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Bird View of Corrosion Behavior of Orthodontic Alloys in Synthetic Saliva Solutions

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ABSTRACT : Orthodontic treatment is vital for improving and maintaining the oral appearances. Different wires are made from different metals and alloys, such as Ni-Ti, Fe-Cr, Co-Cu, Cu-Ni, stainless steel Ni, Cracking Nickel, Different Nickel-Ti orthodontic wire, SS-PCA, Titanium wire, Arch wire, Stainless steel, Cu-Ti and TMA/SS. The corrosion resistance behavior of the different alloys in synthetic saliva (Artificial saliva, Artificial saliva and soft drink, Acidic artificial saliva, Artificial saliva and chemical solutions, pancreatic amylase, Artificial and different PH solution, Artificial saliva and coca-cola lemon juice, Artificial with 1.25% acidulated phosphate fluoride as the electrolytes, Artificial saliva, NaF, Acidic fluoride Artificial saliva) in various environment have been tested by electrochemical studies such as Polarisation, AC Impedance spectra. The metal surface morphology has been examined by surface analysis techniques such as Scanning electron microscopy (SEM), Energy Dispersive Analysis of X-rays (EDAX), Atomic force Microscopy (AFM) and X- diffraction (XRD). The present study of this bird view paper will be helpful to the researchers to investigate the corrosion behavior of various alloys in synthetic saliva and Dentistry area also.

KEYWORDS: Corrosion resistance, artificial saliva, Acidic artificial saliva, electrochemical studies, surface analysis technique, orthodontic alloys.

I. INTRODUCTION

Corrosion resistance of alloys and metals in various body fluids has been impresses the researchers and dentistry. Corrosion behavior of orthodontic alloys in artificial saliva, acidic artificial saliva, Artificial saliva and chemical solutions, pancreatic amylase, Artificial and different PH solution, Artificial saliva and coca-cola lemon juice, Artificial with 1.25% acidulated phosphate fluoride as the electrolytes, Artificial saliva, NaF, Acidic fluoride Artificial saliva has been studied. Corrosion resistance of orthodontic alloys in artificial saliva have been reviewed presently.

II. SYNTHETIC SALIVA

Various testing alloys corrosion behavior have been studied by various electrochemical methods in the presence of different synthetic saliva such as artificial saliva [1,2,5,7,8,10,11-17,19,21,23-28,31,33-36,38-40,42,45], acidic artificial saliva [3], Artificial saliva and chemical solutions [6], pancreatic amylase [9], Artificial and different PH solution[18], Artificial saliva and coca-cola lemon juice[20], Artificial with 1.25% acidulated phosphate fluoride as the electrolyte[22], Artificial saliva NaF [29], Acidic fluoride Artificialsaliva[30].

III. METALS AND ALLOYS

Different types of alloys and metals well used as working wires whose corrosion resistance has investigated in synthetic saliva. Various alloys such as Ni-Ti [1,3,5,-8,12,13,18,24,27,30,35,41,43,47-49], Fe-Cr[2], Co-Cu[9], Cu-Ni[10], stainless steel NI[44], Cracking Nickel-Titanium[45], Different Nickel-Ti orthodontic wire[46], SS-PCA[50], Ni-nitraniumtitanium wire[45], Arch wire[39], Stainless steel- Cu-Ti and TMA/SS[43].

IV. METHODS

Corrosion behavior of alloys, usually investigated by various studies such as electrochemical study (Polarisation[2-4,11,24,35,37,40-42,44], AC Impedance spectra [2-4,11,24,35,37,40-42,44] has been used. From these studies, corrosion parameters of corrosion potential (E_{corr}), corrosion current (I_{corr}), linear polarization resistance (LPR), b_a , b_c , double layer capacitance (C_{dl}), charge transfer resistance (R_t), Impedance value and phase angle have been measured.

V. SURFACE ANALYSIS

Surface morphology of the alloys and metals, to be tested by surface analysis techniques such as scanning electron microscopy (SEM)[1,7,12,14,18,21,28-30,32,35,45,47,49,50], Energy Dispersive Analysis of X-rays (EDAX) [3,13,17,27,45], Atomic force Microscopy (AFM)[7,8,15,30,46,50], X- diffraction(XRD) [14,17,30,36,45,49].

Table 5.1. Corrosion behavior of orthodontic alloys in synthetic saliva solutions

S.No	METALS	MEDIUM	METHODS	FINDING	REF. No.
1	Nickel-Titanium (Ni-Ti) and Beta-titanium alloys	Artificial saliva	Scanning electron microscopy (SEM) and Energy dispersive spectroscopy (EDS)	The fluoride has an important effect on corrosion behavior of experimental wires that can be described as a type of wear.	1
2	Iron, Chromium, Nickel, Molybdenum	Artificial saliva	Electrochemical spectroscopy	The elevated levels of metals in saliva are through to occur by corrosion elements in the alloys or welding materials	2
3	Nickel-Titanium (Ni-Ti) based orthodontic arch wires	Artificial saliva and soft drinks	Polarization, Ac impedance, EDX, SEM.	NiTi wires to fluoride agent decreased associated unloading force	3
4	Orthodontic arch wires	Artificial saliva and mouth wash	Potentiodynamic studies	All orthodontic arch wire generates oxidative stress in vitro.	4



5	Nickel-Titanium (Ni-Ti) alloys and orthodontic wires	Artificial saliva	weight loss method	Surface roughness of NiTi wires were increased in modified fusayama solution with NaF solution	5
6	Nickel-Titanium (Ni-Ti) arch wires	Artificial saliva and chemical solutions	weight loss method	Different brands thermodynamic NiTi arch wire demonstrated different mechanical behavior	6
7	Nickel-Titanium (Ni-Ti) based arch wires	Artificial saliva	Scanning electrons microscopy(SEM) and Atomic force microscopy(AFM)	Corrosion behavior of working materials that can be described	7
8	Nickel-Titanium (Ni-Ti) arch wires	Artificial saliva	Atomic force spectroscopy (AFM)	Thermodynamic NiTi arch wires always can still deliver forces continuously SEM in 8 weeks.	8
9	Copper and cobalt	saliva of sat way amylase and pancreatic amylase	Differential scanning calorimeter (DSC)	Lower corrosion rate	9
10	Copper -Nickel -Titanium orthodontic arch wires	Artificial saliva	Immersion optical microscope (IOP)	The results suggest that fluoride agents leads to corrosion of surface topography indirectly affecting the mechanical properties of the wire that will leads to prolonged orthodontic treatment	10



11	Nickel and stainless steel(NSS)	Artificial saliva	Electrochemical methods	The study confirms that the use of newer bracket sand newer arch wire confirms the negligible release of metal ions from the orthodontic applications	11
12	Nickel-Titanium (Ni-Ti) Arch wires	Artificial saliva	Scanning electron microscopy(SEM) and Laser confocal microscopy (LCM)	Manufacturing processes that produce surface crackers should be avoided in orthodontic applications	12
13	Nickel_ Titanium(Ni-Ti)Arch wire	Artificial saliva	Microstructure, Optical microscopy and EDS	The two orthodontic wire in artificial and composition of the two wire are somewhat different	13
14	Laser-welding orthodontic applications	Artificial saliva	scanning electrons microscopy(SEM) and immersion test, X-rays micro analysis	Laser- welded sample have superior resistance to corrosion	14
15	Low friction elastomeric ligatures and conventional ligatures .	Artificial saliva	Atomic force microscopy (AFM)	All groups assessed from T0 to T1 showed a numerical reduction in friction values, suggesting, that time I ,heat and humidity may cause elastic degradation ,however this was not verified statistically	15
16	Orthodontic brackets	Artificial saliva	Static friction resistance	Preferable to test orthodontic frictional resistance in the dry state.	16



17	Nickel-Titanium wires and carbon nitride (CNs)	Artificial saliva	The energy -dispersive X-rays spectroscopy (EDX), X-ray photoelectron spectroscopy (XPS)	The sp ² C rich structure of the CNx film as well as its protection function for the arch wire was responsible for low friction of the wire brackets sliding system.	17
18	Nickel-Titanium orthodontic arch wires	Artificial saliva and different pH solution	Scanning electron microscopy (SEM)	The method result indicates that binding stress influences the nickel release of NiTi wires	18
19	Stainless steel and nickel - titanium	Artificial saliva	Two way analysis of variance (ANOVA)	The method of brackets manufacturing might be equal or more relevant to galvanic corrosion susceptibility than brackets composition	19
20	Stainless steel branches	Artificial saliva and coca-cola lemon juice	weight loss method	Acidic effervescent soft drinks such as cola have to be eliminated or minimized in the nutritional diet of orthodontic patients because of their harmful effects on the brackets	20
21	Brackets, wires, resin, elastomers, silver solders	Artificial saliva	Scanning electron microscopy (SEM)	Silver solder induced significant cytotoxicity which might have occurred via oxidative stress, although this mechanism is not completely understood.	21
22	Titanium Nitride orthodontic brackets, stainless steel wire	Artificial with 1.25% acidulated phosphate fluoride as the electrolytes	Static and kinetic friction were measured by an EZ- test machine	TiNi -coated metal brackets with corrosion or without corrosion cannot reduce the frictional force.	22



23	Nickel-Titanium and Titanium (Damon copper Ni-Ti)	Artificial saliva	Statistical analysis was performed by one way ANOVA and Turkey test	Damon copper Ni-Ti may be suitable for routine orthodontic treatment in adolescent and adult patients. It suggested that clinicians who want to recycle nickel-titanium wires use autoclave sterilization	23
24	Nickel-Titanium orthodontic wire	Artificial saliva	Electrochemical analysis ,free corrosion potential ,potentiodynamic curves, and impedance spectroscopy.	NiTi under greater corrosion	24
25	Stainless steel, TMA ,ceramic brackets, metal brackets	Artificial saliva	surface profile meter	Ceramic brackets in association with SS wire should be judiciously used, since this system showed a high friction coefficient,	25
26	Stainless steel and Titanium brackets arch wire	Artificial saliva	Elastomeric module	Friction force was seen to be inversely proportional to brackets width, frictional force was inversely proportional to brackets width and in the wet condition were greater than in the dry condition	26



27	Nickel-Titanium orthodontic wires	Artificial saliva	Optical microscopy and EDX analysis, differential scanning calometry(DSC), electrochemical impedance spectroscopy(EIS)	EIS test result indicated that the corrosion mechanism was the same . A wire more protective	27
28	Stainless steel , CuNTi and TMA/SS	Artificial saliva, NaF	Scanning electron microscopy (SEM)	At the on set of corrosion the friction coefficient decrease but that this advantage diminishes after passivation of the alloy surface	28
29	Metal brackets and wire (Ni-Ti), Stainless steel	Artificial saliva, NaF	Scanning electron microscopy(SEM) Potentiodynamic	SEM observation showed that defects or pitting corrosion occurred on the surface of the brackets and wires in all tested media.	29
30	Nickel-Titanium arch wire	Acidic fluoride Artificial saliva	Scanning electron microscopy(SEM), Atomic force microscopy(AFM) and X-rays photoelectron spectroscopy (XPS)	Different NiTi arch wire had dissimilar corrosion resistance in acidic fluoride containing artificial saliva, which did not correspond to the variation in the variation in the surface topography of the arch wire	30



31	Nickel-Chromium	Artificial saliva	Atomic adsorption spectrophotometer (AAS)	Nickel -chromium which reached maximum level at the end of 7 days which was statistically (P0.050)and was very much below the dietary average in taken even for four bands used and was not capable of causingany toxicity	31
32	Iron implanted Nickel-Titanium orthodontic wires	Artificial saliva and fluoride mouth rinse	Scanning electron microscopy(SEM) and X_rays photo spectroscopy (XPS)	XPS result for Neo sent alloy longuardsuggestedthat the layers consists of TiO ₂ and TiN were present on the surface and layers may improve the corrosion properties	32
33	Ceramic brackets arch wire	Artificial saliva	Thirty brackets of each were tested	NiTi wires produced lower friction than those of stainless steel	33
34	Nano-scale ZrO ₂ films on Nickel-Titanium orthodontic wire	Artificial saliva	Inductively coupled plasma- atomic emission spectroscopy (ICP-AES),cyclic potentio dynamic test	The cyclic potentiodynamic test result showed then lower corrosion density of electrolytic ZrO ₂ films than uncoated	34
35	Nickel-Titanium alloys	Artificial saliva	Electrochemical technique, corrosion potential polarization measurement, impedance spectroscopy and SEM	The synergistic action of fluoride and PH acid on NiTI corrosion was not clearly demonstrated.	35



36	Titanium containing dental orthodontic wires, Nickel-titanium copper-titanium Mo-ZrSn , Titanium -Nb alloys	Artificial saliva	X-rays photoelectron spectrometry cyclic potentiodynamic polarization	The different in corrosion resistance of the tested commercial Ti-containing dental orthodontic wires was significantly dependent on the passive film characteristics on wire surface.	36
37	Galvanic corrosion of Nitrinol orthodontic wire	Castillo Artificial saliva	Linear polarization and cyclic polarization, potential theory method and scanning electron microscopy (SEM)	Initiation of localized corrosion on the anode increase the galvanic current up to 45 times and therefore considering the effect of localized corrosion on galvanic corrosion is necessary	37
38	Static frictional resistance	Artificial saliva	Eighty stainless steel brackets were test	The claim by the manufacture that the slides system produces lower frictional resistance than conventional elastomeric modules is upheld.	38
39	Arch wire	Artificial saliva	Gray elastomeric modules	Significant effects of arch model (p=0.000) and wire types (p=0.0000) are found	39
40	Nitrium-Titanium orthodontic wire, Beta-titanium	Artificial saliva	Electrochemical test, polarization resistance and cyclic polarization test	Stress increased the corrosion rate in nickel-titanium and beta -titanium orthodontic arch wires	40
41	Nickel-Titanium orthodontic arch wire	Acidic Artificial saliva	Electrochemical analysis	All the NiTi orthodontic arch wire are well biological safety, bupartients should be careful of sensitization	41



42	Nickel ions released from Nitanium - Titanium wire	Artificial saliva	Pontentiodynamic study	Sterilization of used NiTi wires by either dry heat and steam autoclave does not affect the concentration of nickel ions released into artificial saliva	42
43	Nickel-Titanium wire(NiTi)	Acidic Artificial saliva	Electron microscopy	The acidic artificial saliva could accelerate the corrosion with the time prolongation extent of changes come to be more serious. NiTi orthodontic wire produced from different manufactures have a different corrosion of extents and types.	43
44	Stainless steel Nickel-Titanium wire	Water, citric acid , Artificial saliva	Electrochemical method	Orthodontic wires in acidulated fluoride saliva solution can cause U2OS cell toxicity.	44
45	Cracking Nickel-Titanium orthodontic wire	Artificial saliva	Optical and Scanning electron microscopy, and Energy dispersive X-rays spectroscopy, anodic polarization	At high stress and low PH, this NiTi alloys was most sensitive of cracking	45
46	Different Nickel-Titanium orthodontic wire	Fluoride environmental fluoride mouth wash and Artificial saliva	Atomic force microscopy (AFM)	NITI arch wise increasing a roughness surface	46
47	Nickel-titanium orthodontic wire	Artificial saliva, water, citric acid	Dynamic mechanical analysis (DMA)differential scanning calorimetry and SEM	NiTi wire are a rough surface than steel wire.	47



48	Nickel-Titanium (Ni-Ti) and stainless steel orthodontic wire	Acid artificial saliva	Atomic adsorption spectroscopy	The NiTi wire the highest release amount of metal ion had the maximal increase in surface roughness after immersion test, while a rougher surface did not corresponding to a higher metal ion release.	48
49	Nickel-Titanium orthodontic wires	Artificial saliva with various acidities	Microscopically, scanning electron microscopy, spectrophotometry and X-rays diffraction (XRD)	NiTi arch wire are significantly more stable and resistant to corrosion than stainless steel arch wire	49
50	Orthodontics wire and rackets, stainless steel(SS), Poly crystalline alumina(PCA)	Acid food, soft drink, mouthwash, vinegar	Scanning electron microscopy(SEM) atomic force microscope(AFM)	It is long term implication when acidic food substance are used during fixed orthodontic treatment	50

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