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Influence of dilution and addition of soda water on the corrosion resistance of orthodontic wires immersed in artificial saliva in presence of Copper Barrel, a hard drink

ABSTRACT

Copper barrel brandy can be taken orally with dilution of bisleri water or soda water and without dilution. People clipped with orthodontic wires may take copper barrel brandy orally, with dilution or without dilution. How far the orthodontic wires will be affected by these items? To find an answer the present research work is undertaken. Corrosion resistance of orthodontic wires made of Ni-Ti alloy and Ni-Cr alloy in artificial saliva in the absence and presence of copper barrel, water and soda water has been evaluated by AC impedance spectra. It is generally observed that Ni-Ti alloy is more corrosion resistant than Ni-Cr alloy in artificial saliva in the presence of copper barrel, water and soda water. When orthodontic wire made of Ni-Ti is immersed in artificial saliva, the charge transfer resistance (R_t) value is 31945 Ohmcm². When it is immersed in copper barrel + artificial saliva (AS) system, R_t value increase to 80000 Ohmcm². When it is immersed in soda water + artificial saliva (AS) system, R_t value increase to 76450 Ohmcm². When it is immersed in water + artificial saliva (AS) system, R_t value increase to 82620 Ohmcm². On the other hand, when orthodontic wire made of Ni-Cr is immersed in artificial saliva, the charge transfer resistance (R_t) value is 80930 Ohmcm². When it is immersed in copper barrel + artificial saliva (AS) system, R_t value decrease to 11104 Ohmcm². When it is immersed in soda water + artificial saliva (AS) system, R_t value decrease to 10437 Ohmcm². It implies that the people who have been clipped with orthodontic wire made of Ni-Ti alloy can take copper barrel in any form, namely, with dilution or without dilution. The people who have been clipped with orthodontic wire made of Ni-Cr alloy should avoid taking copper barrel in any form, namely, with dilution or without dilution.

Keywords: orthodontic wires, corrosion resistance, soda water, artificial saliva, a hard drink, Ni-alloys

1. INTRODUCTION

Beautiful objects are symmetrical in nature. Symmetry leads to beauty. Symmetry is a result of regular arrangement. Regular arrangement of teeth leads to attractive and beautiful smiles which attract everyone. Unfortunately by God's grace, some people do not have regularly arranged teeth. To regularize the growth of teeth, people need the help of Dentists.

They make use of orthodontic wires made of various alloys such as SS 316 L, SS 18/9, NiTi, NiCr etc., after clipping these wires, people take many tablets, food items and juices orally. Because of these activities the orthodontic wires undergo corrosion.

Feng et al. have studied the Corrosion Resistance of SLM Denture Scaffold in Simulated Oral Environment [1]. Corrosion of Dental Alloys Used for Mini Implants in Simulated Oral Environment has been investigated by Curkovic et al. [2]. "A Study of the Tribocorrosion occurring at the implant and implant alloy Interface: Dental implant materials" has been undertaken by Mehkri

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et al.[3]. Electrochemical corrosion behavior of LDX 2101® duplex stainless steel in a fluoride-containing environment has been studied by Rosalbino et al. [4]. Mindivan et al. have studied the Microstructure and tribocorrosion properties of pulsed plasma nitrided cast CoCr alloy for dental implant applications [5]. Fretting and fretting corrosion processes of Ti6Al4V implant alloy in simulated oral cavity environment have been investigated by Klekotka et al.[6]. The effect of Cu-doping on the corrosion behavior of NiTi alloy arch wires under simulated clinical conditions has been reported by Wang et al.[7]. In the present study, corrosion resistance of orthodontic wires made of Ni-Ti alloy and Ni-Cr alloy in artificial saliva in the absence and presence of copper barrel, water and soda water has been evaluated by AC impedance spectra.

2. EXPERIMENTAL

Ni-Ti alloy

Ni-Ti alloy (also known as Nitinol) is an alloy with a near-equiatomic composition (i.e., 49%–51%) of nickel and titanium. Ni-Ti belongs to the class of shape memory alloys that can be deformed at a low temperature and are able to recover their original, permanent shape when exposed to a high temperature. The nickel-titanium alloy Nitinol has been used in the manufacture of endodontic instruments in recent years. Nitinol alloys have greater strength and a lower modulus of elasticity compared with stainless steel alloys[8].

Nickel–chromium (Ni–Cr) alloy

Nickel–chromium (Ni–Cr) alloys have been used for dental prostheses because of their low prices and excellent properties in veneered restorations. While most Ni-Cr restorations perform well clinically, corrosion products and components of these alloys are known to have the potential to cause hypersensitivity and other tissue reactions. The nickel content of nickel-chromium alloys can be as high as 73.5%[9].

Preparation of artificial saliva

The preparation of artificial saliva was done using the composition of Fusayama Meyer artificial saliva. Artificial saliva was prepared in laboratory and the composition of artificial saliva was as follows: KCl - 0.4 g/lit, NaCl - 0.4 g/lit, CaCl₂.2H₂O - 0.906 g/lit, NaH₂PO₄.2H₂O - 0.690 g/lit, Na₂S.9H₂O - 0.005 g/lit, urea – 1 g/lit.

Copper Barrel brandy

It is an Indian brandy, made from molasses/Grain spirit, in Kals Distilleries Pvt. Ltd., Kallakottai village, Pudukottai District, Tamilnadu. It

contains demineralised water, neutral spirit, permitted natural colour INS 150a (A dark brown food color produced by heat treatment of sucrose. It is a food additive approved by the European Union and is denoted by INS150a under International Numbering System.) and permitted flavours.

AC impedance spectra

A CHI 660 A workstation model was used in the electrochemical studies. AC impedance spectra were recorded using a three electrode cell assembly. Ni-Ti alloy / Ni-Cr alloy was used as working electrode, platinum as counter electrode and saturated calomel electrode (SCE) as reference electrode.

3. RESULTS AND DISCUSSION

Corrosion resistance of two orthodontic wires, namely, Ni-Ti alloy and Ni-Cr alloy in various systems was evaluated by AC impedance spectra (EIS). The results are discussed in this section.

Ni-Ti alloy system

Electrochemical studies such as AC impedance spectra have been used to investigate the corrosion resistance of metals and alloys in various environments [10-20].

Corrosion resistance of orthodontic wire made of Ni-Ti alloy in artificial saliva in the absence and presence of Copper barrel, water and soda water has been evaluated by AC impedance spectra. The results are shown in Table 1, Scheme A and Figures 1 to 9. When corrosion resistance increases R_t (Charge transfer resistance) value increases, impedance increases and double layer capacitance (C_{dl}) decreases.

One component system

When Ni-Ti alloy is immersed in one component system, namely, copper barrel or water or soda water the corrosion resistances are as follows (Table 1):

Copper barrel > water > soda water > artificial saliva

Implication

Copper barrel alone or water alone or soda water alone can be taken orally, without any hesitation by the people who have been clipped with orthodontic wire made of Ni-Ti alloy.

Three component system

When Ni-Ti alloy is immersed in three component system, namely, copper barrel, water and soda water the corrosion resistances are as follows (Table 1):

CB + Soda + AS > CB + W + AS > AS

Implication

When copper barrel is mixed with soda water, corrosion resistance of Ni-Ti alloy in artificial saliva, is found to be more than that of the system consisting of copper barrel and water in the presence of artificial saliva. Mixing copper barrel with soda water is better than mixing with water, for those people having clipped with orthodontic wire made of Ni-Ti alloy.

Two component system

When copper barrel alone or soda water alone or water alone, is orally intaken, corrosion resistance of Ni-Ti alloy in artificial saliva is as follows (Table 1):

Water alone > copper barrel alone > soda water alone > artificial saliva

Implication

Copper barrel alone or water alone or soda water alone can be taken orally, without any hesitation by the people who have been clipped with orthodontic wire made of Ni-Ti alloy.

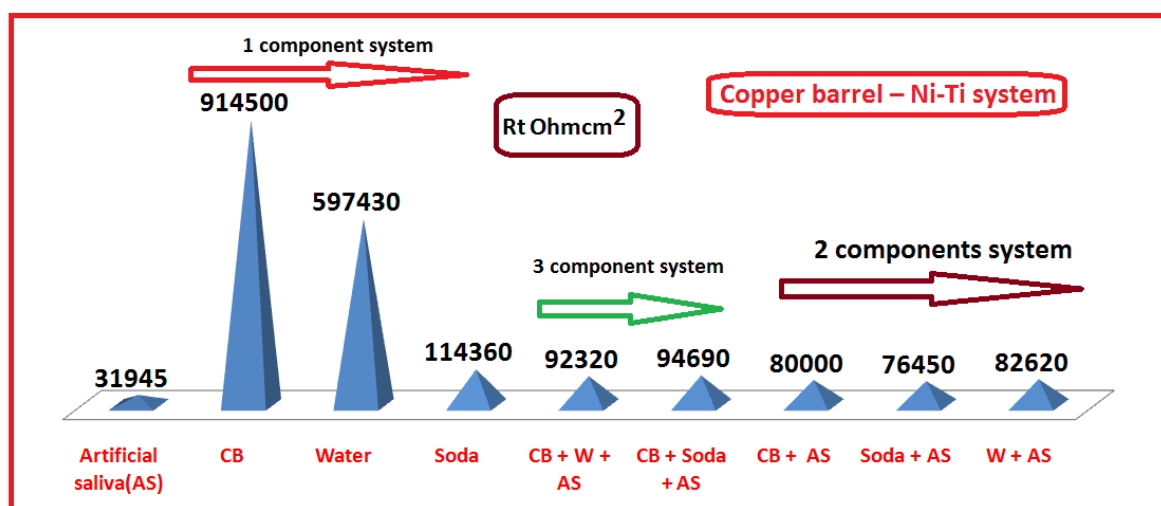
Conclusion

The people who have been clipped with orthodontic wire made of Ni-Ti alloy can take copper barrel in any form namely, with dilution or without dilution.

Table 1. Corrosion Parameters of Ni-Ti alloy immersed in various test solutions containing Copper Barrel obtained by AC Impedance spectra

Tabela 1. Parametri korozije legure Ni-Ti uronjene u različite test rastvore koji sadrže žestoko piće Copper Barrel dobijeno spektrom AC impedanse

System	R_t , Ohmcm ²	C_{dl} , F/cm ²	Impedance, Log(Z/ohm)
Artificial saliva(AS)	31945	1.596×10^{-10}	4.649
CB	914500	1.9227×10^{-11}	6.047
Water	597430	4.0050×10^{-11}	5.913
Soda	114360	3.001×10^{-10}	5.455
CB + W + AS	92320	3.8054×10^{-10}	5.405
CB + Soda + AS	94690	4.0666×10^{-10}	5.4
CB + AS	80000	4.5929×10^{-10}	5.383
Soda + AS	76450	4.8864×10^{-10}	5.373
W + AS	82620	4.5797×10^{-10}	5.375



Scheme A. Comparison of Corrosion Parameters of Ni-Ti alloy immersed in various test solutions containing Copper Barrel obtained by AC Impedance spectra

Šema A. Poređenje parametara korozije legure Ni-Ti uronjene u različite test rastvore, koji sadrže žestoko piće Copper Barrel, dobijeno spektrom naizmenične impedanse

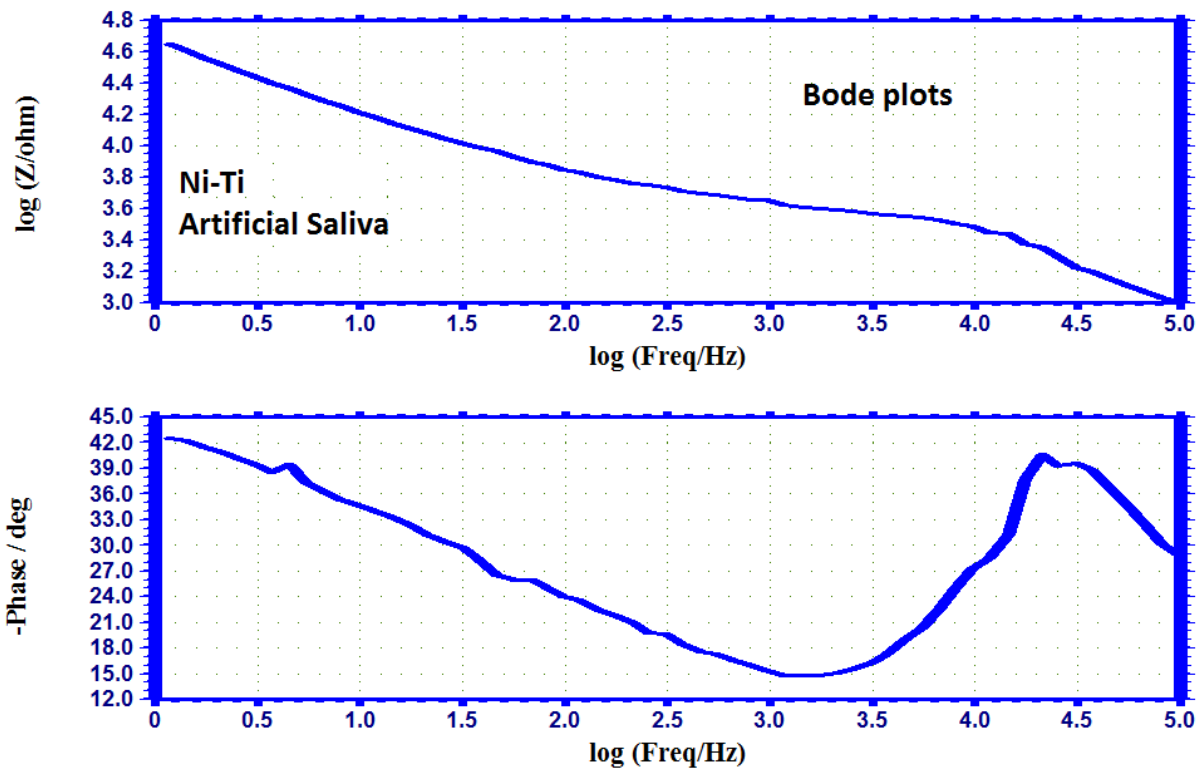


Figure 1. Bode plots of Ni-Ti alloy immersed in Artificial Saliva

Slika 1. Bode-ove krive legure Ni-Ti uronjene u veštačku pljuvačku

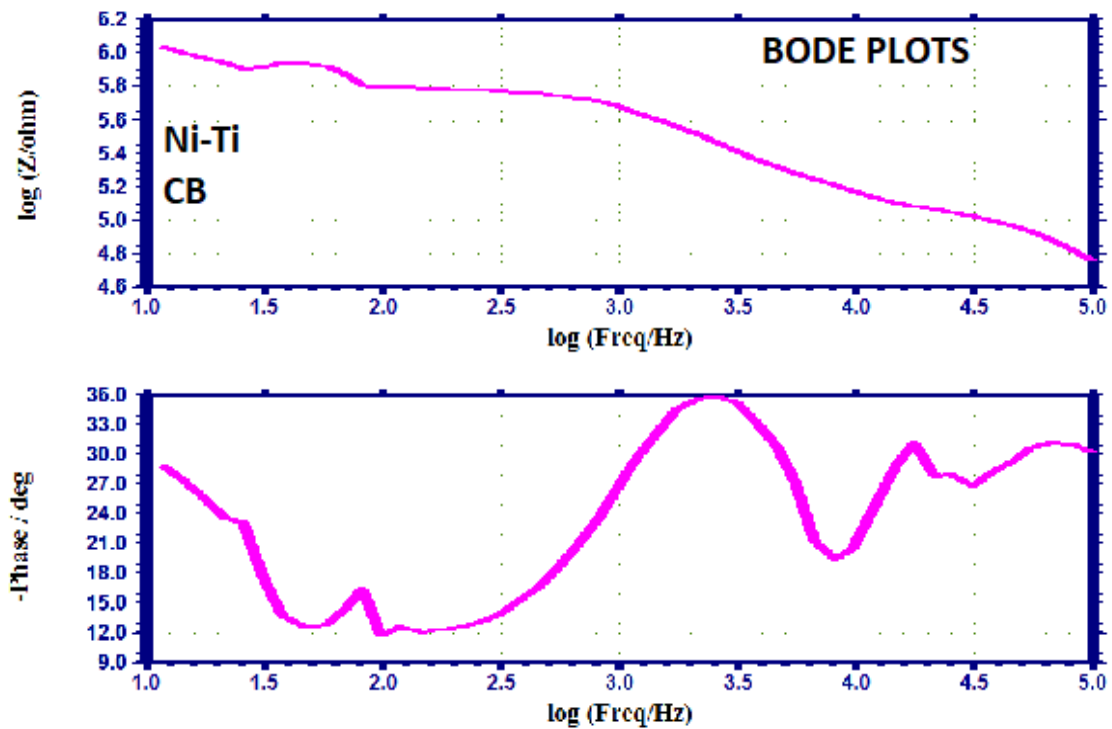


Figure 2. Bode plots of Ni-Ti alloy immersed in Copper barrel

Slika 2. Bode-ove krive legure Ni-Ti uronjene u žestoko piće Copper barrel

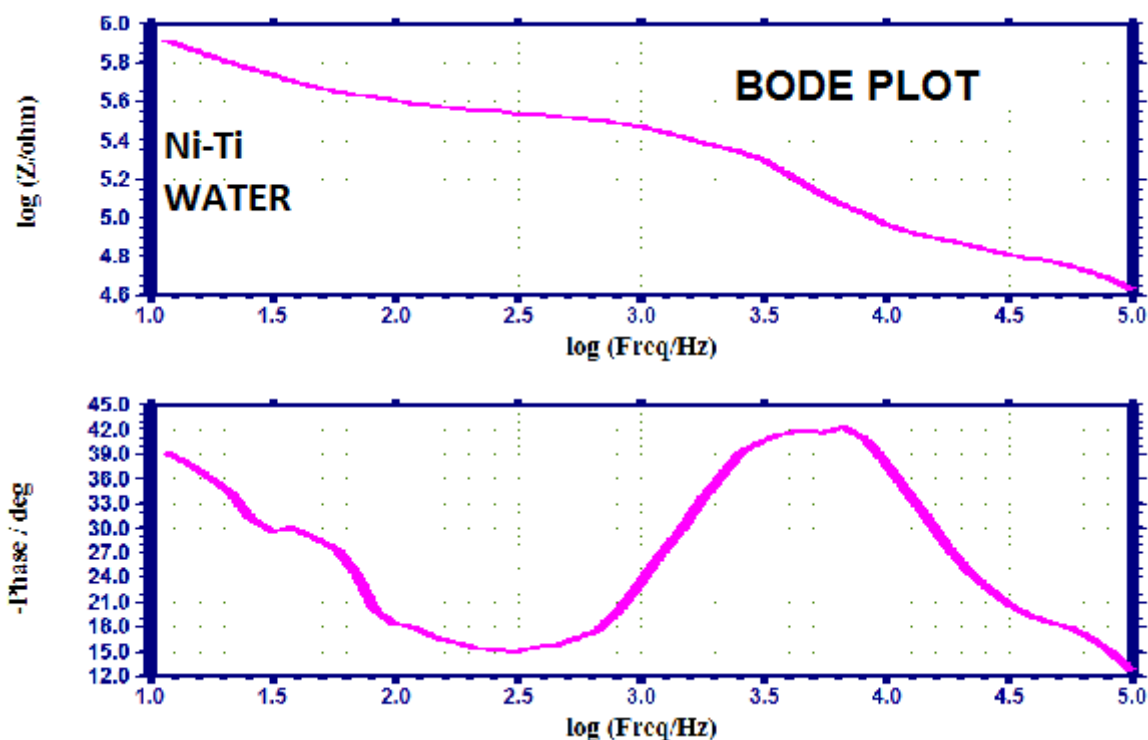


Figure 3. Bode plots of Ni-Ti alloy immersed in Bisleri water
 Slika 3. Bod-ove krive legure Ni-Ti uronjene u vodu Bisleri

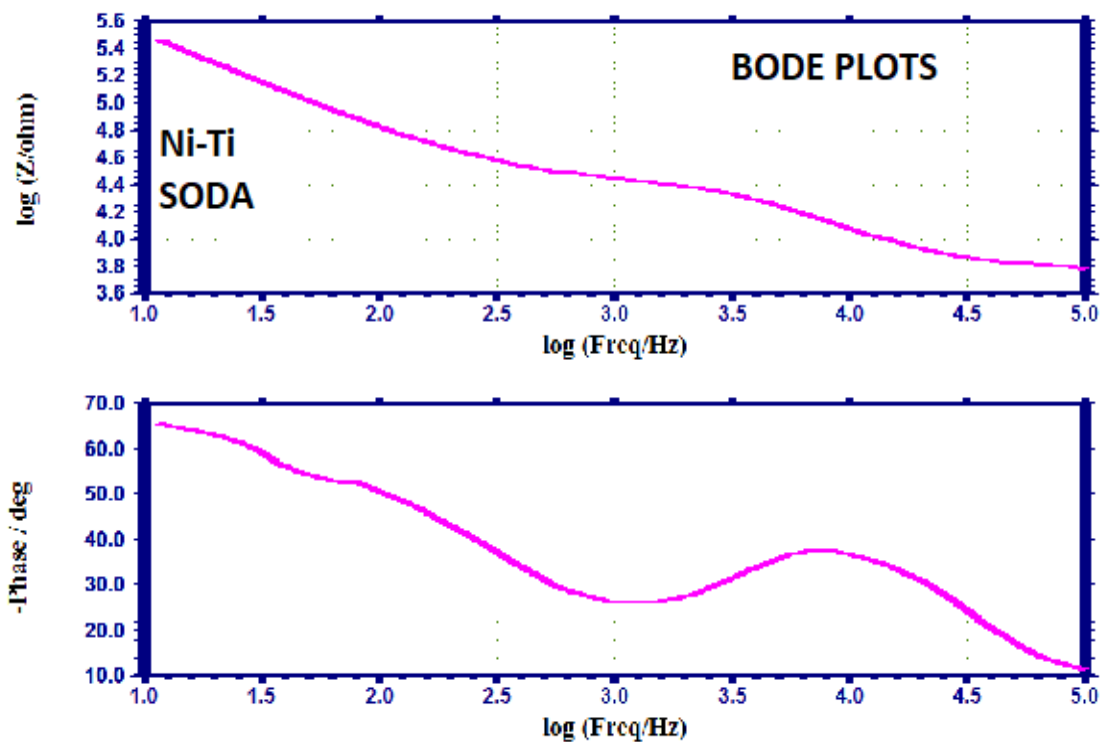


Figure 4. Bode plots of Ni-Ti alloy immersed in Soda water
 Slika 4. Bode-ove krive legure Ni-Ti uronjene u Soda vodu

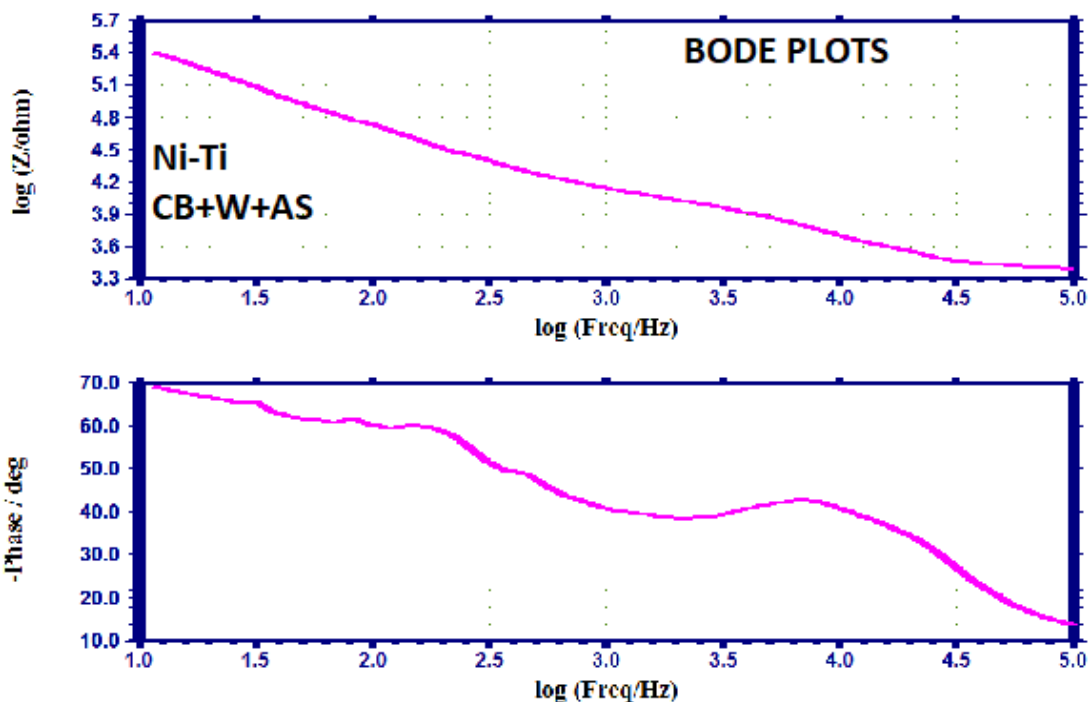


Figure 5. Bode plots of Ni-Ti alloy immersed in Copper barrel + Bisleri water + Artificial saliva
 Slika 5. Bode-ove krive legure Ni-Ti uronjene u žestoko piće Copper barrel + Bisleri voda + veštačka pljuvačka

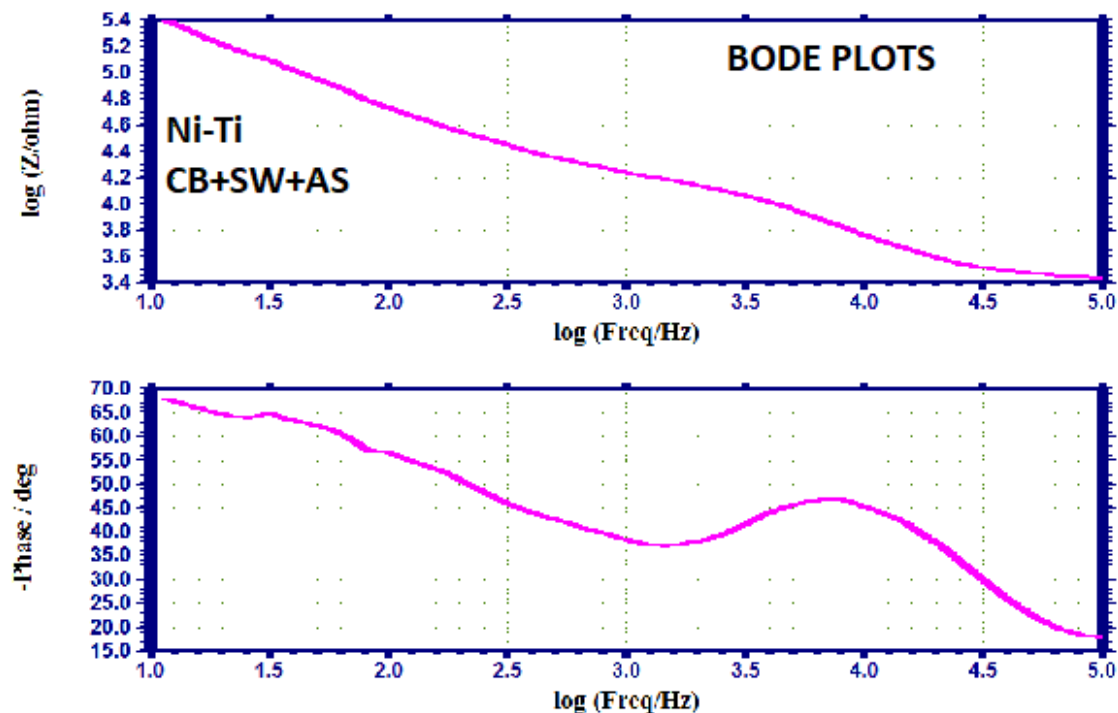


Figure 6. Bode plots of Ni-Ti alloy immersed in Copper barrel + Soda water + Artificial saliva
 Slika 6. Bode-ove krive legure Ni-Ti uronjene u žestoko piće Copper barrel + Soda voda + veštačka pljuvačka

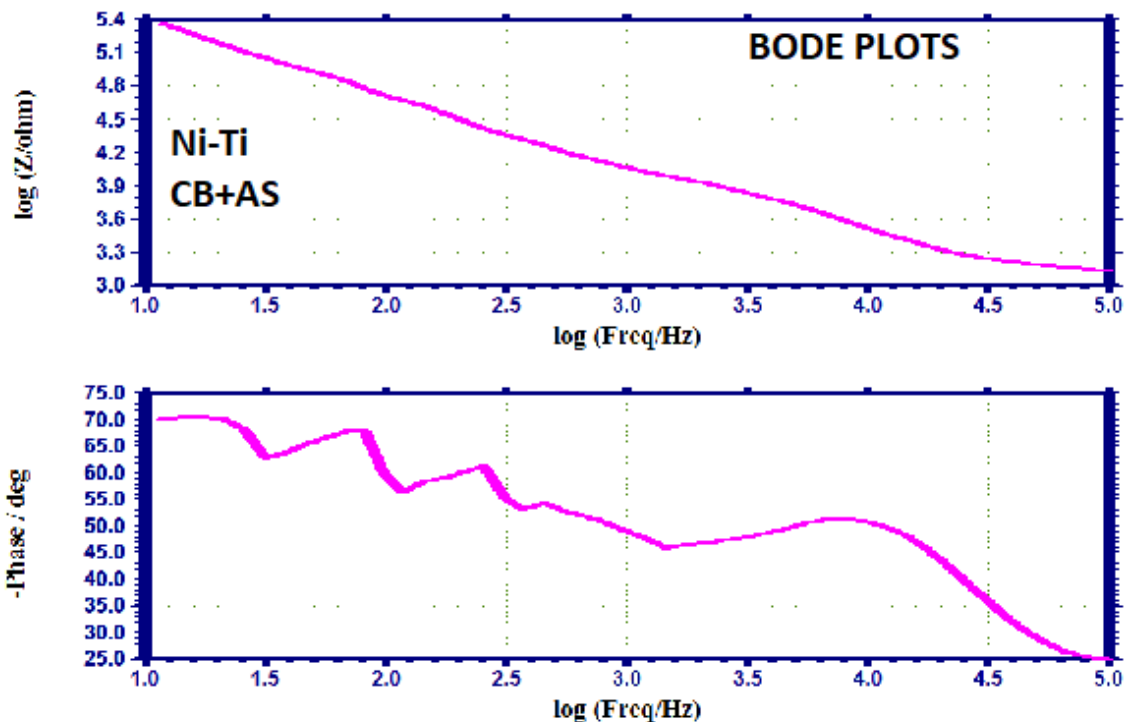


Figure 7. Bode plots of Ni-Ti alloy immersed in Copper barrel + Artificial saliva

Slika 7. Bode-ove krive legure Ni-Ti uronjene u žestoko piće Copper barrel + veštačka pljuvačka

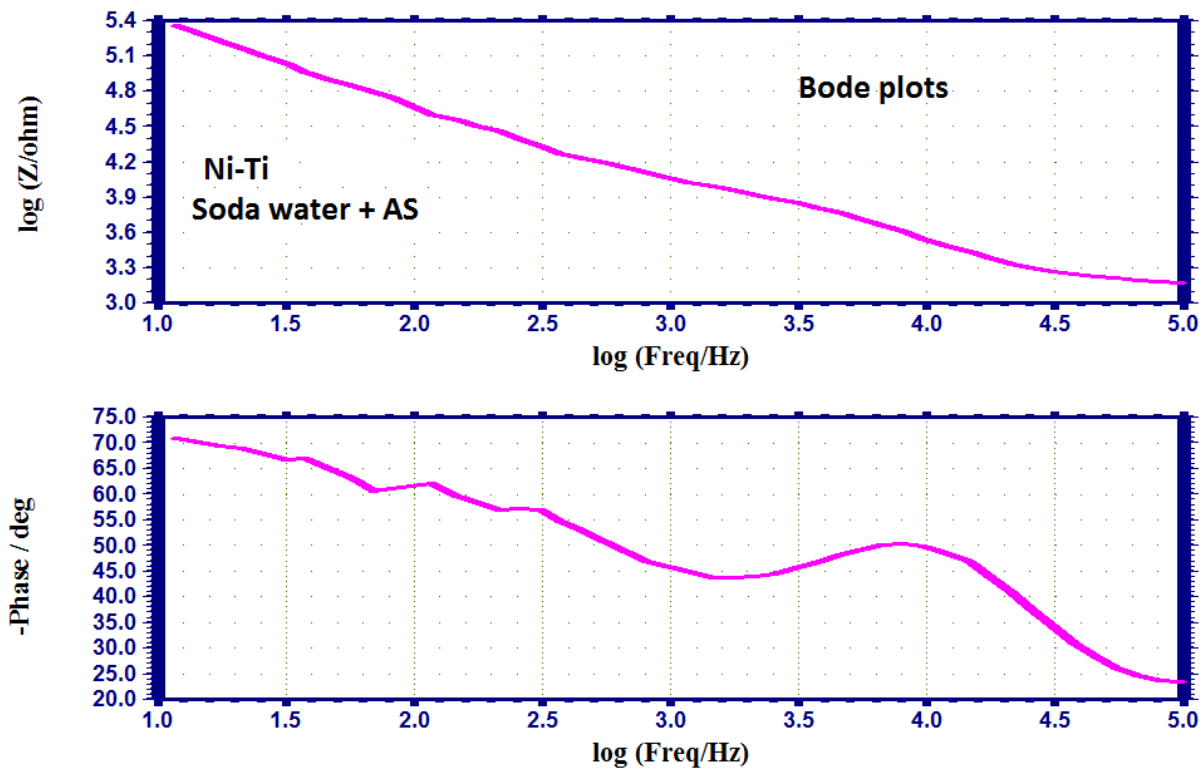


Figure 8. Bode plots of Ni-Ti alloy immersed in Soda water + Artificial saliva

Slika 8. Bode-ove krive legure Ni-Ti uronjene u Soda voda + veštačka pljuvačka

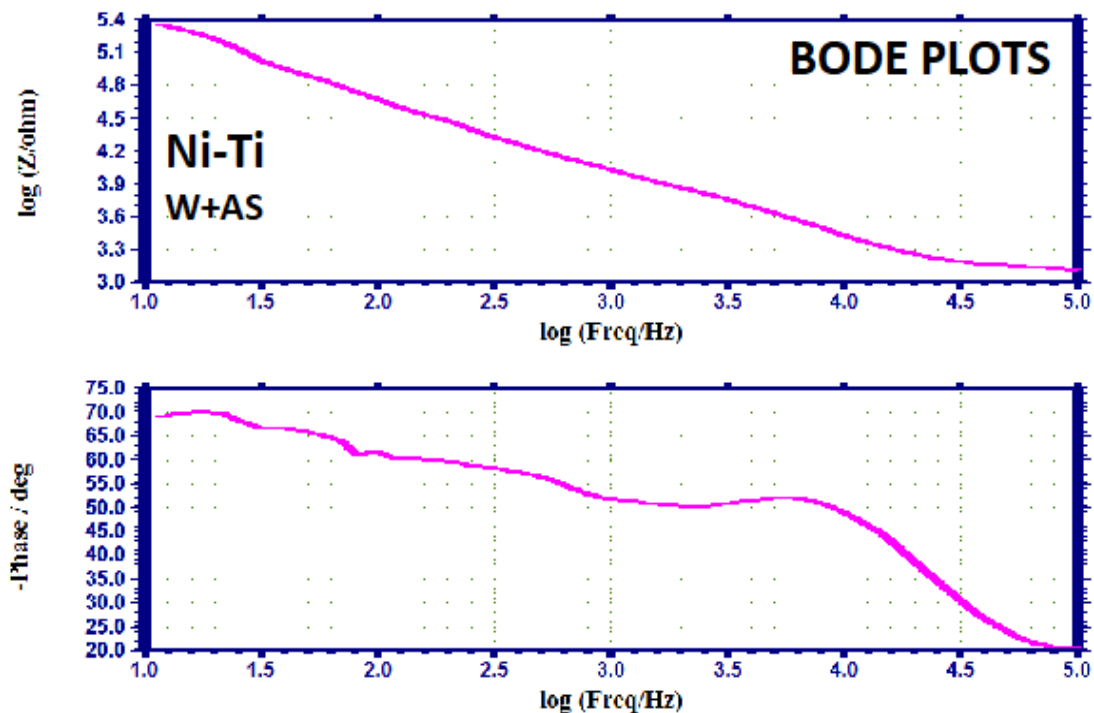


Figure 9. Bode plots of Ni-Ti alloy immersed in Bisleri water + Artificial saliva

Slika 9. Bode-ove krive legure Ni-Ti uronjene u Bisleri voda + veštačka pljuvačka

Ni-Cr alloy system

Corrosion resistance of orthodontic wire made of Ni-Ti alloy in artificial saliva in the absence and presence of Copper barrel, water and soda water has been evaluated by AC impedance spectra. The results are shown in Table 2, Scheme B and Fig. 10-18. When corrosion resistance increases R_t (Charge transfer resistance) value increases, impedance increases and double layer capacitance (C_{dl}) decreases. On the other hand, when corrosion resistance decreases R_t (Charge transfer resistance) value decreases, impedance decreases and double layer capacitance (C_{dl}) increases.

One component system

When Ni-Cr alloy is immersed in one component system, namely, copper barrel or water or soda water (in the absence of artificial saliva) the corrosion resistances are as follows (Table 2):

Copper barrel > water > artificial saliva > soda water

Three component system

When Ni-Cr alloy is immersed in three component system, namely, copper barrel, water and soda water the corrosion resistances are as follows (Table 2):

AS > CB + W + AS > CB + Soda + AS

Implication

When copper barrel is mixed with soda water, corrosion resistance of Ni-Cr alloy in artificial saliva, is found to be less than that of the system consisting of copper barrel and water in the presence of artificial saliva. The corrosion resistance of the two systems are lower than that of the AS system. It is interesting to note that, in the above two systems, corrosion resistance of Ni-Cr alloy in artificial saliva, is found to decrease. Hence it is concluded that people having clipped with orthodontic wire made of Ni-Cr alloy should avoid taking CB + W or CB + Soda orally.

Two component system

When copper barrel alone or soda water alone or water alone, is orally intaken, corrosion resistance of Ni-Cr alloy in artificial saliva is as follows (Table 2):

Artificial saliva > water alone > copper barrel alone > soda water alone

Implication

Copper barrel alone or water alone or soda water alone should not be taken orally, by the people who have been clipped with orthodontic wire made of Ni-Cr alloy.

Conclusion

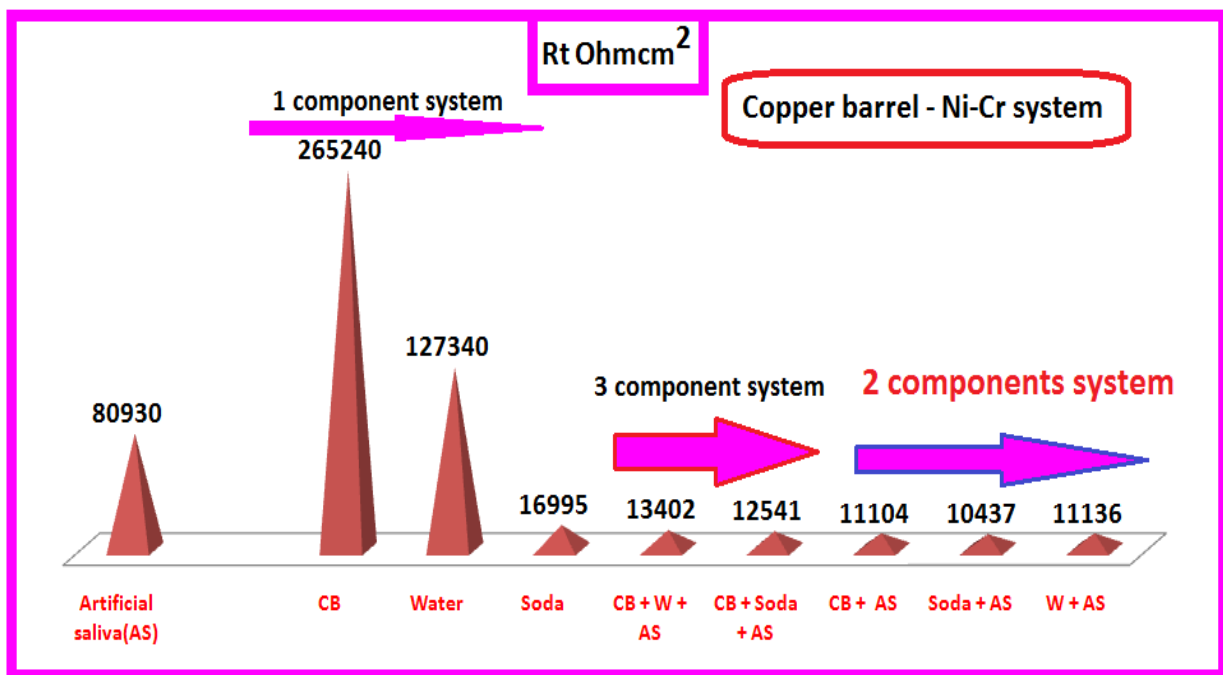
The people who have been clipped with orthodontic wire made of Ni-Cr alloy should avoid

taking copper barrel in any form namely, with dilution or without dilution.

Table 2. Corrosion Parameters of Ni-Cr alloy immersed in various test solutions containing Copper Barrel obtained by AC Impedance spectra

Tabela 2. Parametri korozije Ni-Cr legure potopljene u različite test rastvore koji sadrže žestoko piće Copper Barrel dobijeno spektrom AC impedanse

System	R_t , Ohmcm ²	C_{dl} , F/cm ²	Impedance, Log(Z/ohm)
Artificial saliva(AS)	80930	6.301×10^{-11}	5.239
CB	265240	1.923×10^{-11}	5.474
Water	127340	4.005×10^{-11}	5.172
Soda	16995	3.001×10^{-10}	4.496
CB + W + AS	13402	3.805×10^{-10}	4.444
CB + Soda + AS	12541	4.067×10^{-10}	4.385
CB + AS	11104	4.593×10^{-10}	4.383
Soda + AS	10437	4.887×10^{-10}	4.361
W + AS	11136	4.580×10^{-10}	4.292



Scheme B. Comparison of Corrosion Parameters of Ni-Cr alloy immersed in various test solutions containing Copper Barrel obtained by AC Impedance spectra

Šema B. Poređenje parametara korozije legure Ni-Cr uronjene u različite test rastvore, koji sadrže žestoko piće Copper Barrel, dobijeno spektrom naizmenične impedanse

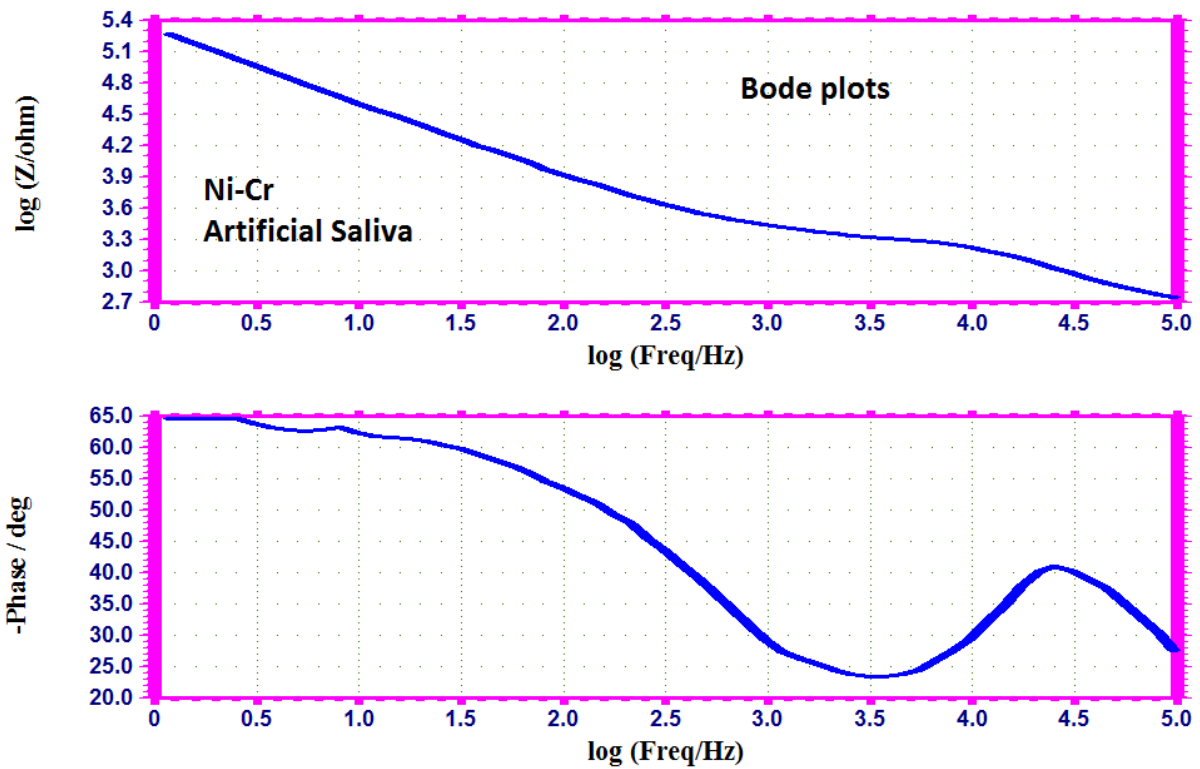


Figure 10. Bode plots of Ni-Cr alloy immersed in Artificial saliva

Slika 10. Bode-ove krive legure Ni-Cr uronjene u veštačku pljuvačku

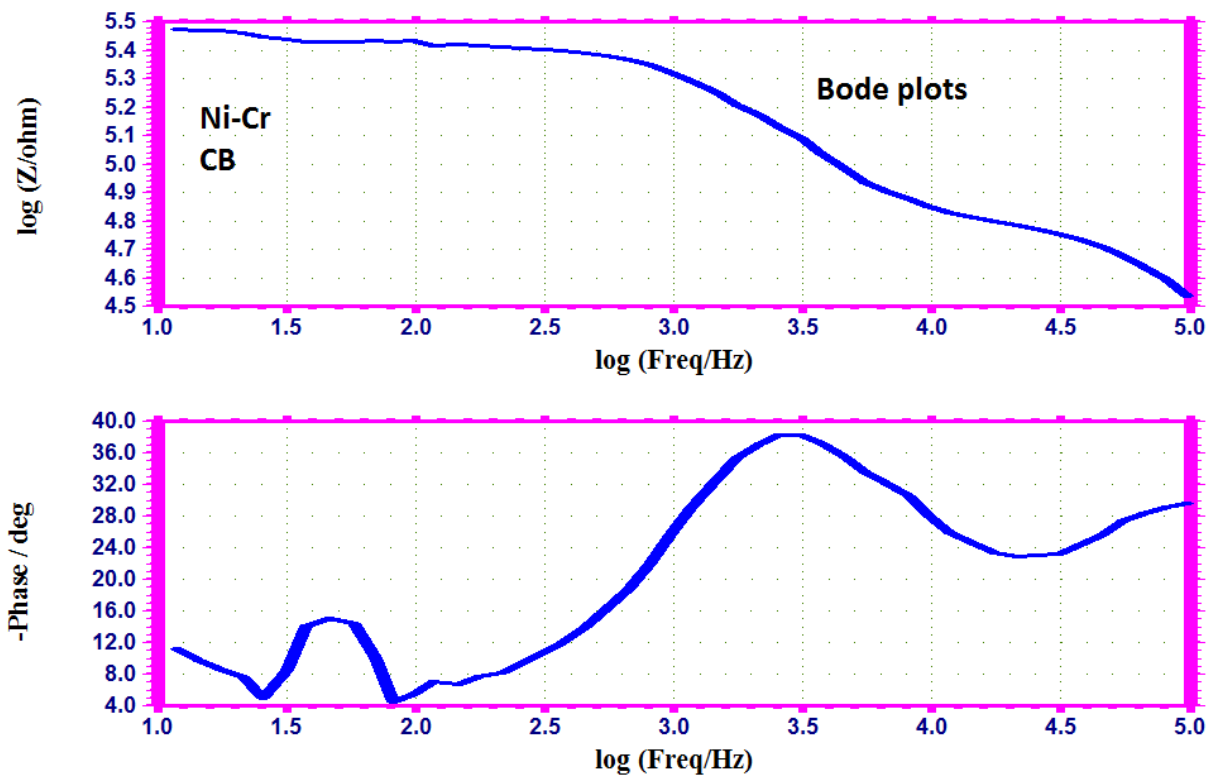


Figure 11. Bode plots of Ni-Cr alloy immersed in Copper Barrel

Slika 11. Bode-ove krive legure Ni-Cr uronjene u žestoko piće Copper Barrel

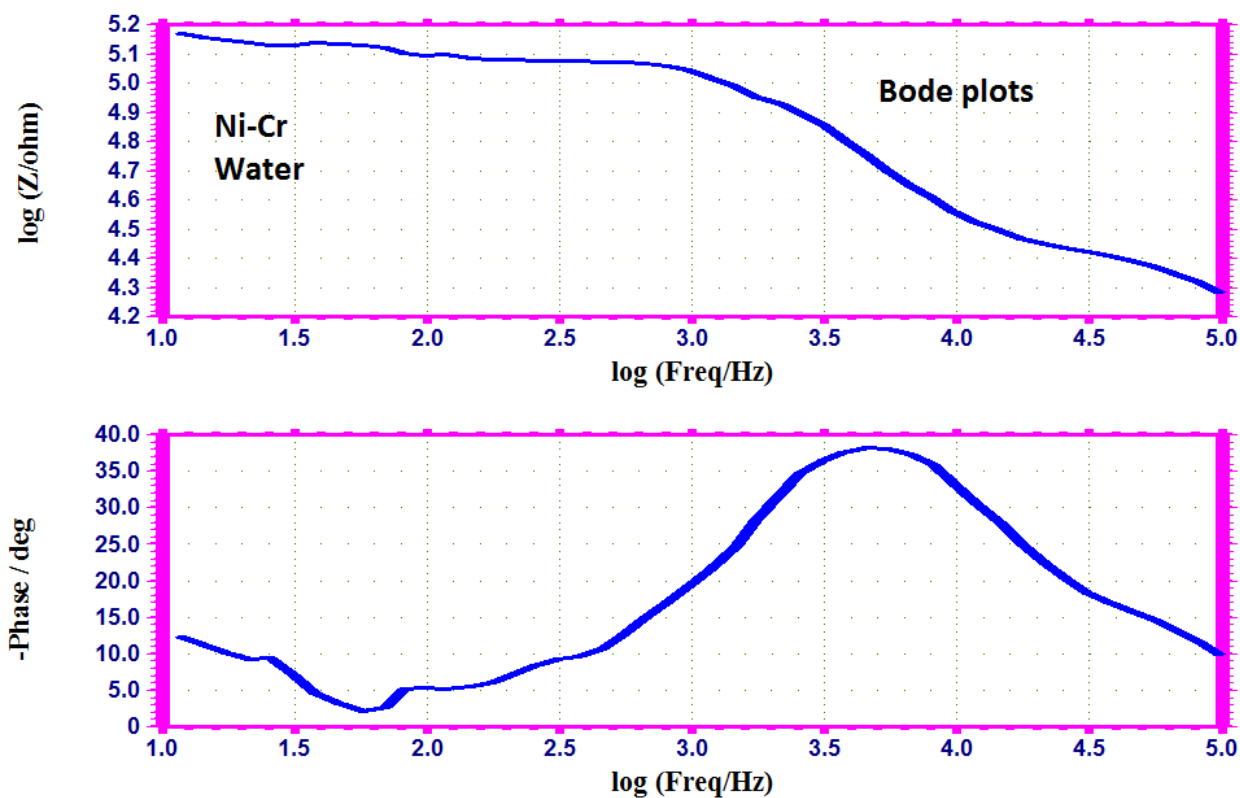


Figure 12. Bode plots of Ni-Cr alloy immersed in Bisleri water

Slika 12. Bode-ove krive legure Ni-Cr uronjene u vodu Bisleri

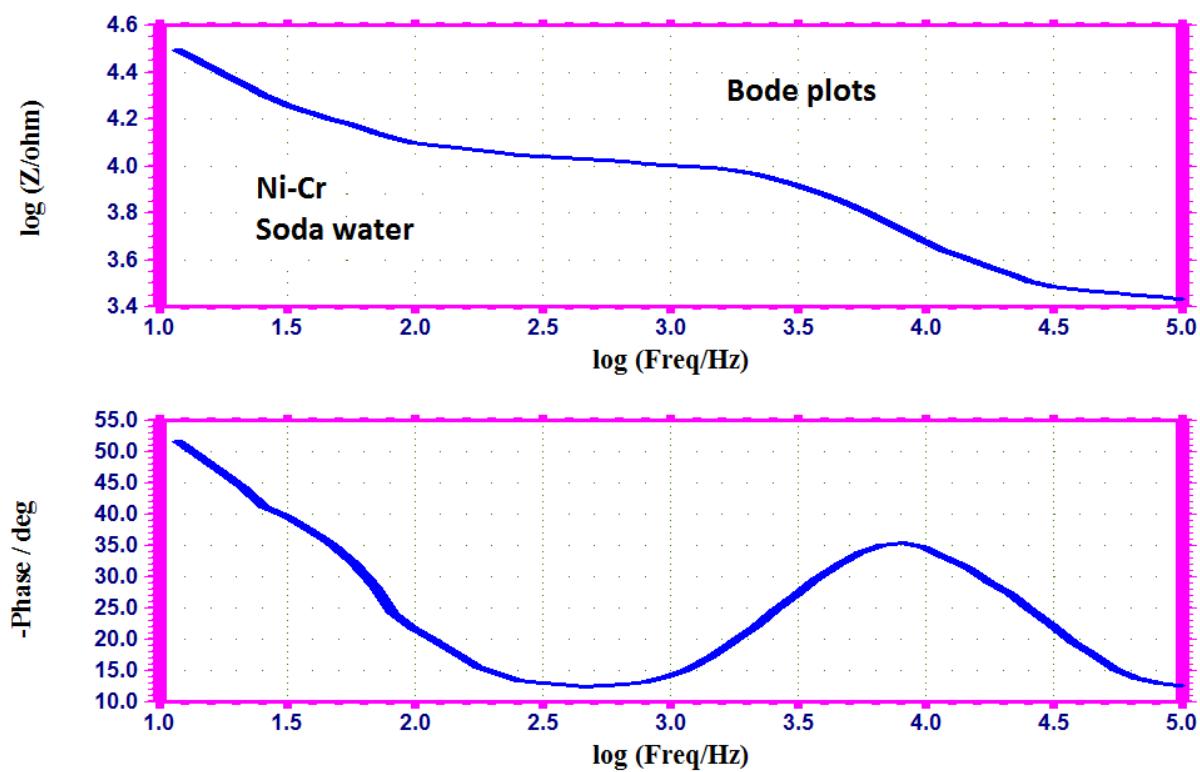


Figure 13. Bode plots of Ni-Cr alloy immersed in Soda water

Slika 13. Bode-ove krive legure Ni-Cr uronjene u Soda vodu

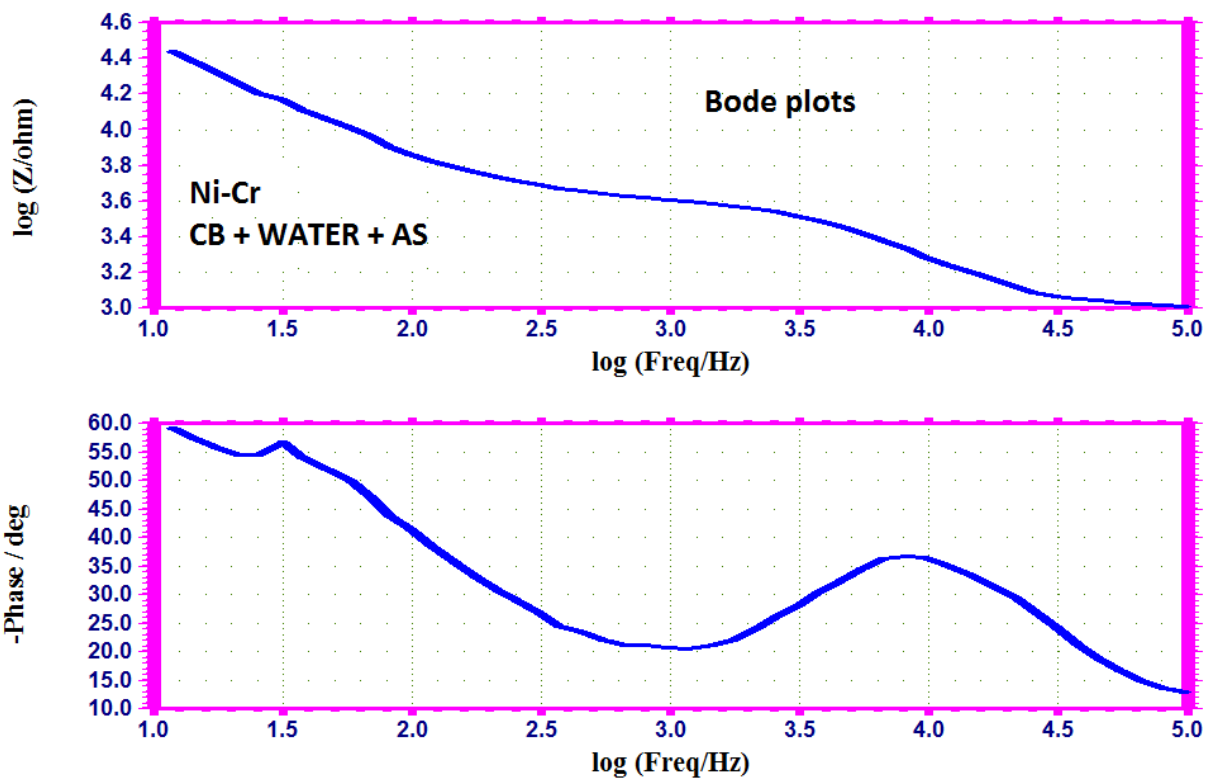


Figure 14. Bode plots of Ni-Cr alloy immersed in CB + water+ AS

Slika 14. Bode-ove krive legure Ni-Cr uronjene u žestoko piće Copper barrel + voda + veštačka pljuvačka

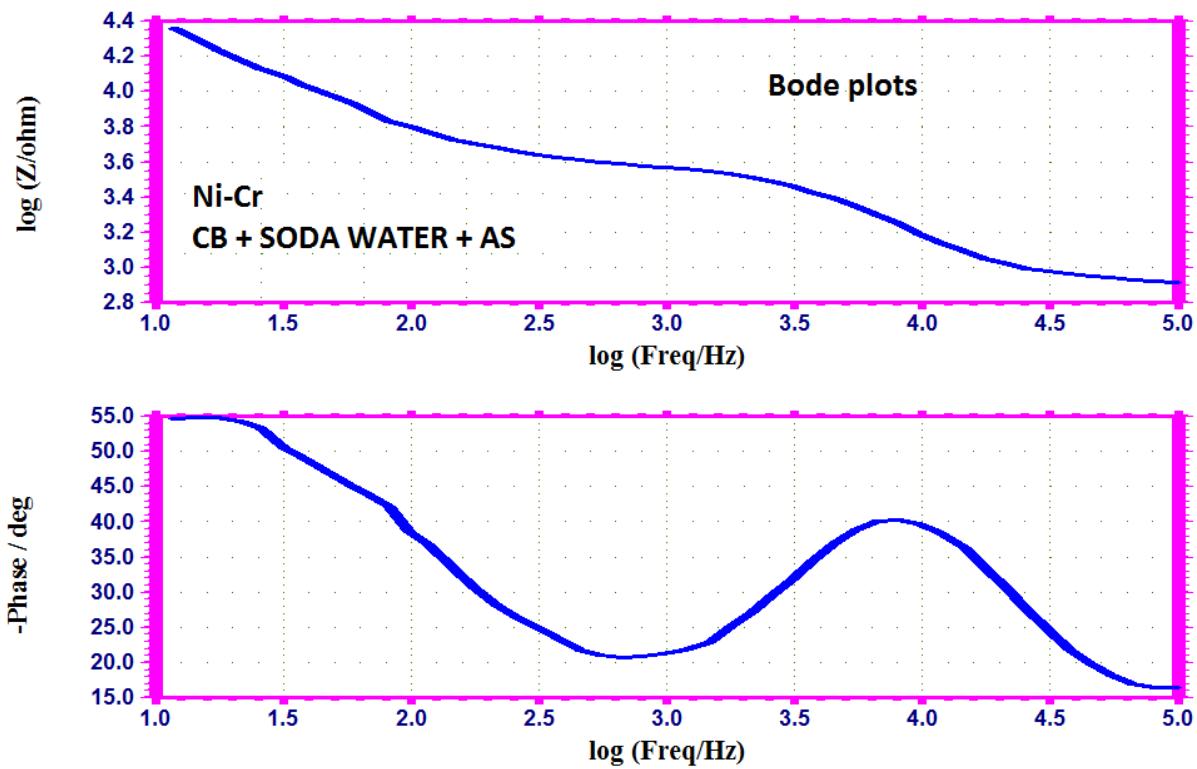


Figure 15. Bode plots of Ni-Cr alloy immersed in CB + Soda water+ AS

Slika 15. Bode-ove krive legure Ni-Cr uronjene u žestoko piće Copper barrel + Soda voda + veštačka pljuvačka

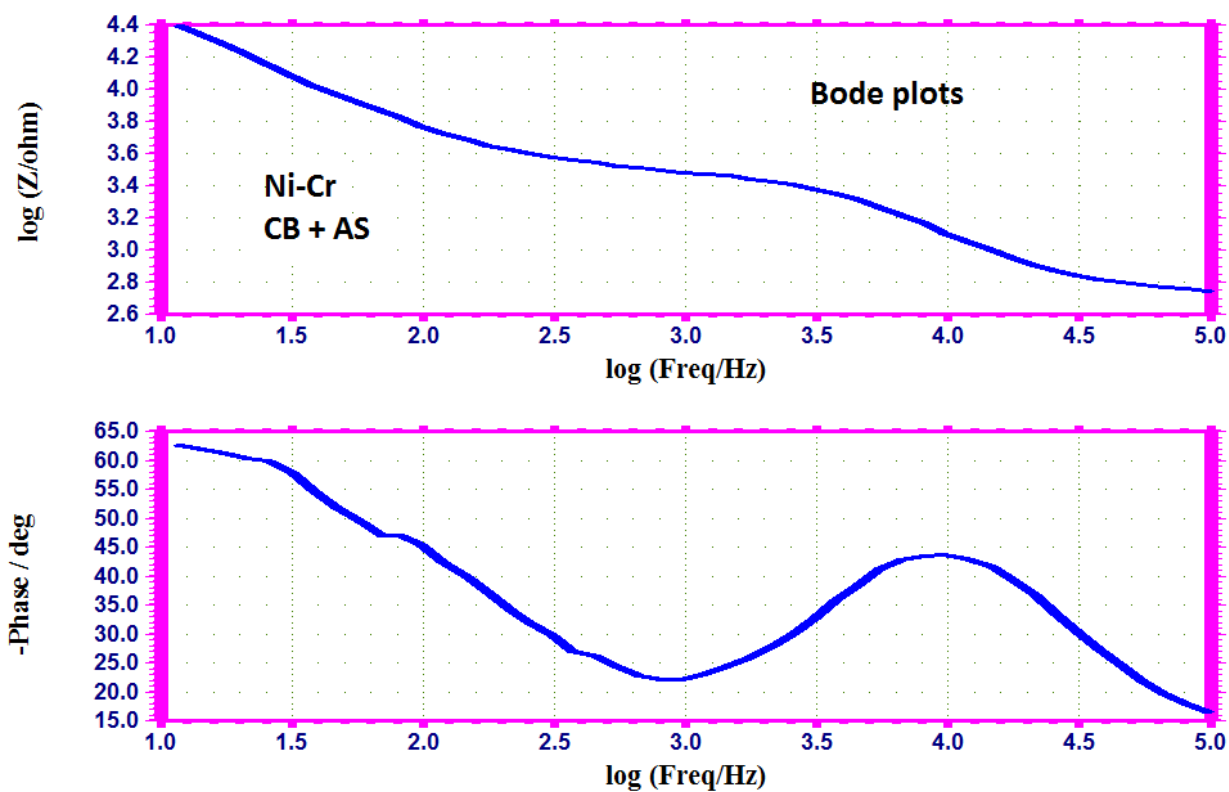


Figure 16. Bode plots of Ni-Cr alloy immersed in CB + AS

Slika 16. Bode-ove krive legure Ni-Cr uronjene u žestoko piće Copper barrel + veštačka pljuvačka

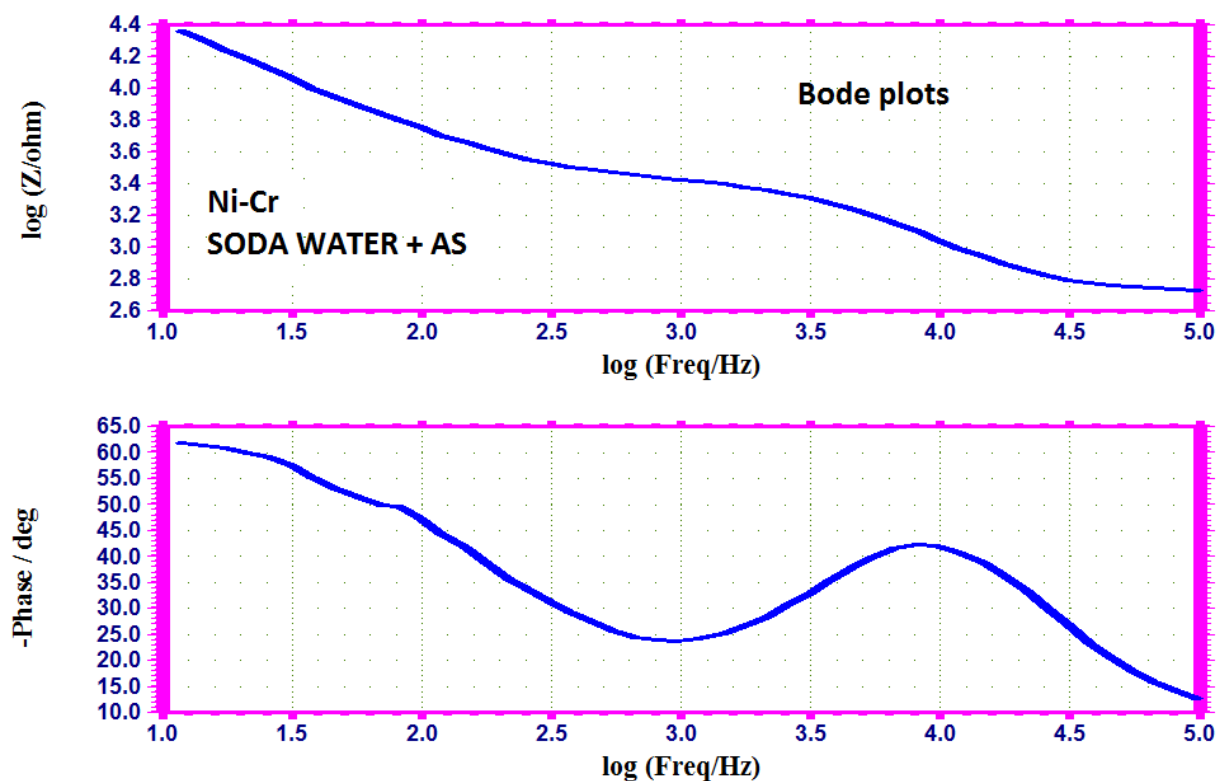


Figure 17. Bode plots of Ni-Cr alloy immersed in Soda water + AS

Slika 17. Bode-ove krive legure Ni-Cr uronjene u Soda voda + veštačka pljuvačka

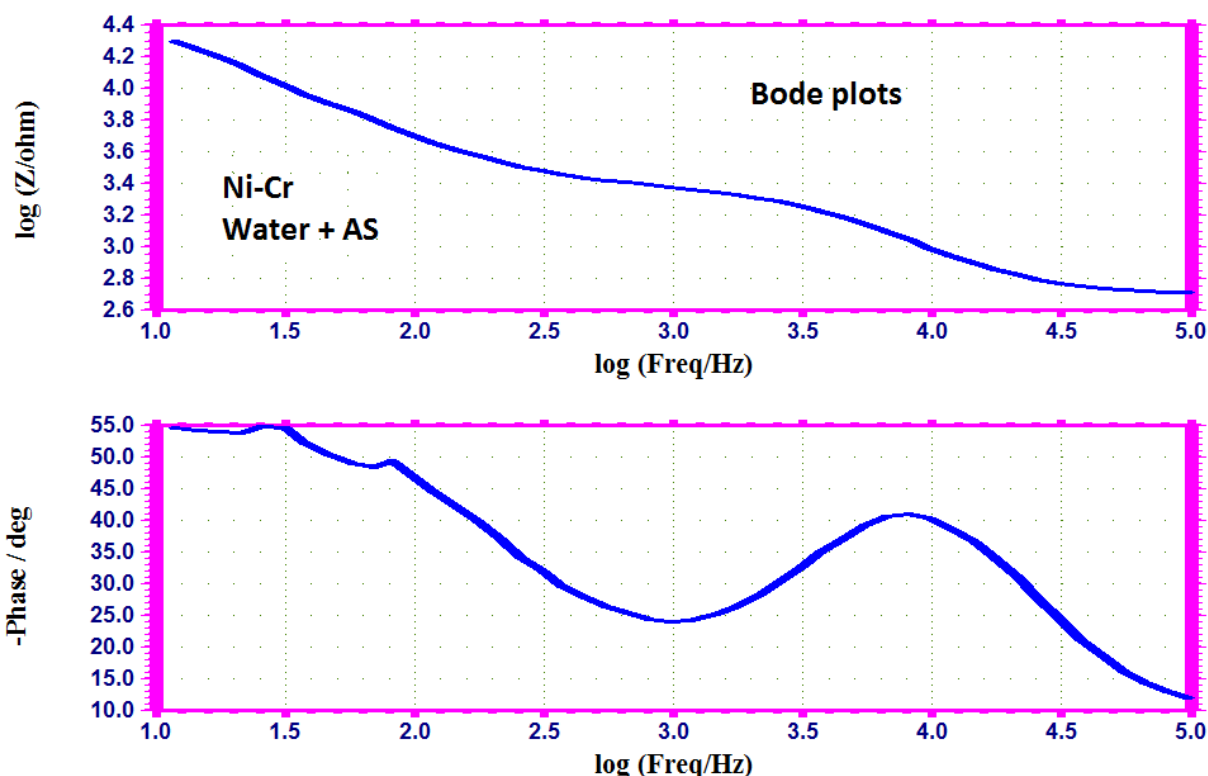


Figure 18. Bode plots of Ni-Cr alloy immersed in water + AS

Slika 18. Bode-ove krive legure Ni-Cr uronjene u voda + veštačka pljuvačka

4. CONCLUSIONS

- The people who have been clipped with orthodontic wire made of Ni-Ti alloy can take copper barrel in any form, namely, with dilution or without dilution using water or soda water.
- The people who have been clipped with orthodontic wire made of Ni-Cr alloy should avoid taking copper barrel in any form, namely, with dilution or without dilution using water or soda water.

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IZVOD

Uticaj razblaživanja i dodavanja soda vode na otpornost na koroziju ortodontskih žica potopljenih u veštačku pljuvačku u prisustvu copper barrel-a, žestokog pića

Žestoko piće Copper Barrel može se uzimati oralno sa razblaženjem soda vodom i bez razblaživanja. Ljudi, koji u ustima imaju ortodontske žice, koriste ovo žestoko piće oralno, uz razblaživanje i bez razblaživanja. Koliko će ovo piće uticati na ortodontske žice? U cilju pronalazjenja odgovora uradjen je ovaj istraživački rad. Otpornost na koroziju ortodontskih žica od legure Ni-Ti i legure Ni-Cr u veštačkoj pljuvački u odsustvu i prisustvu rakije, vode i soda vode je procenjena spektrima AC impedanse. Generalno se primećuje da je legura Ni-Ti otpornija na koroziju od legure Ni-Cr u veštačkoj pljuvački u prisustvu navedenog žestokog pića, vode i soda vode. Kada se ortodontska žica napravljena od Ni-Ti uroni u veštačku pljuvačku, vrednost otpora prenosa naelektrisanja (R_t) iznosi 31945 Ohmcm². Kada je legura uronjena u žestoko piće + sistem veštačke pljuvačke (AS), vrednost R_t se povećavava 80000 Ohmcm². Kada je uronjen u sistem soda voda + veštačka pljuvačka (AS), vrednost R_t se povećavava 76450 Ohmcm². Kada je uronjen u sistem voda + veštačka pljuvačka (AS), vrednost R_t se povećava na 82620 Ohmcm². S druge strane, kada se ortodontska žica napravljena od legure Ni-Cr uroni u veštačku pljuvačku, vrednost otpora prenosa naelektrisanja (R_t) iznosi 80930 Ohmcm². Kada je legura uronjena u žestoko piće + sistem veštačke pljuvačke (AS), vrednost R_t se smanjuje na 11104 Ohmcm². Kada se potopi u sistem soda voda + veštačka pljuvačka (AS), vrednost R_t se smanjuje na 10437 Ohmcm². To podrazumeva da ljudi koji su imali u ustima ortodontsku žicu od Ni-Ti legure mogu da uzimaju navedeno žestoko piće u bilo kom obliku, sa razblaženjem ili bez razblaživanja. Osobe koje su imale u ustima ortodontsku žicu od legure Ni-Cr treba da izbegavaju uzimanje navedenog žestokog pića u bilo kom obliku, sa razblaženjem ili bez razblaženja.

Ključne reči: ortodontske žice, otpornost na koroziju, soda voda, veštačka pljuvačka, žestoko piće, Ni-legure

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