistance of the said alloy. The protective film has been analysed by SEM and X-ray photoelectron spectroscopy (XPS) . The study reveals that the superior corrosion resistance of the NS Ti2448 alloy as well as lower pitting sensitivity and higher tolerance to fluoride due mainly to grain refinement [2]. Electrochemical behavior of two dental alloys: palladium alloy (Palidor) and Ni-Cr alloy (Verasoft) in three types of artificial saliva has been investigated by linear and cyclic polarization curves. It has been reported that metallic dental restorations are permanently affected by the factors of the oral environment [3]. Polarization studies have been conducted to investigate bio-corrosion behaviour of Zr39.5Cu50.5Ag4Ti6 metallic glass. The tests were conducted in various simulated artificial body conditions such as artificial saliva solution, phosphate-buffered saline solution, artificial blood plasma solution, and Hank's balanced saline solution. The bio-

corrosion results of metallic glass were compared with traditional biomaterials. The study has provided bio-compatible properties of Zr39.5Cu50.5Ag4Ti6 metallic glass [4]. Corrosion behaviour of Co-Cr dental alloys processed by alternative CAD/CAM technologies in artificial saliva solutions has been investigated by Savencu et al. Electrochemical studies such as polarisation study, AC impedance spectra and cyclic voltammetry have been employed to note the corrosion resistance of materials and investigation. Computer assisted processing technologies revealed hopeful results, representing a good alternative to traditional manufacturing methods for metallic frameworks for dental prostheses [5]. Dimic et al., have estimated the electrochemical behavior and biocompatibility of ultrafine-grained (UFG) commercially pure titanium (CPTi) and Ti–13Nb–13Zr (TNZ) alloy obtained by high-pressure torsion process. Electrochemical behavior of materials in artificial saliva at 37°C was evaluated by potentiodynamic polarization tests and electrochemical impedance spectroscopy (EIS). The results showed that UFG TNZ alloy showed better corrosion reisistance [6]. Renita D'souza et al. have studied Corrosion Resistance of SS 316L alloy in Artificial Saliva in presence of Sparkle fresh Toothpaste, by electrochemical studies [7]. 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 [8]. Influence of D-glucose on corrosion resistance of SS 316 L in presence of artificial saliva has been studied by Saranya and Rajendran by making use of electrochemical studies [9]. Zhang et al. have investigated the effect of the heat treatment on corrosion and mechanical properties of CoCrMo alloys manufactured by selective laser melting [10].

The present work is undertaken to study the corrosion resistance of orthodontic wire made of 18 K Gold in artificial saliva in the presence of Gelusil Tablet ,a medication used to treat the symptoms of too much stomach acid such as stomach upset, heartburn, and acid indigestion.

Electrochemical studies such as polarisation study and AC impedance spectra have been employed to measure the corrosion resistance.

## Materials and Method

### Preparation of the Metal specimens

A thin wire of 18 K Gold is used as test material in the present sstudy. The orthodontic wire was encapsulated in TEFLON rod. It was polished to mirror finish and used for electrochemical studies.

### Preparation of artificial saliva

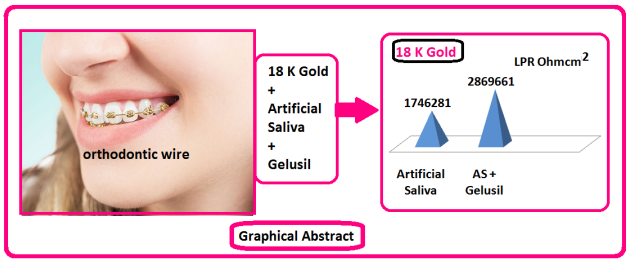
The preparation of artificial saliva was done using the composition of Fusayama Meyer artificial saliva (AS). Artificial saliva was prepared in laboratory. The composition of artificial saliva was as follows: KCl - 0.4 g/lit, NaCl - 0.4 g/lit, $CaCl_2.2H_2O$ - 0.906 g/lit, $NaH_2PO_4.2H_2O$ - 0.690 g/lit,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

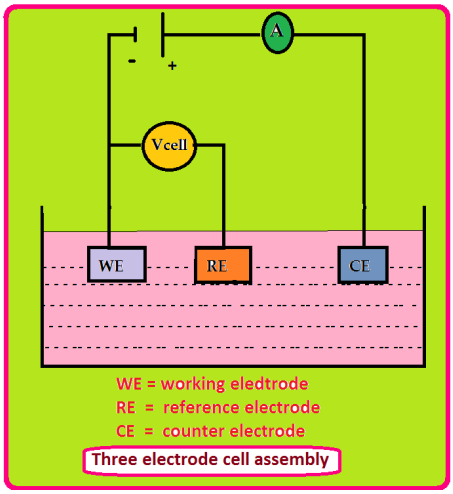
### Gelusil Tablet

This medication is used to treat the symptoms of too much stomach acid such as stomach upset, heartburn, and acid indigestion. It is also used to relieve symptoms of extra gas such as belching, bloating, and feelings of pressure/discomfort in the stomach/gut [11].

### Potentiodynamic polarization study

A CHI 660 A workstation model was used in the electrochemical studies.Polarization study was carried out using a three electrodes cell assembly (Scheme A).18 K Gold 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 Ecorr, corrosion current Icorr and Tafel slopes (ba=anodic Tafel slope and bc= cathodicTafel slope) were measured.




**Scheme A**. Three electrode cell assembly

### 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.

## Results and Discussion

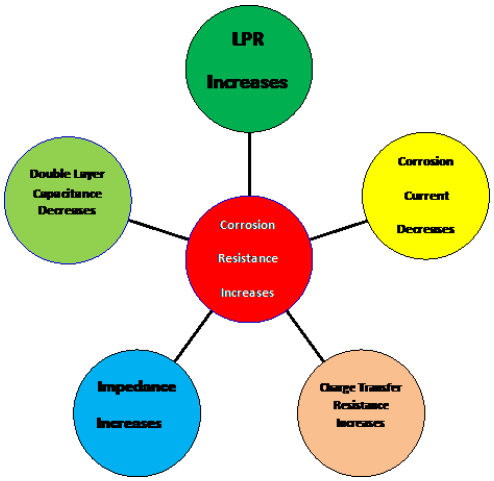
### Influence of Gelusil on corrosion resistance of 18K Gold alloy in artificial saliva

Corrosion resistance of orthodontic wire made of 18 K Gold alloy in presence of Gelusil Tablet has been investigated by electrochemical studies such as Polarisation study and AC impedance spectra appealing

results have been obtained. They are presented and discussed in this section.

It is a fact that when corrosion resistance of a metal or alloy increases, the linear polarization resistance (LPR) value increases and corrosion current ($I_{corr}$) value decreases. Similarly when corrosion resistance value increases.

Charge transfer resistance value increases, impedance value increases and double layer capacitance value decreases (Scheme B) This is due to the fact that when a protective film is formed on the metal surface the flow of corrosive ions on to the metal surface is prevented. Further the loss of electron from the metal surface is also prevented [12-25 ].




**Scheme B.** Correlation among corrosion resistance and corrosion parameters

## Analysis of polarization study

The polarization curves of 18 K Gold immersed in various test solutions are shown in Figures 1 and 2. Corrosion resistance of 18 K Gold immersed in artificial saliva in presence of Gelusil is given in the Table 1. The Linear polarization resistance values of 18 K Goldin artificial saliva in the absence and presence of Gelusil tablet are compared graphically in Figure 3.

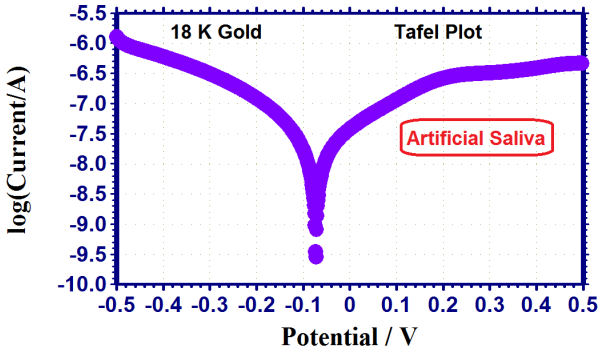



**Figure 1:** Polarization curve of 18 K Goldimmersed in Artificial Saliva

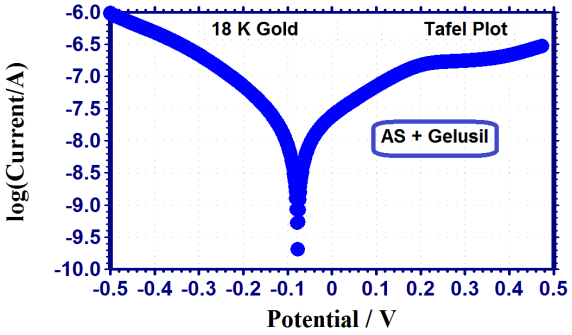



**Figure 2:** Polarization curve of 18 K Goldimmersedin artificial saliva in the presence of Gelusil

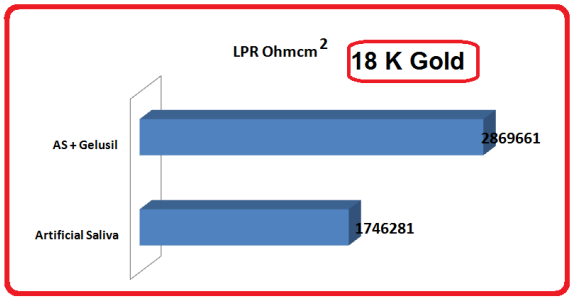



**Figure 3:** Comparison of linear polarization resistance values of 18 K Gold in artificial salivain the absence and presence of Gelusil

When 18 K Gold is immersed in artificial saliva, $E_{corr}$(corrosion potential) is -0.072V vs SCE.The corrosion current ($I_{corr}$) is 2.166 x $10^{-8}$ A/ $cm^2$. CathodicTafel slope ($b_c$) is 6.735 V/decade.The anodic Tafel slope ($b_a$) is 4.758 V/decade. The linear polarization resistance (LPR) is1746281 Ohm $cm^2$.

## Influence of Gelusil

When Gelusil is added to artificial saliva, the corrosion potential ($E_{corr}$) is -0.076 V vs SCE. The corrosion current ($I_{corr}$) is 1.263 x $10^{-8}$A/$cm^2$. CathodicTafel slope ($b_c$) is 6.989 V/decade. The anodic Tafel slope ($b_a$) is 5.006 V/decade. The linear polarization resistance (LPR) is 2869661ohm $cm^2$.

It is observed from the Table 1 that when Gelusil is added to AS, The LPR value increases from 1746281 Ohmcm$^2$ to 2869661 Ohmcm$^2$. The corrosion current decreases from 2.166 x $10^{-8}$ to 1.263 x $10^{-8}$A/ $cm^2$.

This indicates that in presence of Gelusil, the corrosion resistance of 18 K Gold in artificial saliva increases. Hence people clipped with orthodontic wire made of 18 K Gold need not hesitate to take Gelusil orally.

**Table1:** Corrosion parameters of 18 K Gold immersed in artificial saliva (AS) in the absence and presence of Gelusil tablet (500 ppm) obtained by polarization study

| System | $E_{corr}$ V $_{SCE}$ | $b_c$ V/decade | $b_a$ V/decade | LPR Ohmcm$^2$ | $I_{corr}$ A/ cm$^2$ |
|---|---|---|---|---|---|
| Artificial Saliva | -0.072 | 6.735 | 4.758 | 1746281 | 2.166 x 10$^{-8}$ |
| AS + Gelusil | -0.076 | 6.989 | 5.006 | 2869661 | 1.263 x 10$^{-8}$ |

## Implication

Hence people clipped with orthodontic wire made of 18K Gold need not hesitate to take Gelusil orally.

## Analysis of AC impedance spectra

The AC impedance parameters such as charge transfer resistance ($R_t$), double layer capacitance ($C_{dl}$) and impedance values of 18 K Gold immersed in AS in the absence and presence of Gelusil are given in Table 2. The Nyquist plots are shown in Figures 4 and 6. The Bode plots are shown in Figures 5 and 7. The charge transfer resistance and double layer capacitance values are derived from Nyquist plot. The impedance values are derived from Bode plot.

The charge transfer values of 18 K Gold in artificial saliva in the absence and presence of Gelusil tablet are compared graphically in Figure 8.

When 18 K Gold is immersed in artificial saliva, $R_t$(charge transfer resistance) is 113500 Ohmcm$^2$. $C_{dl}$ (double layer capacitance) is 4.493 x10$^{-11}$ F/cm$^2$. Impedance is 5.368 log z/ohm.

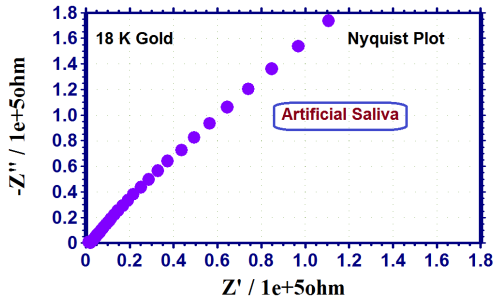



**Figure 4:** AC impedance spectrum of 18 K Goldimmersed in Artificial Saliva

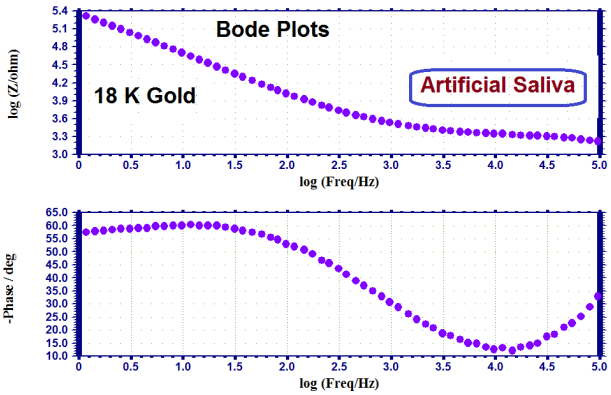



**Figure 5:** AC impedance spectrum of 18 K Gold immersed in Artificial Saliva in the presence of Gelusil

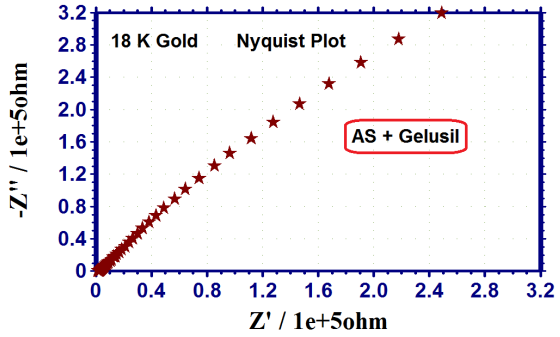



**Figure 6:** AC impedance spectrum of 18 K Gold immersed in Artificial Saliva (Nyquist Plot)

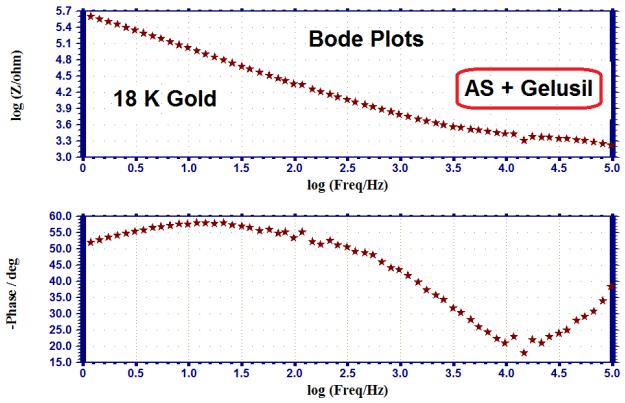



**Figure 7:** AC impedance spectra of 18 K Gold immersed in Artificial Saliva in the presence of Gelusil (Bode Plots)

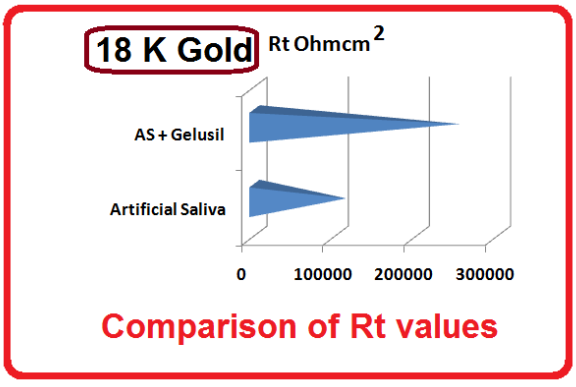



**Figure 8:** Column chart of charge transfer values of 18 K Gold in the absence and presence of Gelusil

### Influence of Gelusil

When Gelusil is added to artificial saliva, the $R_t$(charge transfer resistance) is 253200 Ohmcm$^2$. $C_{dl}$ (double layer capacitance) is 2.014 x10$^{-11}$ F/cm$^2$.Impedance is 5.669 log z/ohm.

It is observed from the Table 2 that when Gelusil is added to AS, the $R_t$ Value increases from 113500 to 253200 Ohmcm$^2$. Double layer capacitance decreases from 4.49x10$^{-11}$ to 2.014x10$^{-11}$ F/cm$^2$. The impedance value increases from 5.368 to 5.669 .

This indicates that in presence of Gelusil, the corrosion resistance of 18 K Gold in artificial saliva increases. Hence people clipped with orthodontic wire made of 18 K Gold need not hesitate to take Gelusil orally.

**Table 2:** Corrosion parameters of 18 K Gold immersed in Artificial Saliva (AS) in the absence and presence of Gelusil (500 ppm) obtained by AC impedance spectra

| System | $R_t$ Ohmcm$^2$ | $C_{dl}$ F/ cm$^2$ | Impedance Log(z/ohm) |
|---|---|---|---|
| Artificial Saliva | 113500 | 4.493 x10$^{-11}$ | 5.368 |
| AS + Gelusil | 253200 | 2.014 x10$^{-11}$ | 5.669 |

### Implication

Hence people clipped with orthodontic wire made of 18K Gold need not hesitate to take Gelusil orally.

## Conclusions

- The corrosion resistance of 18 K Gold in artificial saliva, in the absence and presence of Gelusil has been evaluated by polarization study and AC impedance spectra.
- Polarisation study reveals that in the presence of Gelusil, LPR value increases and corrosion current decreases.
- That is in presence of Gelusil, the corrosion resistance of 18 K Gold in artificial saliva increases.
- AC impedance study reveals that in the presence of Gelusil, $R_t$ value increases and $C_{dl}$ decreases.
- That is in the presence of Gelusil the corrosion resistance of 18 K Gold in AS increases.
- It is concluded that people clipped with orthodontic wire made of 18 K Gold need not hesitate to take Gelusil orally

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