SURFACE CORROSION OF Ni-Cr ALLOYS IN ARTIFICIAL SALIVA WITH XILINA AND CLORAMPHENICOL

COROZIUNEA DE SUPRAFAŢĂ A ALIAJELOR Ni-Cr ÎN SALIVA ARTIFICIALĂ CU XILINĂ ŞI CLORAMFENICOL

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Abstract. *Two non-precious Ni-Cr-Mo based alloys were analyzed with respect to their corrosion behaviour. The main parameters of the corrosion process were evaluated from linear potentiodynamic polarization curves, in Afnor type artificial saliva with added xilina / cloramphenicol. The contact time between the alloy and the corrosive medium influenced the corrosion rate as the corrosion current values decreased with the contact time due to passivation phenomena. The microscopic analysis of the alloy surfaces showed that the passivation processus in the tested solution did not modify the type of the corrosion process. The present investigation results showed that both alloys were susceptible to localized corrosion.*
Key words: Ni-Cr alloys, localized corrosion, Afnor artificial saliva, xilina, cloramphenicol.

Rezumat. *Două aliaje pe bază de Ni-Cr-Mo au fost investigate din punct de vedere al rezistenţei la coroziune. Parametrii de coroziune au fost evaluaţi prin determinarea curbelor de polarizare potenţiodinamică a celor două aliaje în salivă Afnor cu adaos de xilină / cloramfenicol. Timpul de contact dintre aliaj şi mediul coroziv a influenţat rata procesului de coroziune astfel încât valorile curenţilor de coroziune au scăzut în timp datorită fenomenului de pasivare. Analiza microscopică a suprafeţelor aliajelor a evidenţiat că fenomenul de pasivare, dezvoltat în soluţiile testate, nu a influenţat tipul procesului de coroziune. Ambele aliajele au prezentat susceptibilitate faţă de coroziunea localizată.*
Cuvinte cheie: aliaje Ni-Cr, coroziune localizată, salivă artificială Afnor, xilină, cloramfenicol.

INTRODUCTION

The non-precious alloys react easily with the biochemical medium from the oral cavity due to their complex composition, fact inducing their degradation by electrochemical corrosion. The non-precious alloys like Ni-Cr-Mo, Ni-Cr-Fe, and Co-Cr-Mo have become widely used in prosthetics dentistry (Leinfelder, 1997; Mareci *et al.*, 2011; Romas *et a*l., 2013) as a more economically convenient replacement for other much more expensive precious dental metal alloys (Mareci *et al.*, 2012; Sharma *et al.*, 2008), fact explaining the wide variety of commercially available Ni-based dental alloys available on European Union markets (Hildebrand, 1989). Recent works reported

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that Ni-based dental alloys present evidence of localized corrosion process (Dumas *et al.,* 2006). Therefore, it would be of high interest if used Ni-Cr-Mo dental bridge may be recovered without any significant signs of localized corrosion. In order to elucidate this issue, two type of Ni-Cr-Mo dental bridge were tested in vitro, by electrochemical and surface analysis techniques.

MATERIAL AND METHODS

Materials

Two non-precious Ni-Cr-Mo dental casting alloys used in dental prosthetics construcion were investigated. The name and chemichal composition of the dental alloys, according to the data provided by manufacturer, Gialloy BK Giulini, Germany; Wiron99: Bego. Germany, are shown in table 1.

Table 1

Chemical composition of the investigated Ni-based dental casting alloys

Dental biomaterial	Element, wt.%				
	Cr	Mo	Fe	Si	Ni
Gialloy	25.0	11.0	0.2	1.5	bal.
Wiron99	22.5	9.5	0.5	1.0	bal

Test corrosion medium

Corrosion tests were performed for both dental alloys in three different electrolytes:

1. The solution used for studies was the Carter-Brugirard (AFNOR) artificial saliva with the pH = 8.1, and the following composition (g/l): NaCl - 0.7; KCl – 1.2; Na $H_2PO_4 \cdot H_2O$ - 0.26; KSCN 0.33; $NaHCO_3$ 1.5 and urea 1.35.
2. The second medium used was AFNOR artiflicial saliva enriced with 5 mL/100 mL xilina. Xilina being a local anesthetic, it is possible to contaminate the saliva concentration, for a short period of time.
3. The third medium was AFNOR artiflicial saliva enriced with 0.1 g/100mL cloramphenicol.

Electrochemical tests

Electrochemical measurements were carried out in aerated solution at 37°C by using a PARSTAT 4000 potentiostat (Princeton Applied Research, USA) controlled by a personal computer and specific software (VersaStudio®, PAR, USA). A glass corrosion flow cell kit (C145/170, Radiometer, France) with a platinum counter electrode and a saturated calomel reference electrode (SCE) were used to perform the electrochemical measurements. The C145/170 is fitted with a PCTFE sample holder and a freely adjustable Luggin capillary. All potentials referred to, in this article are with respect to SCE. Measurement of linear potentiodynamic polarization curves was initiated after 1 hour time exposure to the test medium. The tests were conducted by scanning the potential at 1 mV s^{-1}

Optical microscopy of corroded surfaces

In order to observe the occurrence of the corrosion surface effects, the some corroded surfaces were observed by OM microscopy, by using an Olympus PME 3 – ADL microscope.

RESULTS AND DISCUSSION

Semi-logarithmic plots of Wiron99 dental alloy in all three tested medium are displayed in figure 1.

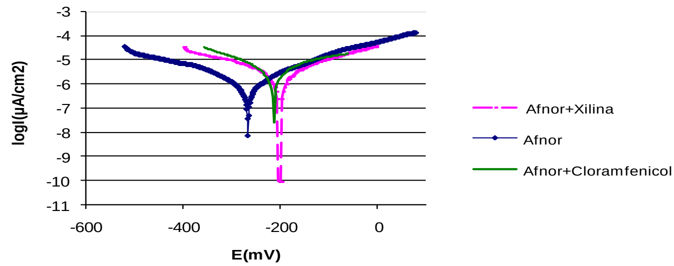


Fig.1 Reprezentative linear potentiodynamic polarisation curves for Wiron99 dental alloy in the tested medium

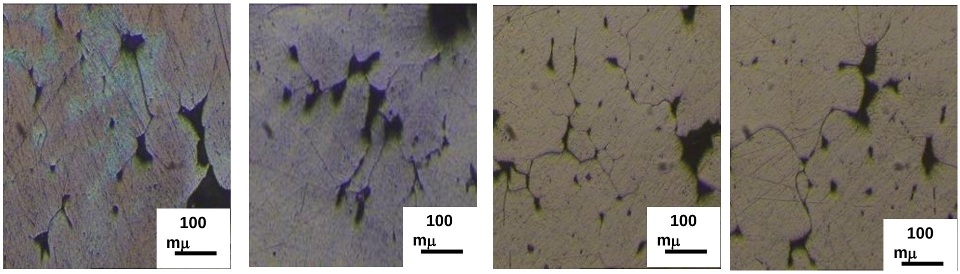
The zero current potential (ZCP) and corrosion current (icorr) values were determined by Tafel analysis of both anodic and cathodic branches of the polarisation plots. The ZCP is defined as the potential at which the current reaches a minimum during the forwarded potentiodynamic polarisation scan. The corrosion current is considered to be representative for the degradation degree of each sample. In the case of Gyalloy dental material, the average values of ZCP and jcorr determined from the polarization curves are presented in table 2. However, approximately similar values were obtained for Wirron99 dental alloys. Low corrosion current density values were obtained from the linear potentiodynamic polarisation curves for both investigated samples, in all tested medium. For both Ni-Cr-Mo dental alloys immersed in Afnor+xilina, the corrosion current density was higher than in Afnor artificial saliva, and Afnor+cloramphenicol, fact suggesting that the characteristics of the passive film were different in this electrolyte medium. In this case, a corrosion layer was formed on the sample surfaces and the anodic polarisation was controlled by a diffusion process. The diffusion rate of the reactants on the sample surface was much slower than the sample's reaction rate.

Table 2

The corrosion parameters of the sudied Gialloy dental material

Test medium	ZCP (mV)	βa	βc	i_{corr} (µA/cm^2)
Afnor Saliva	-292	209.2	198.5	2.1
Afnor+Xilina	-199	170.9	185.2	1.6
Afnor+Cloramphenicol	-316	185.8	143.1	2.8

Figure 2A-D shows the corrosion surfaces of both Ni-Cr-Mo dental alloys after linear potentiynamic polarization in Afnor+xilina/ cloramphenicol at 37^{o}C. The many evident surface cracks prove a similar behavior of both Gialloy and Wiron99 alloys.



(A) (B) (C) (D)

Fig. 2 Surface attack morphology: Gialloy in Afnor+cloramphenicol (A), Afnor+xilina (B) Wiron99 in Afnor+cloramphenicol (C), Afnor+xilina (D)

CONCLUSIONS

1. The present study investigated the electrochemical corrosion behaviour of two Ni-Cr-Mo casting dental alloys in Carter-Brugirard (AFNOR) artificial saliva enriced with xilina and cloramphenicol.

2. The linear polarization tests of both dental alloys highlighted the susceptibility to localized corrosion. Much more, the optoelectrono-microscopy technique, used to observe surface morphology, showed that both dental alloys were similarly corroded, since many craks deffects apeared on the dental alloys surfaces after linear polarization test in artificial saliva enriched with xilina and cloramphenicol.

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