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A STUDY OF HERBAL MEDICINE ON THE CORROSION RESISTANCE OF ORTHODONTIC WIRE OF STAINLESS STEEL IN PRESENCE OF ARTIFICIAL SALIVA

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Abstract: The stainless steel orthodontic wire is one of the appliances often used in orthodontics treatment. Dentists make use of orthodontic wire such as stainless steel, Ni-Ti wire etc., to normalize the growth of teeth. In the saliva environment with various types of food intake such as juices, syrup, medicinal extracts these wires undergo corrosion. Corrosion resistance of stainless steel in artificial saliva (AS), in the presence of herbal medicine such as Kabasurae kudeeneer and Nilavembu extract has been evaluated by electrochemical studies such as polarization study, AC impendence spectroscopy and by means of surface examination studies such as Atomic force microscopy. From the polarization and AC impendence spectroscopy infers the order of corrosion resistance of SS alloy is AS + Kabasurae kudeeneer < AS < AS+Nilavembu extract

Index Terms **- Stainless steel, Artificial Saliva, Kabasurae Kudeeneer, Nilavembu extract, Corrosion, Orthodontic wire**

I. INTRODUCTION

Orthodontic treatment is one of the treatments that play an important role in improving the alignment of teeth, correcting facial malrelations and malformations, so that it can restore the function chewing, speaking and facial appearance [1] Currently, various types of fixed orthodontic wires have been available in the market, including stainless steel wire, cobalt chromium, beta-titanium and nickel-titanium. Orthodontic wire that is often used is orthodontic stainless steel wire which has advantages such as good elasticity, adequate strength, malleability, economy, and resistance to corrosion; however the corrosion-resistant properties of orthodontic stainless steel wire can be affected by conditions in the oral cavity [2, 3,]. When these orthodontic wires are exposed to the oral environment, by the influence of food intake in the form of juices, coffee, tea, soups may influence the corrosion on the orthodontic materials [4]. Orthodontic wire is an important orthodontic appliance made by various metal compositions such as gold, silver, Ni-Ti, stainless steel etc., Stainless steel wire is commonly used because of its low cost and the properties such as good elastic modulus and corrosion durability [5, 6]. Corrosion is defined as damage that occurs in orthodontic wires due to a chemical reaction between the metal and the oral environment such as saliva, normal flora, temperature, and pH of the oral cavity. Corrosion that occurs in orthodontic wire causes a decrease in the physical properties of the wire which will increase the potential for orthodontic treatment failure. In addition, corrosion also affects individual health such as allergic, mutagenic, and carcinogenic reactions [7, 8].Corrosion cannot be prevented but the rate can be reduced. Various ways have been done to reduce the rate of corrosion, one of which is the use of inhibitors [9,10]. The present study was designed to identify the corrosion resistance parameters on orthodontic stainless steel (SS) metal brackets immersed in herbal medicines such as Kabasurae kudeeneer, Nilavembu extract with artificial saliva medium.

II. MATERIALS AND METHODS

2.1 Composition of alloy:

For the present investigation, stainless steel orthodontic wire was used. The composition of SS consists of Manganese (0.181%), Aluminum (0.023%), Chromium (0.036%), Carbon (0.070%), Nickel (0.032%), Sulfur (0.007%), Sulfur (0.082%) and Copper (0.017%), Phosphorous (0.0009%), Titanium (0.002%) and Iron, respectively (99.539%)[11].

2.2 Composition of Artificial saliva:

The composition of artificial saliva (AS) suggested by Fusayama Mayer is given as: KCl (0.4 g/L), NaCl (0.4 g/L), $CaCl_2.2H_2O$ (0.906 g/L), $NaH_2PO_4.2H_2O$ (0.690 g/L), $Na_2S.9H_2O$ (0.005 g/ L) and Urea (1 g/ L)[12].

2.3 Composition of herbal medicine (Kabasurae kudeeneer, Nilavembu extract).

Composition of Kabasurae kudeeneer

Kabasurae kudeeneer powder commercially purchased which hold the composition made of zinger officials, piper longum, Eugenia involucrate, Tragia involucrate, Anacycius pyrethrum, Abactacs antcut, Cyperus rotundas. The kabasurae kudeeneer was prepared by heating 200 ml of boiling water with two tea spoons of Kabasurae kudeeneer powder and filtered.

Composition of Nilavembu extract

Nilavembu powder commercially purchased and the Nilavembu extract was prepared by heating 200 ml of boiling water with two tea spoons of Nilavembu powder and filtered.

2.4 Characterization Methods:

2.4.1 Electrochemical Methods:

The corrosion resistance of Stainless Steel alloy was evaluated using electrochemical studies such as polarization and alternating current impedance spectra. In a CHI electrochemical workstation in Impedance Model 660A, three electrical cell assemblies were used in the prepared test solution [13]. The Stainless Steel alloy was used as working electrode; saturated calomel electrode was employed as a reference electrode and the counter electrode was the platinum electrode. Polarization spectra identifies the corrosion features, such as corrosion potential (Ecorr), corrosion current (Icorr), Linear polar Resistance (LPR). The instrument also used for to record AC impedance spectra. 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 (Rt) and double layer capacitance (Cdl) were calculated from the Nyquist plot and log (z/ohm) value was calculated from Bode plots.

2.4.2 Surface Analysis- Atomic Force Microscopy:

The AFM measurements helps to analyze the roughness of the sample surface. All atomic force microscopy images were obtained with the help of a NT-MDT-Ireland incorporation AFM instrument operating in contact mode in air. The scan size of all the AFM images are 50µm areas at a scan rate of 1 µm/second, direction of scanning is down, line by line scanning rate is 256. The varying scan rate depends upon the frequency and scanning area of the sample. The two dimensional (2D), three dimensional (3D) AFM morphologies, AFM cross- sectional profile and histogram images of surface for stainless steel alloy surface in AS+ test solutions and in surface in AS was studied.

III. RESULTS AND DISCUSSION

3.1 ANALYSIS OF POTENTIODYNAMIC POLARIZATION CURVES:

Corrosion parameters of Stainless steel immersed in artificial saliva and artificial saliva with test solutions are given in Table.1. The Potentiodynamic polarization curves are shown in Fig.1.From the results observed, it is found that, LPR value of AS is 43063.2Ohm cm^2 and the Icorr is 1.026×10^{-6}A/cm^2. When SS alloy immersed with, herbal medicine in presence of Artificial Saliva, the LPR value increased for AS+N as 1960526.5Ohm cm^2 and decreased for AS+Kabasurae kudeneer as 15120.5 Ohm cm^2 and so the system's corrosion resistance behaviour is given as follows:

AS + Kabasurae kudeeneer < Artificial Saliva < As+Nilavembu extract

Table: 1 Corrosion parameters of Stainless steel immersed in artificial saliva (AS) and AS + herbal medicine

Alloy	System	Ecorr V (Vs) SCE	bc V/ decade	ba V/ decade	LPR (Ohm) $Ohmcm^2$	I (cor) A/cm^2
Stainless Steel	AS +Kabasara extract(AS+K)	-0.6577	6.987	4.253	15120.5	2.558×10^{-6}
	Artificial saliva (AS)	-0.4435	5.052	4.786	43063.2	1.026×10^{-6}
	As+Nilavembu extract(AS+N)	-0.278	5.127	3.665	1960526.5	0.02522×10^{-6}

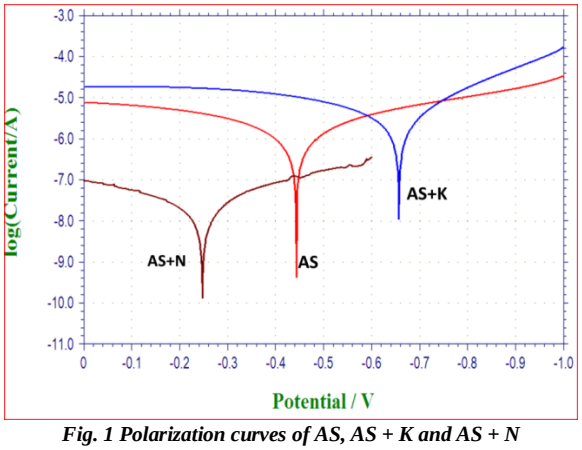

Fig. 1 Polarization curves of AS, AS + K and AS + N

3.2 ANALYSIS OF ALTERNATING CURRENT IMPEDANCE MEASUREMENTS:

From the AC impedance measurements the detection of the development of protection layers in the metal surface is observed and analyzed. The resistance to load transfer (Rt) is decreased and capacitance in dual layers (Cdl) is improved for AS+K and it is viceversa for AS+N system when compared with AS. The parameters of the alternating current impedance are shown in Table 2 such as load transfer resistance (Rt), dual layer capacitance (Cdl), impedance value (Z/ohm) and stainless steel

impedance log (Bode plot), submerged in artificial saliva and test solutions. Plots of Nyquist are illustrated in Fig.2and Bode plots shown in Fig 3, 4.

Table2. Corrosion parameters of Stainless steel immersed in artificial saliva (AS), AS+K and AS + N by AC impedance spectra

Alloy	System	Nyquist plot		Bode plot
		R_t ohm cm^2	C_{dl}, F/cm^2	Impedance Log(Z/ohm)
Stainless Steel	AS +Kabasara extract(AS+K)	642.9	7.777×10^{-9}	3.35
	Artificial saliva (AS)	1531.1	3.266×10^{-9}	3.55
	AS+Nilavembu extract(AS+N)	7014.7	0.7128×10^{-9}	4.05

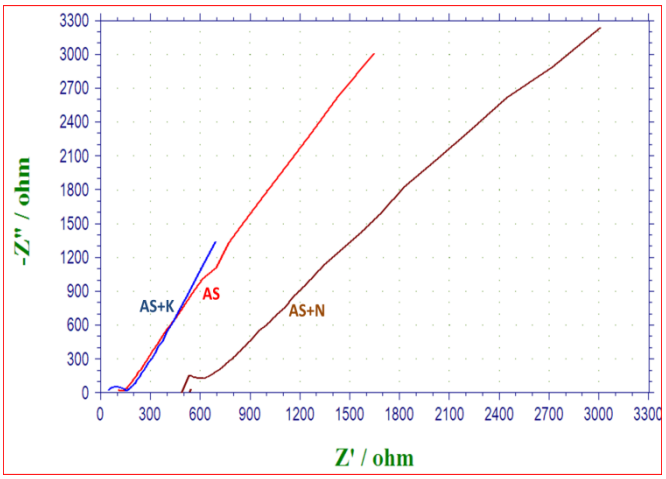

Fig. 2 AC impedence curves of AS, AS + K and AS + N

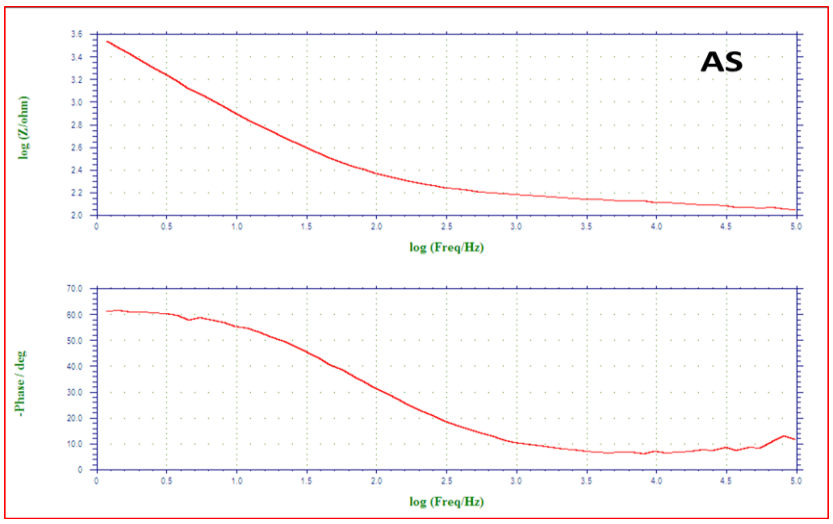

Fig.3 Bode plot of Artificial saliva

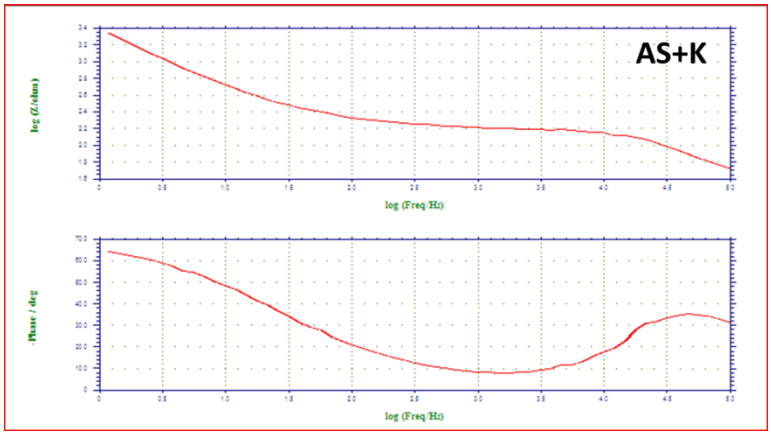

Fig. 4 Bode plot of AS + Kabasurae kudeeneer(K)

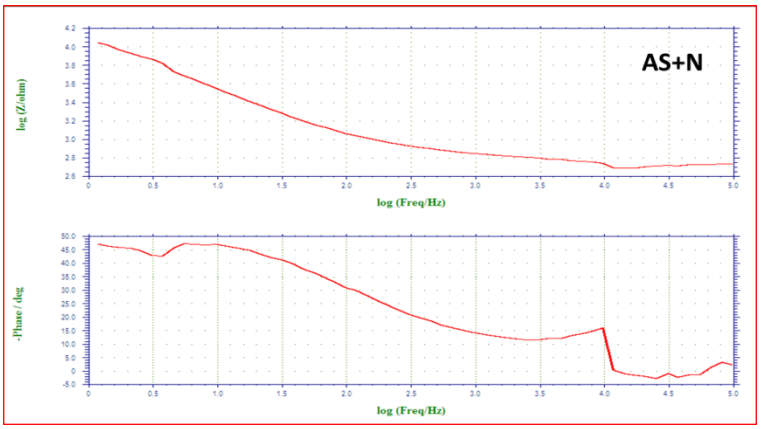

Fig. 5 Bode plot of AS + Nilavembu extract(N)

3.3 ANALYSIS OF ATOMIC FORCE MICROSCOPY

System in stainless steel	RMS Rq (nm)	Average roughness Ra (nm)
AS +Kabasara extract(AS+K)	1876	1075
Artificial saliva (AS)	664.35	757.08
As+Nilavembu extract(AS+N)	137.28	161.95

The value of RMS and Ra for the SS alloy surface in AS are 664.35nm and it increases to 1876nm for AS+K and decreases to 137.3nm for AS+N, which shows a more homogeneous surface, with some places in which the height is lower than average depth for AS+N system and slight roughness observed on other systems due to atmospheric corrosion.

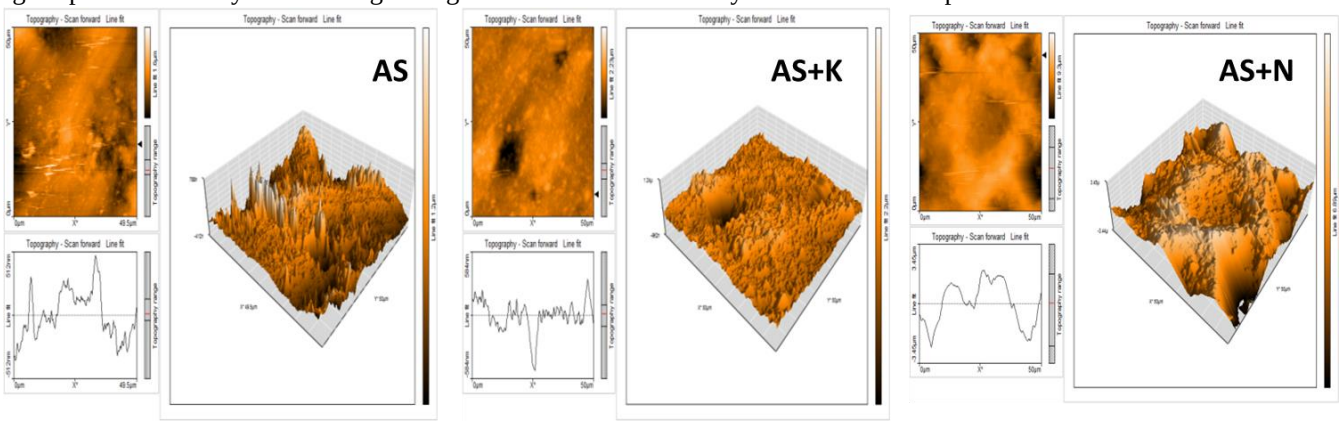

Fig 8: Surface morphology of SS in AS, AS+K, and AS+N

4. CONCLUSION

- The orthodontic arch wire of SS alloys and its corrosion resistance in the absence and presence of herbal medicine in artificial saliva has been evaluated by electro chemical study such as polarization study.
- This study leads to the following conclusions.
  The polarization studies and Impedance measurements states that when SS alloy is immersed in test solutions, there is an increasing order of corrosion resistance of SS alloy is as follows:

  AS + Kabasurae kudeeneer < AS < AS + Nilavembu extract
- An AFM study reveals smoothness in surfaces in the sample immersed with AS+Nilavembu extract and more roughness in surfaceobserved in the sample immersed with AS+ kabasurae kudeeneer compared with artificial saliva medium.
- Hence, it is recommended to people clipped with SS alloy can take nilavembu extract without hesitation and can avoid kabasurae kudeeneer.

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