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An *In-Vitro* Study, the Effect of Saliva on Structure, Surface Properties and Microbial Adhesion on Ni-Cr based Dental Alloy

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Abstract

Internal structure (phases and solubility atoms) for $Ni_{63}Cr_{24.6}Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy is changed after aging (stored) in saliva for a different time. Vickers hardness, maximum shear stress (m) and roughness parameters values for Ni-Cr based alloy are increased after aging in saliva. Microbiological investigation shows the *Candida spp*. stuck on the surface of Ni-Cr based dental alloy which reached the maximum value at four weeks. That is meant the growth of it dependent on aging time.

Keywords: Saliva, Structure; Hardness; Roughness parameters; Ni-Cr alloy

Introduction

In the medical industry due to financial motives the Ni-Cr or Co-Cr non-precious dental alloys are used because are they considerably cheaper, less density and high mechanical properties. In artificial saliva media, the Co-Cr alloys have less corrosion resistance compared to in Ni-Cr alloys [1]. In Afnor type artificial saliva, the chief parameters of the corrosion procedure from linear and cyclic polarization curves for five Ni-Cr or Co-Cr alloys are studied [2]. The corrosion behavior of Cr-Co and Cr-Ni alloys was studied after stored in distilled water, orange nectar, cola, artificial saliva and then compared it [3]. In acidic artificial saliva, (pH 5 at 37°C), the corrosion behavior for the Ni-Cr-Mo dental alloys was studied [4]. The corrosion parameters and passive film characteristics of Co- Cr, Ni-Cr and Cu-Ni-Al alloys and commercially titanium in artificial saliva medium were studied using Electrochemical impedance spectroscopy, Tafel polarization and cyclic polarization [5]. The Ag-Pd and Co-Cr alloys have slightly good corrosion resistance in artificial saliva and that appears from polarization curves and electrochemical impedance spectroscopy [6]. Morphologies change due to casting method has only fringe effect on the corrosion rate and corrosion resistance property for the Co-Cr alloy [7]. D Roachm report that the ratio of Cr and Mo in Co-Cr and Ni-Cr alloys is influenced by their electrochemical corrosion behavior [8]. El-Bediwi et al. showed that structure and surface properties such as hardness and roughness parameters of Co-Cr based alloy are changed after aging in saliva for different time [9]. The aim of this work is to study the aging effect for different interval time on structure, surface properties and bacterial adhesion for Ni-Cr based alloy.

Methods

The commercial $Ni_{63.09}Cr_{24.6}Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy, from Travagliato (BS)-Italy is used after re-melted and casting it in convenient shape for all tests. Shimadzu X-ray Diffractometer [(Dx-30, Japan) of Cu-Kα radiation with =1.54056 Å at 45 kV and 35 mA and Ni-filter in the angular range 2 ranging from 0 to 100 in continuous mode with a scan speed 5 deg/min] is used to study the structure (phases) of used alloys. Micro-hardness test of used specimens is conducted using a digital Vickers micro-hardness tester FM-7 from Tokyo, Japan by applying a load of 100 gm for 5 seconds via a Vickers diamond pyramid. The mean value of hardness is calculated by recorded ten measurements for each sample. Also surface roughness as behavior and parameters are measured by surftest S.J 201.P and Voltage Lab PGZ 100 instrument.

Results and Discussion

Structure

Figure 1 shows the diffraction patterns of $Ni_{63}Cr_{24.6}Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy before and after aging in normal pooled saliva for one, four and six weeks using x-ray diffractometer. The analysis of x-ray diffraction patterns shows that Ni- Cr alloy consists of gamma solid solution, (Ni-Cr), and Ni cubic phase. The shape (Intensity of the peak which indicated to the degree of crystallinity, broadness which indicated to crystal size and position which indicated to

orientation) of formed crystalline phases also changed after aging in normal saliva for 1, 4 and 6 weeks due to the chemical/or biological interaction of saliva with the alloy.

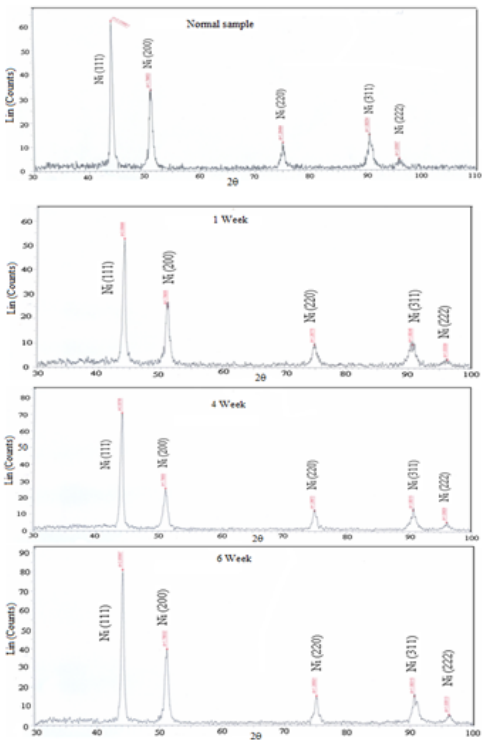

Figure 1: X-ray diffraction patterns for Ni- Cr alloy before and after aging in saliva.

Surface measurements

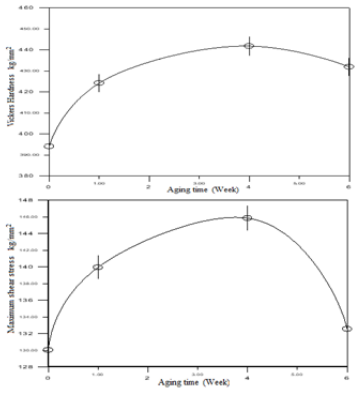

Figure 2: Vickers hardness and maximum shear stress of Ni-Cr alloy versus aging time.

Aging effect on hardness measurements for $NiCr_{24.6}Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy is studied using digital Vickers microhardness tester FM7 at a load of 100 g for 5 s. **Figure 2** shows Vickers hardness and maximum shear stress (τm) values for Ni-Cr alloy which increased after aging because chemical/or biological interaction of saliva with the alloy surface formed sub hard layers in it.

Figure 3a shows roughness profiles for $Ni_{63}Cr_{24.6}Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy before and after storing in saliva for different interval time. Also the average roughness parameter Ra is shown in **Figure 3b**. **Table 1** presented other roughness parameters for Ni-Cr dental alloy before and after stored in normal saliva for 1, 4 and 6 weeks which are increased because growth of bacterial and fungal formed cracks and pits after aging.

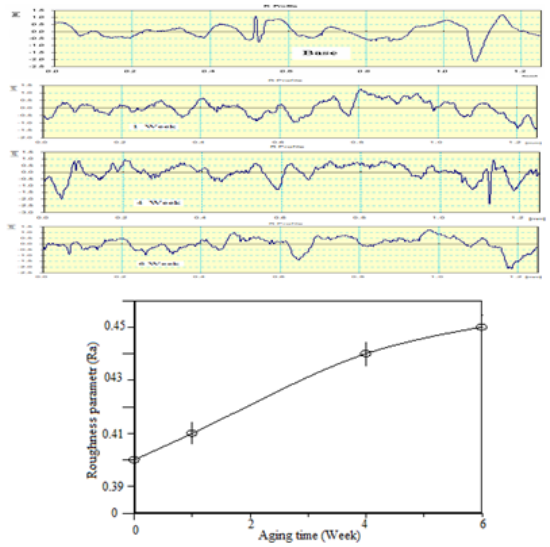

Figure 3: (a): Roughness profiles for Ni- Cr based alloy at different time; (b): The roughness parameter Ra for Ni-Cr alloy versus aging time.

Table 1: Roughness parameters of Ni-Cr alloy at different aging time.

Roughness parameters/μm	Aging time/week			
	Base	1	4	6
Rz	1.81	1.61	2.23	2.02
Rq	0.49	0.48	0.55	0.56
Rt	3.35	2.72	3.33	3.44
Rp	0.86	0.72	0.85	0.89

Microbiological examination

Microbiological examination, importance and explanation for $Ni_{63}Cr_{24}.6Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy after stored in regular pooled saliva from a pool of ten equal samples from apparently healthy individuals for one, four and six weeks at 37°C is studied. The microbiological investigation exposed the *Candida spp*. stuck on the alloy surface. **Figure 4** shows the optical micrographs of $Ni_{63}Cr_{24.6}Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy before and after aging. The investigation shows the growth of

Candida spp. at four weeks is more than one week. That is meant *Candida spp*. growth dependent on aging time.

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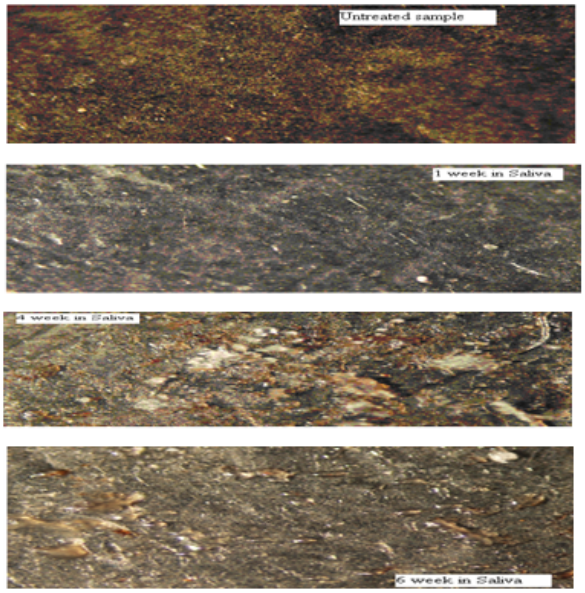

Figure 4: *Candida spp.* growth on the Ni-Cr alloy surface.

Conclusion

Structure (Formed phases), surface parameters and *Candida spp.* of $Ni_{63}Cr_{24.6}Mo_{10.77}Si_{1.50}Mn_{0.03}C_{0.01}$ alloy are changed after stored in saliva for a different time.

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