Can People Clipped with Thermo Active Orthodontic Wire Take Copper Barrel Brandy Orally?

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Abstract

The corrosion rate of an orthodontic wire (OW) made of thermo active alloy (TAA) immersed in artificial saliva (AS), in the absence and presence of copper barrel brandy (CBB), was herein examined by potentiodynamic polarization study, and it was observed to decrease. When TAA was immersed in AS, in the presence of CBB, linear polarization resistance value decreased from 208.94 x 10^3 to 37.97 x 10^3 Ohm/cm^2, and corrosion current increased from 2.192 x 10^{-9} to 12.99 x 10^{-9}A/cm^2. It was therefore determined that individuals using OW composed of TAA should refrain from orally ingesting CBB. The change in corrosion potential was observed to be within 50 mV, suggesting that CBB acted as a mixed-type additive. This implies that it enhanced both anodic and cathodic processes of corrosion. The results of this research could be utilized in the field of dentistry. TAA's surface morphology was investigated by scanning electron microscope.

Keywords: artificial saliva; copper barrel brandy; corrosion rate; dentistry; potentiodynamic polarization; scanning electron microscope; thermo active alloy.

Introduction•

To regulate irregular growth of teeth, dentists employ OW (orthodontic wire) made of stainless steel (SS) 316 L, Ni-Cr, SS 18/8 and the like. After have been clipped with OW, people ingest many food items, juices, tablets and beverages. Hence, OW

•The abbreviations list is in page 437.

may undergo corrosion. Several research papers have been published in this regard [1-10].

Corrosion behavior of SS 18/8 OW in artificial saliva (AS) in the presence of an aqueous extract of *Spillanthes acmella* leaves has been investigated by [1]. Electrochemical studies such as PDP technique and AC impedance spectra have been employed. The protective film has been analyzed by FTIR and AFM. The outcome of the study is that patients who use these metal alloys for orthodontic purpose can chew and place leaves of *Spillanthes acmella* in the teeth cavities to get relive from toothache pain without any hesitation and fear [1].

Corrosion mitigation by esomeprazole tablet (Esiloc-40 mg), on OW made of SS 18/8 alloy in AS, was studied by [2], using electrochemical analysis. PDP indicated that, in the presence of esomeprazole, polarization resistance value increased, and corrosion current (I_{corr}) decreased. It has been reported that people clipped with OW made of SS 18/8 alloy need not worry about orthodontic corrosion, when taking esomeprazole tablet for the treatment of gastro esophageal reflux disease and other medicinal purposes [2].

TI/Mo and SS wires are most commonly availed for orthodontic treatment. Meanwhile, patients are encouraged to employ mouthwashes containing fluoride, to maintain their oral hygiene. To assess the effect of different fluoride prophylactic agents on TI/Mo and SS wires, for specific time periods, namely 10 min, 1 h and 24 h, surface roughness was measured by scanning electron microscope (SEM). The study has led to the conclusion that Orthodontists must avoid contact with OW containing Ti protective coating, using prophylactic agents [3].

Copper barrel brandy (CBB) may be administered orally, either diluted with Bisleri water, soda water, or taken undiluted. People clipped with OW may take CBB orally, with or without dilution. How far OW will be affected by these items? To find an answer, a study has been undertaken by [4]. CR of OW made of thermo active alloy (TAA) and Ni-Cr alloy in AS, in the absence and presence of CBB, water and soda water, has been evaluated by AC impedance spectra. The study led to the conclusion that people who have been clipped with OW made of TAA can take CBB in any form, namely, with or without dilution. People who have been clipped with OW made of Ni/Cr alloy should avoid taking CBB in any form, namely, with dilution or dilution [4].

CR of OW made of Au 18K alloy in AS, in the presence of Éclairs milky candy, has been evaluated by [5]. It has been inferred that: (i) for polished 18K Au in AS + Éclairs milky candy, AFM (atomic force microscopy) parameters were very low. This was due to the smoothness of the protective film formed on the 18K Au surface; (ii) for polished 18K Au, in AS, AFM parameters were very high. This was due to the formation of corrosion products on the Au 18K surface; and (iii) for polished 18K Au system, AFM parameters were in between those two systems [5].

A study on the evaluation of the effects of povidone iodine and hydrogen peroxide mouthwashes on orthodontic archwires has been undertake by [6]. Preprocedural mouth rinses may result in surface irregularities on the wires, which can subsequently increase friction at the bracket-wire interface. This increase in friction can hinder effective tooth movement, prolonging the duration of orthodontic treatment.

Beta Ti OW is known to have good CR, but is weak in acidic environments, which advances corrosion rate (CR). One natural inhibitor that can be used to decrease corrosion is kiwi peel extract, which has a high antioxidant level. The study by [7] has aimed to examine the ability of the extract to decrease CR and microstructural changes in beta Ti, at an acidic pH (pH 5). The extract has demonstrated the most significant reduction in CR, and alterations in the microstructure of the wire, when applied at a concentration of 400 ppm.

Corrosion of Cu/Ni/Ti archwire in chlorhexidine (CHX), NaF and chitosan mouthwashes has been investigated by [8]. The use of mouthwashes containing CHX, NaF and chitosan could further alter the passive layer and cause higher Ni and Cu ion release, and has increased Cu/Ni/Ti archwire surface structure porosity. However, there has been no distinction between mouthwashes concerning release of unloading force within two until four weeks.

Research has been conducted on antibacterial, antifungal and anticorrosion properties of hydroxyapatite coating applied to an orthodontic alloy, as referenced in [9]. In that work, an electrochemical deposition procedure has been used to establish a hydroxyapatite coating on an SS orthodontic alloy. SEM and X-RD have been used to analyze produced films. Corrosion behavior of SS in an AS environment was investigated and characterized using PDP and EIS methodologies.

The influence of 500 ppm Éclairs chocolate on the CR of OW made of Au 18K in the presence of AS, has been studied by [10]. It has been observed that CR of Au increased.

The present work undertook to investigate CR of super elastic shape memory TAA in AS, in the presence of a hard drink namely CBB. The influence of CBB on the CR of OW made of TAA in AS has been evaluated by PDP study.

Experimental procedure

Preparation of metal specimens

Super elastic shape memory TAA

The predominant shape memory material utilized was an alloy composed of Ni and Ti, known as Nitinol. This specific alloy exhibits outstanding electrical and mechanical characteristics, an extended fatigue lifespan, and high corrosion resistance. SMA also display super elasticity, which is a mechanical type of shape memory. This effect is observed when alloys are strained just above their transformation temperature. Mechanical characteristics of shape memory alloys

fluctuate across the temperature spectrum that encompasses their transformation. TAA, a near-equiatomic composition (i.e., 49%–51%) of Ni and Ti belongs to the class of SMA that can be deformed at low temperatures, and still be able to recover their original, permanent shape, when exposed to high temperatures. In metallurgy, SMA is an alloy that can be deformed when cold, but returns to its pre-deformed ("remembered") shape when heated. It is also referred to by various other names, including memory metal or alloy, smart metal or alloy and muscle wire. The "memorized geometry" can be modified by fixating the desired geometry and subjecting it to a thermal treatment, for example, a wire can be taught to memorize the shape of a coil spring [11]. A slender wire composed of TAA was utilized as test material for this study. The OW was encapsulated in Teflon rod (Invento). It was polished to mirror finish, and used for electrochemical studies.

Preparation of AS

Herein, AS was prepared in laboratory, using composition of Fusayama Meyer AS: 0.4 g/L potassium chloride, 0.4 g/L sodium chloride, 0.906 g/L calcium chloride dehydrate, 0.690 g/L sodium dihydrogen phosphate dihydrate, 0.005 g/L sodium sulfide nonahydrate and 1 g/L. urea The pH of the solution was 6.5.

Copper barrel brandy

CBB is an Indian brandy, made from molasses/Grain spirit, in Kals Distilleries Pvt. Ltd., Kallakottai village, Pudukottai District, Tamilnadu, India. It contains demineralized water, neutral spirit and permitted INS 150a (A) natural dark brown food color produced by heat treatment of sucrose. It is a food additive that has received approval from European Union, and is identified as INS150a in International Numbering System, along with authorized flavors.

PDP technique

A workstation model designated as CHI 660 A was utilized for electrochemical research. PDP study was carried out using a three electrodes cell assembly (Fig. 1).

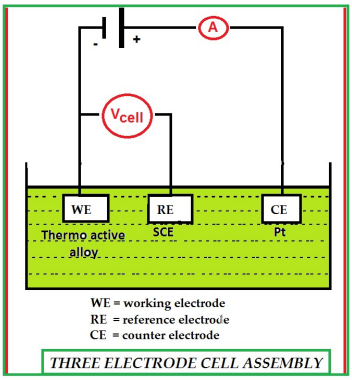

Figure 1: Three electrode cell assembly.

TAA, Pt and SCE were used as working, counter and reference electrodes, respectively. After having done iR compensation, polarization study was carried out at a sweep rate of 0.01 V/sec. Corrosion parameters, such as linear polarization resistance (LPR), corrosion potential (E_{corr}), I_{corr}, and anodic and cathodic Tafel slopes (β_a and β_c), were measured.

Surface characterization study

Mild steel (MS) specimens were submerged in different test solutions during one day. Following this period, specimens were removed and allowed to dry. The characteristics of the film that developed on the metal surface were examined through surface characterization techniques, including scanning electron microscopy (SEM).

Scanning electron microscopy

MS specimens, after being immersed in different test solutions, for one day, were removed, rinsed with double distilled water, dried, and then examined for surface characteristics. The surface morphology measurements of the MS surface were carried out by SEM, using CAREL ZEISS make model EVO-18.

Results and discussion

Electrochemical studies

Electrochemical investigations, including polarization studies and AC impedance spectroscopy, have been extensively employed to assess corrosion resistance of metals and alloys in diverse environments [12-16].

Polarization study

Polarization curves of OW from TAA immersed in AS, without and with CBB as hard drink, are shown in Figs. 2-4. Various corrosion parameters, such as I_{corr}, LPR, β_c, β_a and E_{corr}, are given in Table 1. When CR decreased, LPR value decreased and I_{corr} increased (Figs. 4-7).

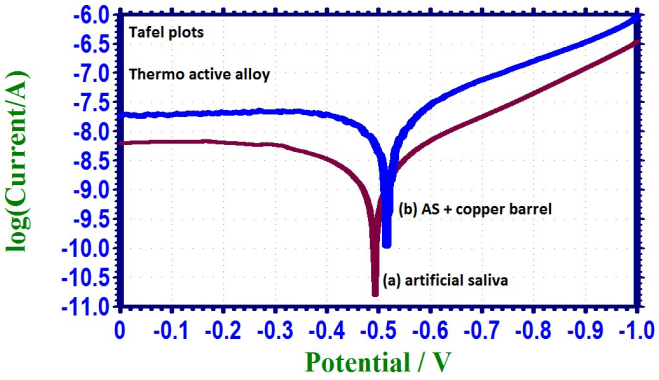

Figure 2: Polarization curves of TAA in various test solutions.

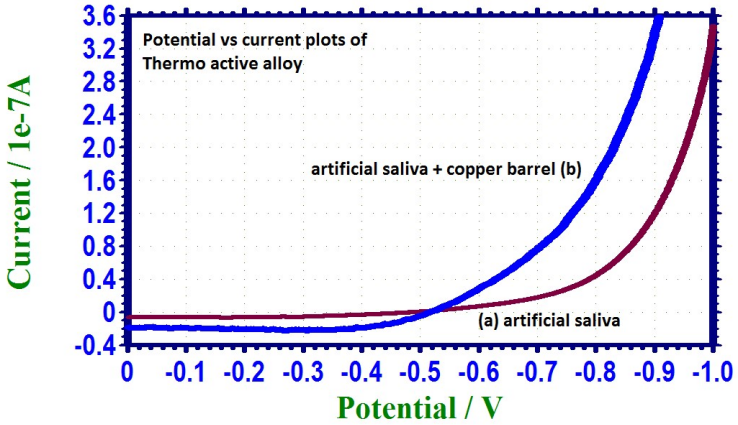

Figure 3: Current *vs*. potential curves.

TAA with AS system

When TAA was immersed in AS system, LPR value was 20893716 Ohm/cm^2 and I_{corr} was 2.192 x 10^{-9} A/cm^2 (Fig. 4).

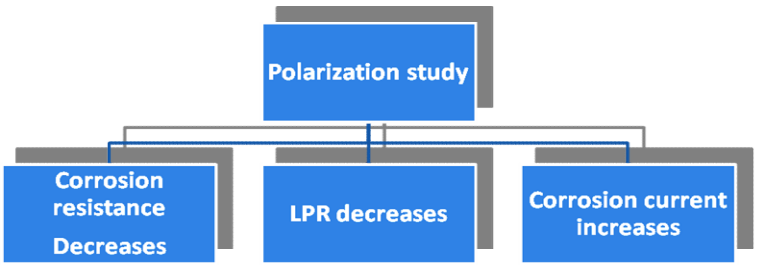

Figure 4: Correlation among corrosion parameters.

Table 1: PDP corrosion parameters for TAA immersed in various test solutions.

System	E_{corr} mV *vs.* SCE	β_a mV/decade	β_c mV/decade	LPR Ohm/cm^2	I_{corr} A/cm^2
TAA in AS	-493	3.464	6.029	208.94 x10^3	2.192 x10^{-9}
TAA in AS with CBB (5%V/V)	-516	3.028	5.787	37.97 x 10^3	12.99 x10^{-9}
Inference	Accelerated corrosion reaction processes at anode and cathode.			Decreased. So, CR decreased.	Increased. So, CR decreased.

TAA with AS and CBB system

When 4 mL CBB were added to the AS system, LPR value (Fig. 5) decreased to 3796692 Ohm/cm^2 and I_{corr} increased to 12.99 x 10^{-9}A/ cm^2. This indicates that, in CBB presence, CR of TAA in AS decreased (Fig. 6).

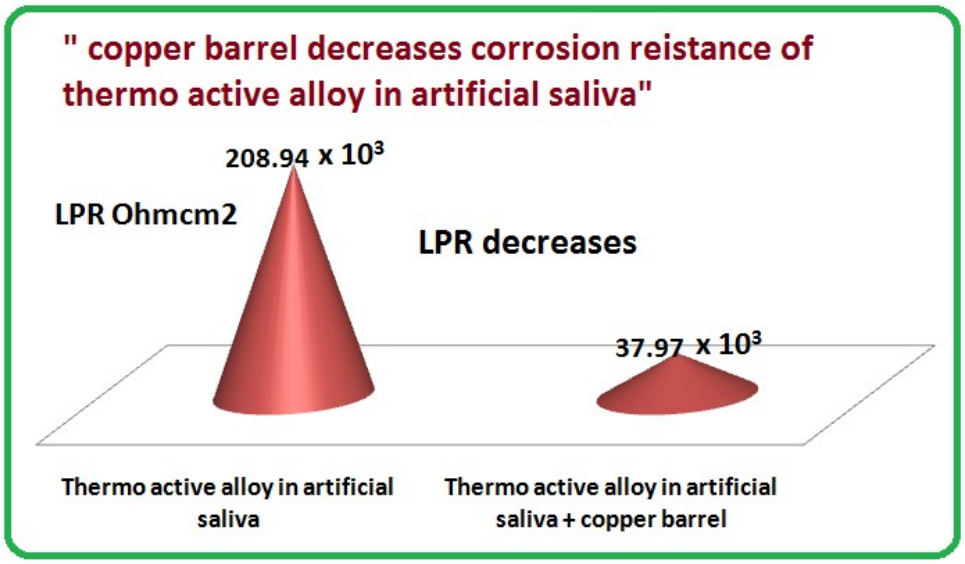

Figure 5: Comparison of LPR values for various systems.

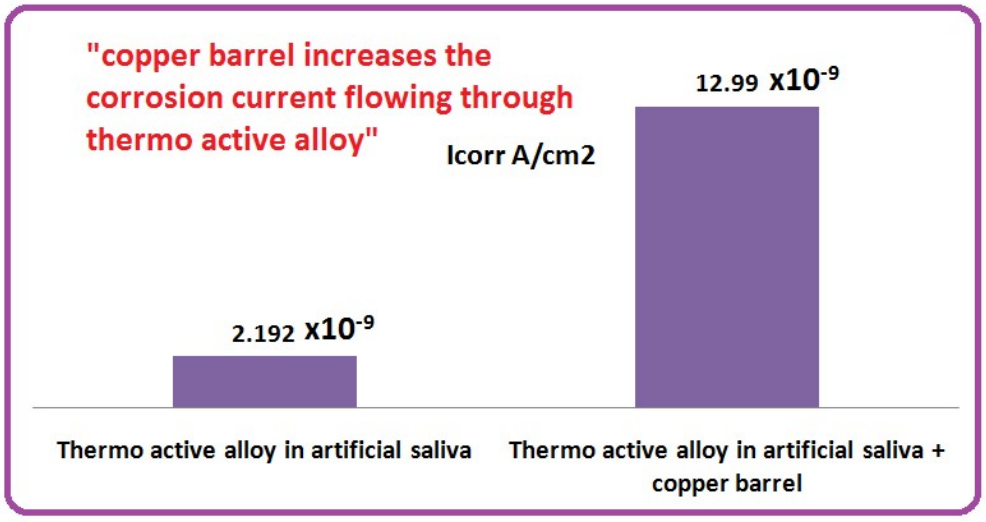

Figure 6: Comparison of I_{corr} for various systems.

E_{corr}

The shift in E_{corr} was within 50 mV (Fig. 7). This suggests that CBB operates as a hybrid type of corrosion accelerator, as anodic and cathodic reactions of corrosion processes are accelerated when TAA is in the inhibitor system.

It is inferred, from Fig. 3, that the change in current with potential is abrupt in the presence of CBB.

Therefore, in the presence of CBB, CR of TAA in AS decreased. Individuals who wear OW constructed from TAA should refrain from administering CBB orally.

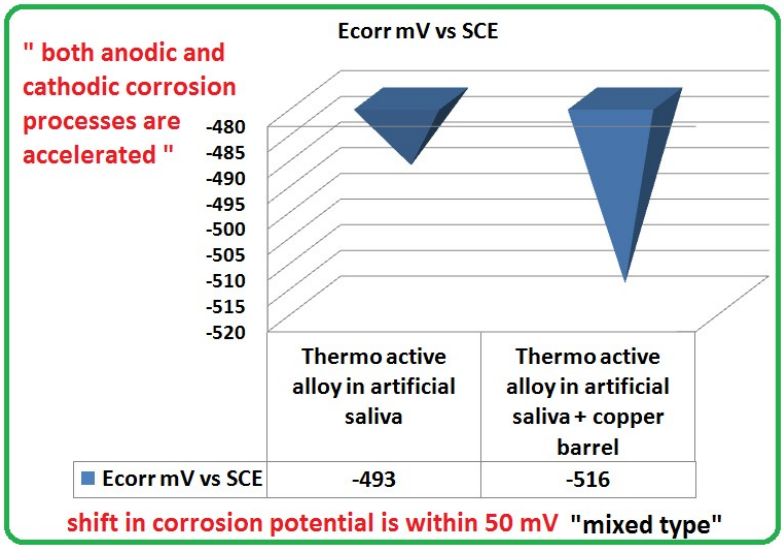

Figure 7: Comparison of E_{corr} values of various systems.

SEM images

SEM images have been utilized in studies focused on corrosion inhibition [17-19]. SEM images of various surfaces are shown in Fig. 8. When TAA is immersed in AS with CBB, pits are noticed. CBB accelerated TAA corrosion. This aligns with findings of PDP studies.

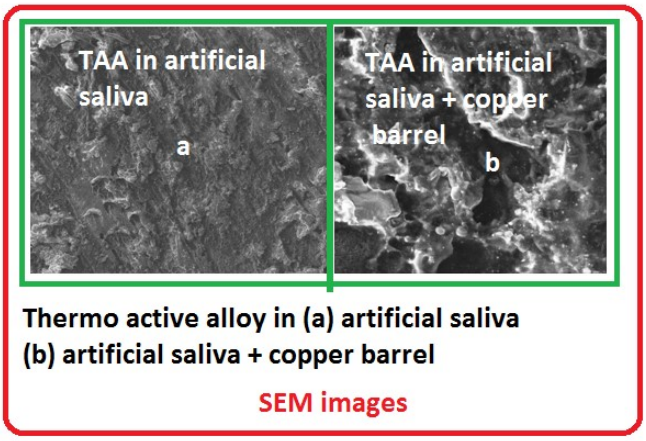

Figure 8: SEM images of TAA's surface.

Conclusions

Corrosion behavior of super elastic shape memory TAA, in AS without and with of CBB has been evaluated by polarization study. The presence of CBB has been noted to reduce corrosion behavior of TAA in AS. This was revealed by the fact that there

was a decrease in LPR and an increase in I_{corr}. Analysis of SEM images show pits in the presence of CBB. This implies that people clipped with OW made of TAA should avoid taking CBB orally.

Scope for further study

In the future, subsequent studies may be conducted. Other type of OW may be used. Alternative techniques, including electrochemical impedance spectroscopy, may be utilized. AFM and FT-IR may be employed. Other soft and hard drinks may be used.

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Authors' contributions

I. S. Vinnarasi, K. Kavipriya and N. Anitha: conceptualization and validation; review and editing. **S. Kavipriya, R. Hema, S. J. Priya, J. J. Celciya, M. Jasmine, G. Jayapriya, S. Jenci, S. Kelvina, R. V. L. Pamila and C. Moniswari**: recording electrochemical study, SEM. **S. Rajendran**: writing; correspondence. All authors have read and agreed to the published version of the manuscript.

Abbreviations

AFM: atomic force microscopy
AS: artificial saliva
β_a: anodic Tafel slope
β_c: cathodic Tafel slope
CBB: copper barrel brandy
CHX: chlorhexidine
CR: corrosion resistance
E_{corr}: corrosion potential
FT-IR: Fourier transform-infrared spectroscopy
I_{corr}: corrosion current
LPR: linear polarization resistance
MS: mild steel
NaF: sodium fluoride
OW: orthodontic wire
PDP: potentiodynamic polarization
SCE: saturated calomel electrode
SEM: scanning electron microscope
SMA: shape memory alloys
SS: stainless steel
TAA: thermo active alloy
X-RD: X-ray diffraction

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