CORROSION RESISTANCE OF METALS AND ALLOYS IN ARTIFICIAL SALIVA – AN OVERVIEW

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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 alloy 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. The corrosion resistances of these materials have been evaluated by electrochemical studies such as polarization study and AC impedance spectra. The film formed on the metal surface has been analysed by surface analysis techniques such as SEM, EDX, X-ray, and AFM.

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Introduction

Over the past two decades, with the accelerated development of tissue engineering, the demand for a variety of synthetic and natural biomaterials has dramatically increased. Biomaterial sales have already exceeded $240 million per year and due to the rapid development of biomaterials, the market will only increase in the years ahead for tissue engineering and artificial organ materials. Specifically, costs related to organ replacement account for 8% of all global healthcare spending and by 2040 as much as 25% of the US gross domestic product (GDP) is expected to be related to healthcare. Such demands require unique, better performing biomaterials for regenerative medicine. For example, it is necessary to develop better material mechanical properties and biocompatibility properties. Conventional biomaterials (or those materials with constituent dimensions greater than 1 μm) have not satisfactorily met clinical demands. Researchers, clinicians and other investigators are thus seeking better novel materials to serve as the next generation of tissue engineering and artificial organ materials. Artificial organs, when implanted in body undergo corrosion. Corrosion behaviour of metals and alloys in simulated body fluids has been investigated.[1-75] Corrosion resistance of metals and an alloy in saliva has attracted the attention of several researchers (Figure 1). This review article will be a boon to researchers who would like to do research on corrosion behaviour of biomaterials in synthetic body fluids especially in simulated saliva.

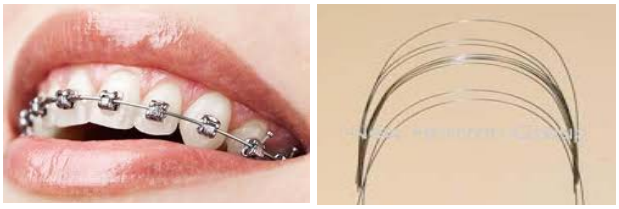

Figure 1. Orthodontic wires

Metals and Alloys

Corrosion behaviour of various metals and alloys have been investigated in various synthetic body fluids such as blood plasma, urine and saliva.[1-75] Titanium metal,[12,28,46,52,72,73,75] Ni-Cr,[10,56,57] Ti-Mo,[4,37] Ni-Ti,[13,64] Co-Cr,[14,53,61,63] SS316, MS, MS-Zn,[23,24] Ti-Ag,[3,68] Ni-Ti orthodontic wires[18,27,33] have been used in dentistry.

Medium

Usually corrosion behaviour metals and alloys have been studied in artificial saliva (AS) whose composition is given in Table 1.[23]

Table 1. Composition of artificial saliva

KCl	0.4 g/l
NaCl	0.4 g/l
$CaCl_2 \cdot 2H_2O$	0.906 g/l
$NaH_2PO_4 \cdot 2H_2O$	0.690 g/l
$Na_2S \cdot 9H_2O$	0.005 g/l
Urea	1 g/l

In some studies aerated and deaerated saliva has been used.[8,10,46,55] AS containing hydrogen peroxide,[6] fluoride,[2,4,6,22,38,43,45,60,73] spirulina,[23] D-Glucose,[42] electoral,[24] physiological solution (ps),[17,25,40] lactic acid,[17,51,71] spices extract,[29] bacteria,[33,53] mouthwash,[34,37] NaF,[36,39,67,71] citric acid,[75] Ringer brown solution,[39,50] have been used.

Temperature

Usually the study is carried out at 37 ± 1ºC.

Methods

Weight loss method, polarization study, AC impedance spectra have been used to evaluate the corrosion resistance of various metals and alloys in AS.[1,4,5,6,7,10,19,20,21,22,23,24,54] The protective film form in the metal surface has been analysed by various surface analysis techniques such as SEM,[2,6,7,9,21,26,35,36,41,49,59,68,73,75] XRD,[3,17,68,71] EDX,[9,14,34,41,59,75] F-test has also been used by some authors.[11] Cyclic voltammetry,[13, 25] AAS,[26] and XPS[3,16,17,25,58,68,71] have also been used.

A list of various materials used in dentistry, the methods used to evaluate the corrosion resistance of different metals and alloys, various methods employed and important findings are summarized in Table 1.

Influence of Fluoride ion on corrosion resistance of orthodontic wires

To strengthen the lifetime of teeth, fluoride is added in tooth pastes. This addition of fluoride may influence the strength of orthodontic wires. To know this influence several investigations have been undertaken. Corrosion resistance of metals and alloys in artificial saliva, in presence of fluoride has been investigated.[31,38,43,45,51,71,73] It has been found that fluoride ion reduces the corrosion resistance of Titanium and Ti6AlV alloy. This has been proved by electrochemical studies.[31] Similar observation is made with Ni-Cr-Ti alloy also.[38] Surprisingly the presence of fluoride ion increases the corrosion resistance of Ti-Cr alloy.[43] Robin and Meirelis observed that presence of fluoride in saliva enhanced porosity of the oxide film.[45] Mareci et al observed that fluoride increased the corrosion rate of Ti6Al7Nb and Ti30Ta alloys.[51]

Influence of extracts of natural of products on corrosion resistance of metals and alloys in artificial saliva

Extracts of natural products are added to the tooth paste. These extracts will definitely influence the corrosion resistance of orthodontic wires. Hence the corrosion resistance of extracts of plant materials on the corrosion resistance of orthodontic wires has to be studied thoroughly. But only a few studies have been made in this regard.[29,73]

Presence of coriander in artificial saliva inhibited the pitting corrosion of AISI 304L orthodontic bands and stainless steel orthodontic bands.[29] Eugenol has protected Titanium from the attack of fluoride ions. Further, Eugenol has formed a protective film on titanium and prevented the dissolution of Titanium. This has been proved by electrochemical measurements and surface analysis techniques such as SEM.[73]

Types of corrosion undergone by orthodontic wires.

There are several types of corrosion undergone by metals and alloys in the natural environment. Depending on the environment, they undergo general corrosion, galvanic corrosion, pitting corrosion etc. Similarly orthodontic wires also undergo several types of corrosion, depending on the natural of metals and alloys and the oral environment. Ti-6Al-4V undergoes fretting corrosion in presence of fluoride ion.[2] Ni-Cr and Co-Cr alloys undergo pitting corrosion in artificial saliva due to inhibition in artificial saliva for a long time.[5] Hence the orthodontic wires have to be replaced every now and then. Vieira et al observed that Titanium undergoes fretting corrosion in artificial saliva.[12] This has been proved by electrochemical studies. Ludek Joska et al have noticed the non-uniform corrosion undergone by palladium-silver-copper alloy in model saliva.[16] Orthodontic wires made of Ni-Ti alloy undergo pitting corrosion in artificial saliva. Similarly metals and alloys undergo non-uniform corrosion[58] and galvanic corrosion.[62]

Influence of temperature on the corrosion resistance of orthodontic wires.

The average body temperature is 37 ºC. Hence the experiments are carried out at 37 ± 0.1 ºC. However, when hot liquids such as hot water, hot coffee or tea, orally taken, they will affect the corrosion resistance of orthodontic wires in the oral environment. Hence researchers have carried out experiments at various temperatures also.[8,19,46] It is observed[8] that the corrosion rate of non precious dental alloys increases when the temperature is increased (20, 37 and 50 ºC). At low temperature, passive films are formed. At 25 ºC a passive film is formed on pure Titanium.[46]

Influence of pH on the corrosion resistance of orthodontic wires.

Influence of pH on corrosion and passivity is a well established concept. At lower pH, because of acidic environment, many metals and alloys undergo corrosion. Same thing happens to metals and alloys of orthodontic wires in the oral environment.[11,26,36,38,45,52,60,72] At pH 4 and 6, in presence of sodium fluoride, and artificial saliva, stainless steel and nickel-titanium alloy undergo pitting corrosion.[36] This has been proved by SEM. At low pH value of saliva, the oxide film formed on Ti-23T alloy was found that to be porous, which may enhance corrosion than at low pH =2.5. The corrosion of Ti6AlNb and Ti30Ta alloys increased, in presence of fluoridated saliva.[51] At low pH values, the bonding strength was reduced in Titanium-Porcelain.[60]

Table 1. Corrosion resistance of different metals and alloys

No.	Metals	Medium	Methods	Findings	Ref.
1	Aluminum-bronze dental alloy	Artificial saliva (AS)	Polarization test, Polarization resistance measurements & weight loss method	Beverages are in contact with dental alloy in the oral environment.	1
2	Ti-6AI-4V	AS Containing 0, 190, 570, 1140 ppm of fluoride ions	Free corrosion potential measured as a function of time SEM & non – contact optical profile meter	Fretting corrosion behaviour dependence on the fluoride ion concentration.	2
3	Ti-Ag	AS	X - ray photoelectron spectroscopy (XPS) & X- ray diffraction (XRD) methods.	The addition of Ag to Ti is found to be effective in reducing corrosion current density and increasing OCP of Ti in AS environment.	3
4	Ti-15Mo alloy	0.15 M NaCl solution containing varying concentration fluoride ions (190, 570, 1140, 9500, ppm)	Potentiodynamic polarization, electrochemical impedance, spectroscopy (EIS) & Chronoamperometric current time transient (ctt)	Passivity at anodic potentials at all concentration of fluoride ions.	4
5	Recasting Ni-Cr & Co-Cr Non precious dental alloy	AS	(Chemical & Electro chemical technique) induced coupled plasma mass spectrometry (ICP/MS), potentiodynamic & impedance measurement	Alloy surface forming definite patches which may be the nucleus of pitting corrosion due to immersion for long time. Non-precious alloy have high corrosion resistance.	5
6	Non- precious dental alloy	Artificial saliva containing different concentration of hydrogen peroxide, carbamide peroxide & fluoride ions.	Potentiodynamic studies were conducted by (ACM) auto tafel potentiostat	Alloys suffer less corrosion rates in presence of carbamide peroxide than hydrogen peroxide. Wiron99 > wirolloy > wironit	6
7	Fe Pt – based alloy	AS at 37 °C	Electrochemical polarization measurements & SEM	Highly stable also during long-term exposure	7
8	Non precious dent alloy	Aerated AS (20 °C, 37 °C, 50 °C)	Linear polarization method	Corrosion rate increased with increasing temperature.	8
9	Nickel-Based dental casting alloy	AS at different values of pH in the presence of crevice	Energy Dispersive X-ray analysis (EDX), SEM	Importance of the level of Cr in Ni-based alloy. Higher Cr (25wt%)led to a superior corrosion resistance	9
10	Ni-Credential casting alloy	De-aerated & aerated artificial saliva	Polarization studies	Alloys with low Cr content and without Mo always corrode.	10
11	i) Composition of the high noble metal, ii) Composition of noble metals, iii) Composition of base metals alloy	Acidified artificial saliva (pH=2.3)	ICP-AES, F-test	Corrosion resistance results obtained from the two methods were ranked and compared	11
12	Titanium	AS	Electrochemical measurements	Higher corrosion rate during fretting corrosion.	12
13	Nickel-Titanium	Fluoridated AS at 37 °C	TLA, Voltammetry	Corrosion behavior of Ni-Ti alloy is highly affected by the fluoride content.	13
14	Cobalt–Chromium dental alloy doped with precious metals	AS	Coulometric analysis, metallography & EDX	Gold doping produces heterogeneous microstructures that are vulnerable to corrosive attack	14
15	Palladium-Silver binary alloy	AS	Polarization resistance, potentiodynamic measurements, thermodynamic calculation	Commercial dental alloys containing Ag and Pd as major compounds.	15
16	Palladium-Silver-Copper alloy in model saliva	Model saliva	XPS, thermodynamic analysis	The alloying of the palladium silver binary system with copper leads to change in the corrosion behavior of the alloy	16
17	Au-Pd-In alloy	Physiological solutions i) 0.9N NaCl , ii) 0.1N NaCl, iii) +0.1N Lactic acid & AS	XPS, X-ray diffraction, Impedance spectroscopy and DC Voltammetry	In_2O_3 main corrosion product on the surface. Same corrosion rate assuming different oxides on the surface	17
18	Ni-Ti Orthodontic wires	AS at 40 °C	ASTM F746, Potentiodynamic test	Ni-Ti wires have sufficient resistance against pitting corrosion in AS.	18
19	TiNi shape memory alloy (SMA) & Stainless steel (SS)	AS at 37 °C	Potentiodynamic polarization test	Lower the corrosion potential & the higher the current density.	19
20	TiO_2 nanotubes	AS	Open circuit potential (OCP),Electrochemical impedance spectroscopy (EIS) & Potentioedynamic polarization test	Diameter that too large leads to decreased corrosion resistance.	20

Table 1. (cont.)

No.	Metals	Medium	Methods	Findings	Ref.
21	Dental alloys containing palladium	AS	Open-circuit potential (OCP) Potentiodynamic polarization,SEM	Optimal corrosion resistance values were obtained	21
22	Austenitic & duplex stainless steels	AS with addition of fluoride	Open-circuit potential (OCP), Electrochemical impedance spectroscopy(EIS) and Potentiodynamic measurements	The passive films on both materials predominantly contained Cr oxides.	22
23	i) SS316 ii) MS iii) MS-Zn	AS in the absence & presence of spirulina	Potentiodynamic polarization study, AC impedance spectra	Order of corrosion resistance SS316 > MS > MS-Zn	23
24	i) SS316 ii) MS iii) MS-Zn	AS in presence of electoral	Potentiodynamic polarization study, AC impedance spectra	Order of corrosion resistance SS316 > MS-.Zn > MS	24
25	Austenitic316L duplex2205 stainless steel	AS and Hank's solution(PS)	Cyclic voltammetry, Electrochemical atomic force microscopy (EC-AFM) and XPS	Corrosion products formed during the oxidation process was observed.	25
26	Metal-ceramic dental casting alloy	AS (pH=2.3, 6.5); 0.9% saline solution of pH=7.3	Atomic absorption spectroscopy(AAS), SEM	Wirocer plus alloy presents a better electrochemical behavior & biocompatibility then Vera soft alloy	26
27	Nickel-titanium orthodontic arch wires	AS	Continuous bending stress throughout the 14 days experimental process	Bending stress, loading condition with respect to corrosion behavior	27
28	Titanium alloy	AS at 37 °C	Electron beam melting (EBM), Dynamic potentiostatic polarization	All the mechanical properties & corrosion character were tested	28
29	AISI304L Orthodontic bands (or) Stainless steel orthodontic bands	AS containing spice extract	Electrochemical experiments were using analysed corrosion parameters	Coriander was found to inhibit pitting.	29
30	SUS304 stainless steel	AS	Polarization resistance measurements	Nano crystalline 304SS is more corrosion resistant than the microcrystalline 304SS	30
31	Ti &Ti6Al4V	AS	Electrochemical methods	Fluoride concentration increases corrosion resistance is decreased	31
32	Titanium Nitride (TiN) plating	AS with 1.23% acidulated phosphate fluoride (APF)	EZ test	TiN plating is a method to prevent metal corrosion and can increase the surface smoothness.	32
33	Nickel-titanium orthodontic wires	Solution containing streptococcus mutans oral bacteria & i) Ringer sterile AS ii) AS enriched with a sterile iii) addition of bacteria	Free corrosion potential, potentiodynamic curves & impedance spectroscopy	Ti coated metal a bracket with corrosion or without corrosion can't reduce the frictional force.	33
34	Titanium nitride plating metal brackets i) Blank control group ii) DLC coated group iii) TiN-coated gp	AS and mouthwash	Energy Dispersive spectroscopy, EZ- test.	The DLC coated groups exhibited lower static and kinetic than TiN-coated bracket	34
35	Dental metal-ceramic	Acidic AS	SEM-EDS	Decrease of mechanical strength of conventional metal-ceramic interface after immersion.	35
36	i)Stainless steel ii)nickel -titanium	Acidulated sodium fluoride (NaF) & AS pH=4 & 6	SEM	Pitting corrosion occurred on the surfaces of the brackets & wires	36
37	TiMo alloy	AS and commercial mouth wash solution with 450 ppm at 25 °C	Open-circuit potential (OCP),Electrochemical impedance spectroscopy (EIS)and potentiodynamic measurements	Superior corrosion resistance	37
38	Ti & Ni-Cr-Ti	AS contains 0.2 % NAF	Electrochemical technique, electric potential of corrosion (Ecorr), current density of corrosion (Icorr), polarization resistance(Rp)	AS containing fluoride ions decreases of the corrosion resistance of pure titanium	38
39	Ag20Pd5Au1.5Ti alloy	Carter-Brugirard AS un-doped & doped with 0.05M NaF different pH values Ringer brown solution	Potentiodynamic and linear polarization, EIS	High corrosion resistant.	39
40	Ni50.2Ti49.8	Hank's solution & AS	High pressure torsion (HPT) technique.	Nano crystalline higher pitting corrosion potential & than that of microcrystalline	40

Table 1. (cont.)

No.	Metals	Medium	Methods	Findings	Ref.
41	Type lll gold alloy Group I (100% as received metal); Group II (50%wt new metal 50%wt once recast metal) Group III (100% once recast metal)	AS at 37 °C	SEM, X-ray energy-dispersive spectroscopy	Recasting protocol should produce acceptable corrosion resistance	41
42	i)SS316 ii)MS iii)MS-ZN	AS in the absence & presence of D-Glucose	Potentiodynamic polarization study, AC impedance spectra	Order of corrosion resistant SS 316L > MS-Zn > MS.	42
43	Ti-Cr	AS containing fluoride	Potentiodynamic polarization study, (ESCA) Electron spectroscopy for chemical analysis.	Greater resistance to corrosion in the fluoride containing AS	43
44	i) Nickel alloy ii) Co-Cr alloy iii) AuAgPd	Fusayama-Meyer AS addition of Yeast extract	Open-circuit potential (OCP).	Ni Co-Cr alloy are passivity character AuAgPd alloy higher corrosion current	44
45	Ti-23Ta alloy	AS with different pH fluoride concentration	Electrochemical Impedance spectroscopy (EIS)	The presence of fluoride and low pH of saliva enhance porosity of the oxide film.	45
46	Pure titanium	Naturally aerated AS solution at 25 °C	Open-circuit potential (OCP), Potentiodynamic polarization.	Protective passive film is formed.	46
47	Casting alloy Ni-Cr(M1); Co-Cr(M2); Palladium based (M3) Gold based (M4)	AS at 37 °C	Potentiodynamic polarization test, Inductively coupled plasma mass spectrometry	Au and Pd based noble alloys dissolved less than Ni-Cr and Co-Cr based alloy	47
48	Y-TZP dental ceramic	AS	Static loading & Cyclic loading	Corrosion Plays an important role in the fatigue behaviour of dental zirconia	48
49	Dental implant system (in vivo & invitro)	AS at 37 °C	Potentiostat FE-SEM &EDS	Rp for clinically non-used implant system increases compared with clinically used implant system	49
50	Ag-20Pd-5Au-1.5Ti alloy	Carter-Brugirard AS undoped and doped with 0.05MNaF different pH values &Ringer- brown solution	Poetntiodynamic &linear polarization, EIS, OCP	Corrosion resistance is high	50
51	Ti6Al7Nb&Ti30Ta	i) AS pH=8.0 ii) 9.8g/l lactic acid pH=2.5 iii) Fluoridated saliva 1.0g/lF pH=8 iv) Fluoridated acidified saliva 9.8g/l lactic acid,1.0 g/l F pH=2.5	OCP linear sweep voltametric analysis were used	The Corrosion of Ti6Al7Nb&Ti30Ta alloys is enhanced in fluoridated acidified saliva	51
52	Titanium alloy	AS &simulated body fluid (SBF) solution at 25 °C pH=2.5	Potentiodynamic polarization test	Hydroxyapatite layer has influence on corrosion resistant properties	52
53	Cobalt-chromium	Saliva &bacteria	Voltamperometri study	acidity of the salivary solution has a negative effect on the alloy Co-Cr	53
54	Ni-Cr-Mo dental alloy	AS	Electrochemical character	Friction & wear of dental alloy does not change their corrosion resistance	54
55	Ti50Ni47.2Co2.8	Deaerated AS	OCP, Potentiodynamic and potentiostatic technique and XPS	The addition of co had little effect on the corrosion behaviour of NiTi as well as the formation of passive film	55
56	i) Ni-Cr ii) Co-Cr iii) c.p-Ti & one ceramic (three dental casting alloy)	AS brushed without or with one of four tooth pastes of different relative dentine abrasivity (RDA 50, 52, 80 & 114)	Non-parametric test	Variations in micro hardness & surface roughness were not clinically relevant	56
57	i) Ni-Cr ii) Co-Cr iii) c.p-Ti & one ceramic (three dental casting alloy)	AS brushed without or with one of four tooth pastes of different relative dentine abrasivity (RDA 50, 52, 80 & 114)	Inductively coupled plasma mass spectrometry, ANOVA and non-parametric test	Increase of the micro hardness, decrease of the corrosion resistance &an increase of the ion release	57

Table 1. (cont.)

No.	Metals	Medium	Methods	Findings	Ref.
58	Palladium-Silver-copper alloy	Model saliva	XPS,thermodynamic analysis	Non-uniform corrosion	58
59	Cast high noble alloy (72.7%-75.7% Au; 4.5 to 7 Pd; 10.7 to 11.1 Ag; 7.8-8.4% Cu & 1.0-1.4% Zn	Fusayama As(n=3) at 37°c	Potentiodynamic polarization, SEM, X-ray Energy dispersive.	Retained passivity under electrochemical conditions similar to the oral environment	59
60	i) Titanium – Porcelain ii) Interface between porcelain & Titanium	AS with addition of fluoride pH (2.7, 5.4, 7.0) F–(pH=7.0, 100 ppm) AS pH = (2.7, 5.4,7.0) AS pH = (2.7,5.4,7.0)	Three - point flexure test.	i)Reduction of bonding strength ii) No decreasing of the bonding strength of Ti- Porcelain occurred	60
61	Dental cobalt – chromium alloy dental amalgam	AS	Potentiodynamics & potentiostatic polarization	Alloys could be reused by adding 50 % of new alloy pellets	61
62	Non – precious dental alloy & pure titanium (Co-Cr –Mo & Ni – Cr-Mo) & dental amalgam	AS	Cyclic polarization in each medium.	Galvanic corrosion does not pose a greater threat to the alloys than ordinary corrosion	62
63	Cobalt-Chromium dental alloy joints	AS	Potentiodynamic polarization &EIS	Corrosion resistance of the laser-welded joints was better than that of the brazed	63
64	Nickel-titanium orthodontic brackets	AS	EIS	Greater free corrosion potential, much lower passive current density and no breakdown upto1.5v	64
65	Chromium based alloy(galvanic coupling between amalgam)	AS	Potentiodynamics and potentio- static polarization	Correct design and use of dental alloy are important when determining the appropriate treatment for a specific patient	65
66	Ti-6Al-7Nb alloy brazed with bulk metallic glasses	AS	X-ray tomography	Pd40cu30Ni10P20 promising brazing filler for dental (or) biomaterial devices	66
67	Titanium containing orthodontic wires	Acidic As and different NaF concentration. (0%, 0.2%, 0.5%)	Potentiodynamic polarization, photoelectron spectrometry	Decreasing the corrosion rate& anodic current density.	67
68	Ti-5Ag	With and without thermal oxidation in AS solution	XRD, X-ray photoelectron spectroscopy,SEM	Thermal oxidation was an effective way to improve the corrosion resistance	68
69	Metallic orthodontic wires(Cr Ni, NiTi &CuNiTi)	AS	Potentiodynamic method	NiTi material is most resistant	69
70	Ag-Pd &Co-Cr	AS	Polarization resistance, EIS, coulometric analysis	Co-Cr alloy excellent corrosion resistance	70
71	Ti-Nb &TMA	AS with and without the addition of lactic acid sodium fluoride	X-ray diffraction, EIS, Potentiodynamic polarization, SEM& X-ray photoelectron	Ti-Nb β alloy when fluoride is necessarily needed during dental procedures	71
72	Three CP Titanium(A,B,C)	AS(saliva with pH=5.5)	Open-circuit potential measurements, EIS & potentiodynamic polarization	Corrosion resistance & stability of their passive oxide films are quite different	72
73	Titanium	AS containing Fluoride enriched with eugenol at different concentration	Electrochemical measurements &SEM	The effects of eugenol are not only the protection of titanium from fluoride attack but also the suppression of dissolution of titanium ions via formation of eugenol films	73
74	Dental Silver amalgam	AS	Physical and Chemical properties	Practical problems are discussed	74
75	Ti	AS with citric acid, sodium nitrite, calcium carbonate(or) benzotriazole	Electrochemical Noise technique (TEN), SEM, EDX & Electrochemical Emission Spectroscopy	Fretting corrosion behavior of the material, resulting in a surface that is electrochemical more active with respect to the non-worn surface	75

Conclusion

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 alloy 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. The corrosion resistances of these materials have been evaluated by electrochemical studies such as polarization study and AC impedance spectra. The film formed on the metal surface has been analysed by surface analysis techniques such as SEM, EDX, X-ray and AFM.

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