Research Article

# Corrosion Resistance of SS316L in Synthetic Saliva in Presence of D-Glucose

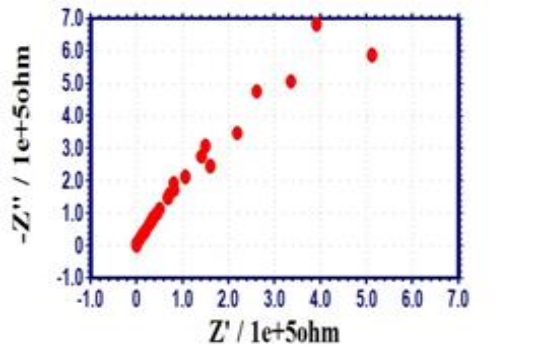
R. Saranya*[1,2] and Susai Rajendran[3,4]

[1]Research and Development Centre, Bharathiar University, Coimbatore 641046 India.
[2]Department of chemistry, Jayalakshmi Institute of Technology, Dharmapuri 636532,India.
[3]Corrosion Research centre, PG & Research Department of chemistry, GTN Arts college,Dindigul 624005,India.
[4]Department of chemistry, RVS School of Engineering & Technology, Dindigul 624005, India.

**Abstract**

One of the primary requisites of any metal (or) alloy that is to be used in the mouth is that it must not produce corrosion products that could be harmful to the body. Some metallic elements that are completely safe in the elemental state can form hazardous or even toxic ions (or) compounds. Besides, the degradation of the Alloy should be limited in order to guarantee its service life. Several metals and alloys have been in dentistry as bracket, band, orthodontic wires it is essential to know the corrosion resistance of this materials in the presence of saliva. corrosion resistance of three metallic materials, namely 18ct gold,22ct gold,SS316L has been evaluated in artificial saliva in the presence of (100)ppm D-glucose.AC impedance spectra have been used to investigate the corrosion behavior of these metals.

The corrosion resistance these materials in artificial saliva in presence of D-glucose, decreased in the following order **SS316L>22ctgold>18ctgold.**




**Keywords:** Corrosion resistance of metals, artificial saliva (AS), D-glucose, dentistry, oral hygiene.

***Correspondence**
R.Saranya,
Email: Senthilkumar944@gmail.com

## Introduction

Corrosion resistance of metals and alloys in various body fluids has attracted the attention of many researchers. Corrosion resistance of various metals have been investigated in various body fluids such as bloodplasma[1,2];urine[3,4];Hanksolution[5,6];Ringersolution[7,8];bovineserum[9];artificialsweat[10,11] And artificial saliva[12,14].

In the oral environment, orthodontic appliances are exposed to potentially damaging physical and chemical agents which may cause metallic corrosion [15]. Factors such as quantity and quality of saliva,salivery pH, the amount of protein in the saliva, physical and chemical properties of foods and liquids general and oral health conditions may influence corrosion in the oral cavity. corrosion will occur continuously in the mouth due to the release of ions with abrasion by foods and liquids. salivary fluid is an exocrine secret in consisting of approximately 99% of water, containing a variety of electrolytes(sodium,potassium,calcium,chloride,magnesium,bicarbonate,phosphate) and proteins represented by enzymes, immunoglobulin and other antimicrobial factors, mucosal glycoproteins,traces of albumin and some polypeptides and oligopeptides of importance to oral health[16].

Generally oral environment, dental implants are exposed to several adverse factors such as change of temperature and oxygen level (due to the food and changes in the saliva),masticatory force and chemical components which contribute to the degradation process of implants (Nakagawa et al.2002).In addition, the electrolytes from saliva can induce crevice corrosion in the peri-prosthetic space of the implant(Nikolopoulou 2006),The $P^H$ of saliva varies in

area around dental implants. Food such as milk, calcium-fortified foods and nuts can alkalify the oral pH (Murell et al. 2010). Several situations can acidify the pH of saliva such as infections, certain foods ( sugary food, pickled food, sour candies, fruits, soft drinks and juices-$P^H$ around 2.5-3.5), mouthwash products ( Dong et al. 1999; Gregory-Head et al. 2000; Murrell et al. 2010),smoking chronic, systemic diseases and medication, which may also contribute to the corrosion of dental implants also contribute to the corrosion of dental implants (Nikolopoulou 2006 ; Vieria et al. 2006; correa et al. 2009).As a consequence of those corrosion products, inflammatory mediators produced by macrophages are released, contributing to bone loss (Nikolopoulou 2006; Denaro et al. 2008). This issue has been investigated in depth in orthopedics. In density, literature that describes the clinical implications of the corrosive nature of dental implants is limited [17].

The present work was under taken to study the corrosion behavior of 18ct gold, 22ctgold and SS316L in the artificial saliva in the presence of 100 ppm D-glucose has been evaluated by AC impedance spectra. An aqueous solution of D-glucose is orally administered to get energy at once. It will be interesting to investigate if this glucose will corrode the orthodontic wires metal plates used for complete and dentures, crowns and bridges. corrosion behavior metals and alloys have been studied in artificial saliva in many researchers the composition is given table-1

**Table 1** Composition of artificial saliva[12-14]

| Content | Quantity $gL^{-1}$ |
|---|---|
| KCl | 0.4 |
| NaCl | 0.4 |
| $CaCl_2.2H_2O$ | 0.906 |
| $NaH_2PO_42H_2O$ | 0.690 |
| $Na_2S.9H_2O$ | 0.005 |
| Urea | 1 |

In electrochemical studies, the metal specimens were used as working electrodes. Artificial saliva was used as the electrolyte. The temperature was maintained at 37±1˚C Commercially available D-glucose[Indian pharmacopeias grade] was used in this study.100 ppm of D-glucose was used in AS

**Experimental:**
**Materials and Methods**:

**Table 2** Composition of 18 ct gold [18, 19]

| | |
|---|---|
| Gold | 75% |
| Copper | 5-15% |
| Silver | 10-20% |

**Table 3** Composition of 22ctgold [20]

| | |
|---|---|
| Gold | 91.67% |
| Silver | 5% |
| Copper | 2% |
| Zinc | 1.33% |

**Table 4** Composition of SS316L [21, 22]

| | |
|---|---|
| Cr | 18 |
| Ni | 12 |
| Mo | 2.5 |
| C | <0.03 |
| Iron | Balance |

The18ctgold, 22ctgold and SS316L where used in the present study. Their composition is given in table 2,3and 4.

**AC impedance spectra**:

AC impedance spectra were recorded on the same instrument used for polarization study using the same type of three electrode cell assembly. The real part and the imaginary part of the cell impedance were measured in ohms for various frequencies. The charge transfer resistance (Rt) and double layer capacitance values are derived from Nyquist plots. Impedance values,log(Z/ohm) are derived from Bode plot. The result are summarized in **table-5**

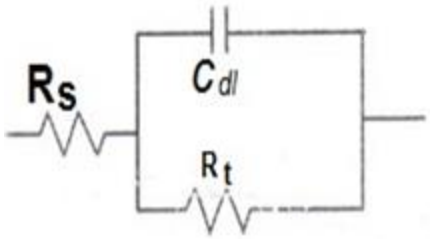



**Figure 1**

$\mathbf{R_t=(R_s + R_t)-R_s}$
Where,
$R_s$ =solution resistance
$R_t$ =charge transfer resistance
Where, Fmax=frequency at maximum imaginary impedance

C=Double layer capacitance
$\mathbf{C=1/2\pi R_t fmax}$

**Table 5** Corrosion parameters of metals immersed in Artificial saliva(AS) in the presence of D-Glucose obtained from AC impedance spectra

| METAL | SYSTEM | $R_t$ohm $cm^2$ | $C_{dl}$µF/0.00785$cm^2$ | IMPEDANCE log(Z/ohm) |
|---|---|---|---|---|
| 18 ctgold | AS+100ppmD-glucose | 235928 | $3.38164x10^{-11}$ | 5.6 |
| 22 ctgold | AS+100ppmD-glucose | 471540 | $4.06809x10^{-11}$ | 5.79 |
| SS316L | AS+100ppmD-glucose | 510413 | $3.75827x10^{-11}$ | 5.88 |

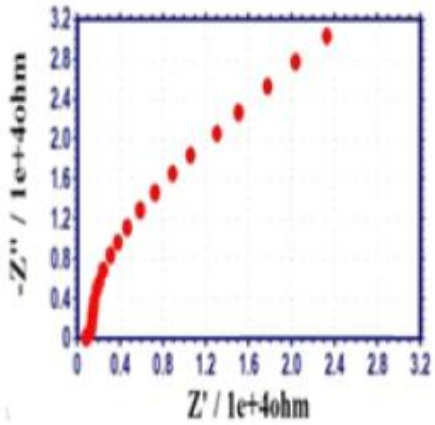



**Figure 2** AC impedance spectra (Nyquist plots) of 18ctgold immersed in AS

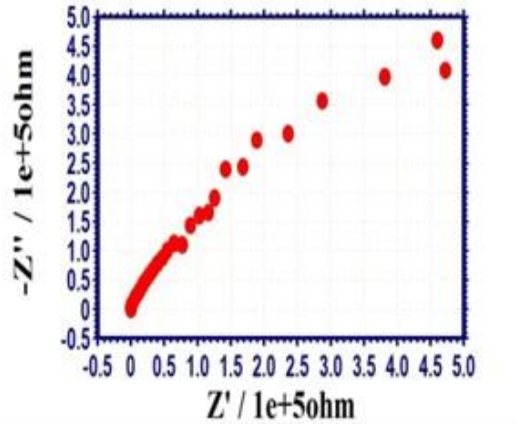



**Figure 2a** AC impedance spectra (Nyquist plots) of 22ct gold immersed in AS+100ppmD-glucose

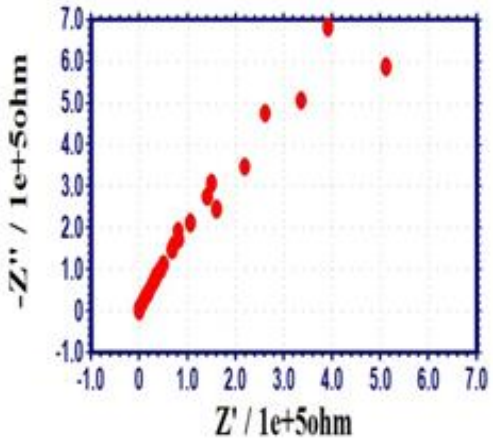



**Figure 2b** ACimpedance spectra (Nyquist plots) of SS316L immersed in AS+100ppmD-glucose

## Result and Discussion

Corrosion resistance of three metals namely 18ctgold, 22ctgold,SS316L in AS in the presence of D-glucose has been investigated by AC impedance spectra. When corrosion rate decreases due to formation of protective film, the charge transfer resistance ($R_t$) value increases and double layer capacitance ($C_{dl}$) value decreases, the impedance log (Z/ohm) value increases [23-39].

### Corrosion behavior of metals in AS containing D-glucose

#### 18ct gold

When 18ctgold was immersed in AS containing D-glucose (100ppm) the charge transfer resistance was 235928 ohmcm$^2$.The double layer capacitance was 3.38164x10$^{-11}$F/0.00785cm$^2$.The impedance value log(Z/ohm) was 5.6.It is observed that the charge transfer resistance value increased, double layer capacitance decreased. There was an increase in the value of impedance log (Z/ohm).These observations indicated AS containing D-Glucose, the corrosion rate of 18 ct gold was reduced, due to the formation of a protective film formed on the metal surface.

#### 22ct gold

When 22 ct gold was immersed in AS containing D-glucose (100ppm) the charge transfer resistance was 471540ohmcm$^2$.The double layer capacitance was 4.06809 x10$^{-11}$F/0.00785cm$^2$.The impedance value log(Z/ohm) was 5.79compared with 18ctgold the $R_t$ value increased and $C_{dl}$ value is decreased. There was an increase in the value of impedance log (Z/ohm).It is inferred that a protective film is formed on the metal surface in the presence of D-glucose. It prevents the corrosion of metal in AS.

#### SS316L

When SS316L immersed in AS containing D-glucose (100ppm) the charge transfer resistance was very high 510413 ohm cm$^2$; the $C_{dl}$ value was very low 3.75827x10$^{-}$11F/0.00785cm$^2$;The impedance value was high 5.88.These observations indicate that the corrosion resistance of SS316L in AS increased in the presence of D-glucose. The film formed on the metal surface suggests SS316L was more stable and also prevented the loss of electron from the metal. Because of the presence of the film, the charge transfer resistance increased and the double layer capacitance value decreased because they are inversely related to each other.SS316L was able to withstand the attack of aggressive ions present in AS. So SS316L was more corrosion resistant, when compared with 18ct gold and 22ct gold. Thus AC impedance spectra study leads to the conclusions that in the presence of D-glucose, the corrosion resistance of all three metals in AS increased.

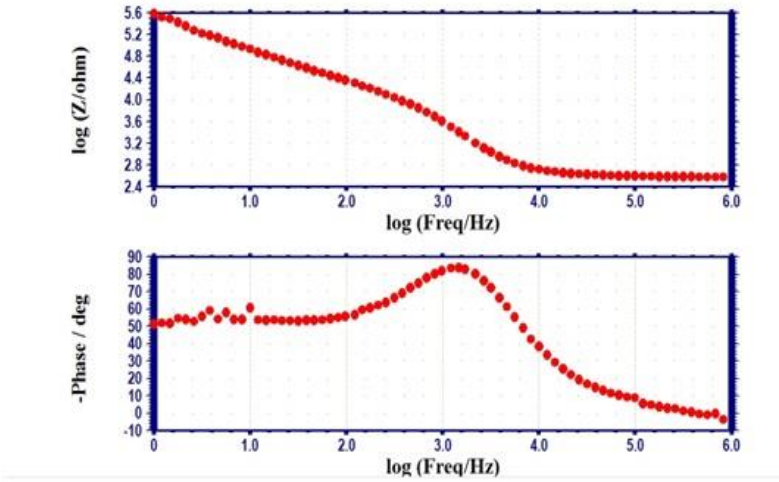



**Figure 3** AC impedance spectra (Bode plots) of 18 ctgold immersed in AS

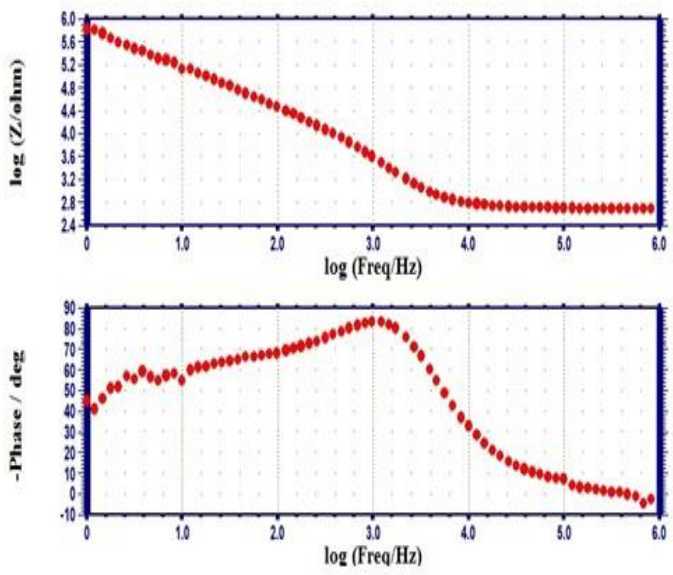



**Figure 3a** AC impedance spectra (Bode plots) of 22ct gold immersed in AS+100ppm D-glucose

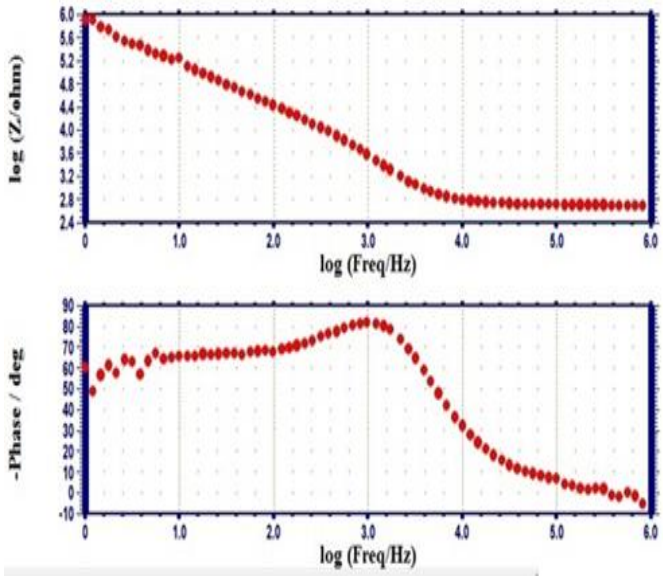



**Figure 3b** AC impedance spectra (Bode plots) ofSS316L immersed in AS+100ppm D-glucose

## Conclusion

In the presence of D-glucose all three metals showed better corrosion resistance. The decreasing order of corrosion resistance is **SS316L>22ctgold>18ctgold.** People who make use of SS316L orthodontic wires need not hesitate to take D-glucose solution orally, since the corrosion resistance of the metal increases in the presence of D-glucose.

**Acknowledgement**

The authors of thankful to their management and St.Joseph's research and community development trust,Dindigul for their help and encouragement.

## References

[1] Quach WC, Schmutz P, Eur. Cell. Mater, 2007, 14, 4.
[2] Faszenda Z, Waske W, Ziebowic Z, J. Achiev Mater Manuf Engg,2007, 28, 293.
[3] Przondziono J, Walke W, Arch.Mater. Sci. Eng. 2009, 35(1), 21.
[4] Walke W, Preondziono J, Solid State Phenomena, 2010, 165, 404.
[5] Wang Y B,Li H F, Cheng Y, Wei S C, Zheng Y F, Electrochem Commun, 2009, 11(11), 2187.
[6] Tamilselvi S, Raman V, Rajendran, N, J Appl Electrochem, 2010, 40(2), 285.
[7] Singh R, Kurella, A, Dahotre N B, J Biomater Appl, 2006, 21(1), 49.
[8] Popa M V, Vasileseu E, Prob P,Vasilescu C, IFMBE Pro, 2009, 25(10), 24.
[9] Hang R, Ma S, Jiv Chu, P K, Electro Chim Acta, 2010, 55(20), 555.
[10] Randin J P, J Biomed Mater Res, 1988, 22(7), 649.
[11] Rezic I, Curkovic L, Ujevic M, Corrosci, 2009, 51, 1985.
[12] Rajendran S, Paulraj J, Rengan P, Jeyasundari J, Manivannan M, J Dentistry Oral Hug 2009, 1(1), 001.
[13] Meyer J M, Corrosci, 1997, 17, 971.
[14] Christoper M A, BrettIoanaMuresan, Key Eng Mater, 2002, 230, 459.
[15] Hussien A H, Ausama Al-Mulla, J Bagh Coll Dentistry, 2010, 22(1), 68.
[16] Patricia Del, Ana Maria Trindade, Maria Angela Naval, Antonio Adilson, Luciana Resis, The Journal of contemporary Dental Practice, 2008, 9, 3
[17] Valentim A R Barao, Mathew T Mathew, Wirley Goncalves Assuncao, Judy chia-chun yuan, Markus A wimmer, Cortino sukotjo, Clinical oral implants research, 2011,1055-1062.
[18] Raykhtssaum G, Agarwal D P, GoldTechnol, 1997, 10, 26.
[19] AgilaDevi S, Rajendran S, Jeyasundari J, Pandiarajan M, Eur Chem Bull. 2013, 2(2), 84.
[20] Nishio A, Gold Technol, 1996, 19, 11.
[21] Rajendran S, Chitradevi P, Johnmary S, Krishnaveni A, Kanchana S, Lydiachristry, Nagalakshmi R, Narayanasamy B, ZastitaMater, 2010, 51, 149.
[22] Rajendran S, Uma V, Krishnaveni A, Jeyasundari J, Shyamaladevi B, Manivannan M, The Arabian Journal for Science and Engg, 2009, 34, 147.
[23] JohnAmalraj A, WilsonSahayaraj J, Kumar C, Rajendran S, PeterpascalRegis A, Selvaraj S K, Mohan R, Eur Chem Bull, 2013, 2(6), 315.
[24] Jeyasundari J, BrightsonArulJacob Y, Rajendran S, J Chem Bio Phy Sci, 2012, 3(1), 58.
[25] Rajendran S, Kangamani M, Sivakalaivani M, Jeyasundari J, Narayanasamy B, Rajam K,ZastitaMater. 2008, 49, 19.
[26] AgnesiaKanimozhi S, Rajendran S, J Chem Bio Phy Sci, 2012, 2(1), 82.
[27] Rajarathinam C, JohnAmalraj A, Kumar C, PeterPascalRegis A, Rajendran S, MariaMichael S, WilsonSahayaraj J, Eur Chem Bull, 2014, 3(1), 58.
[28] Rajendran S, Agasta M, Bamadevi R, Shyamaladevi B, Rajam K, Jeyasundari J,ZastitaMater, 2009, 50, 77.
[29] SyedAbuthahir S S, Jamal Abdul Nasser A, Rajendran S, Eur Chem Bull,2014, 3(1), 40.
[30] LeemaRose A, NoreenAntony, Felicia RajammalSelvarani, Peter Pascal Regis, Rajendran, S,ZastitaMater, 2009, 50, 167.
[31] Sathiyabama, Rajendran S, Arockiaselvi J, Jeyasundari J, The Open Corrosion Journal, 2009, 2, 76.
[32] LeemaRose A, Peter Pascal Regis A, Rajendran S, Felicia RajammalSelvarani, Krishnaveni, A, ZastitaMater, 2010, 51, 221.
[33] Rajendran S, Sumithra P, Shyamaladevi B, Jeyasundari J, ZastitaMater, 2009, 50, 223.
[34] AgnesiaKanimozhi S, Rajendran S, International Journal of Elect Chem Sci, 2009, 4, 353.

[35] Noreen Antony H, Benita Sherine, Rajendran S, ZastitaMater, 2010, 51, 11.
[36] Kalaivani R, Narayanasamy B, Selvi J A, Amalraj A J, Jeyasundari J, Rajendran S, Portugaliae Electrochemica Acta, 2009, 27, 177.
[37] Rajendran S, Muthumegala T S, Krishnaveni A, Manivannan M, Shyamaladevi B, Narayanasamy B, HajaraBeevi, LeemaRose A, ZastitaMater, 2011, 52, 35.
[38] JosephRathish R, Rajendran S, LydiaChristy, Shyamaladevi B, Johnmary S, Manivannan M, Rajam K, Rengan P, The Open Corrosion Journal, 2010, 3, 38.
[39] WilsonSahayarai J, Rajendran S, Muthumegala J, John Amalraj, ZastitaMater, 2010, 51, 232.



Publication History
Received 07th July 2014
Revised 15th July 2014
Accepted 20th July 2014
Online 30th July 2014