

SEM investigation on a Ni-Cr-Mo dental alloy subjected to electrochemical corrosion in an artificial environment

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Abstract. Corrosion consists in the degradation of a material under the chemical or electrochemical action of the environment where it is located. The investigations performed aimed to highlight the structural modifications produced within the Ni-Cr-Mo alloy of Ugirex III type (Ugin dentaire, France) subjected to electrochemical corrosion in Fusayama-Mayer artificial saliva. The surfaces of the specimens subjected to experimental tests were analysed structurally by scanning electron microscopy (SEM).

1. Introduction

In dental medicine metals and alloys have acquired a large usage in the making of prosthetic restorations as they are selected by the dentist according to the chemical reactivity and the biological integration determined in time. The quality of a material highlighted through the set of properties it has helps the dentist correctly choose a product.

The first non-noble alloys that were used in the metal-ceramic technique contained chemical elements in their composition such as cobalt, chrome, iron, nickel and other metals. Non-noble alloys exhibit a lower resistance to corrosion than the noble alloys but they have a higher hardness an elasticity module, lower fluidity and the mechanical processing is harder to perform.

Corrosion consists in the degradation of a material under the chemical or electrochemical action of the environment where it is located. Among the main failure causes of fixed restorations we may mention the degradation by corrosion of the metals and alloys, their mechanical wear, etc. [1, 2, 3, 4].

Specialized studies have shown that the nature of the corrosion products solubilized from the dental alloys into the gum tissues adjacent to restorations depends on the chemical component of the alloy, the resistance to corrosion [5, 6, 7], the structure formed during casting, the mechanical properties and the subsequent burning protocols [8, 9].

2. Paper goal

The goal of this study consists in the determination of the structural modifications occurred within the Ni-Cr-Mo alloy of Ugirex III type (Ugin dentaire, France) resulted following the electrochemical corrosion tests in Fusayama-Mayer artificial saliva.



3. Material and method

The semi-finished materials from the dental non-noble alloy for this study were purchased from the manufacturing companies, they having the values of the chemical composition and the physical and chemical properties according to the product's technical sheets.

For our experimental researches we made our own specimens of a cylinder shape from the material mentioned above that were mounted on Teflon holders.

The specimens prepared this way were analysed structurally. For this purpose we used a scanning electron microscope. Then, they were subjected to the electrochemical corrosion tests in Fusayama-Mayer artificial saliva (table 1). To identify the structural modifications occurred within the alloy following the corrosion process, we repeated the microscopy tests.

Table 1. Electrolytic solution of artificial saliva for electrochemical corrosion tests.

Artificial saliva / Compounds	NaCl g/l	KCl g/l	NaHCO ₃ g/l	Urea g/l	CaCl ₂ g/l	NaH ₂ PO ₄ H ₂ O g/l	Na ₂ S g/l
Fusayama	0.4	0.4	0.69	1	0.65	0.69	0.05

The pH characteristic was measured by means of a multi-parameter analyser of CONSORT 831C type and the actual pH value of Fusayama-Mayer saliva was 7.

4. Results and discussions

The (SEM) images obtained on the surfaces of the specimens from Ugirex III alloy (Ugin dentaire, France) in their initial phase are presented in figure 1.

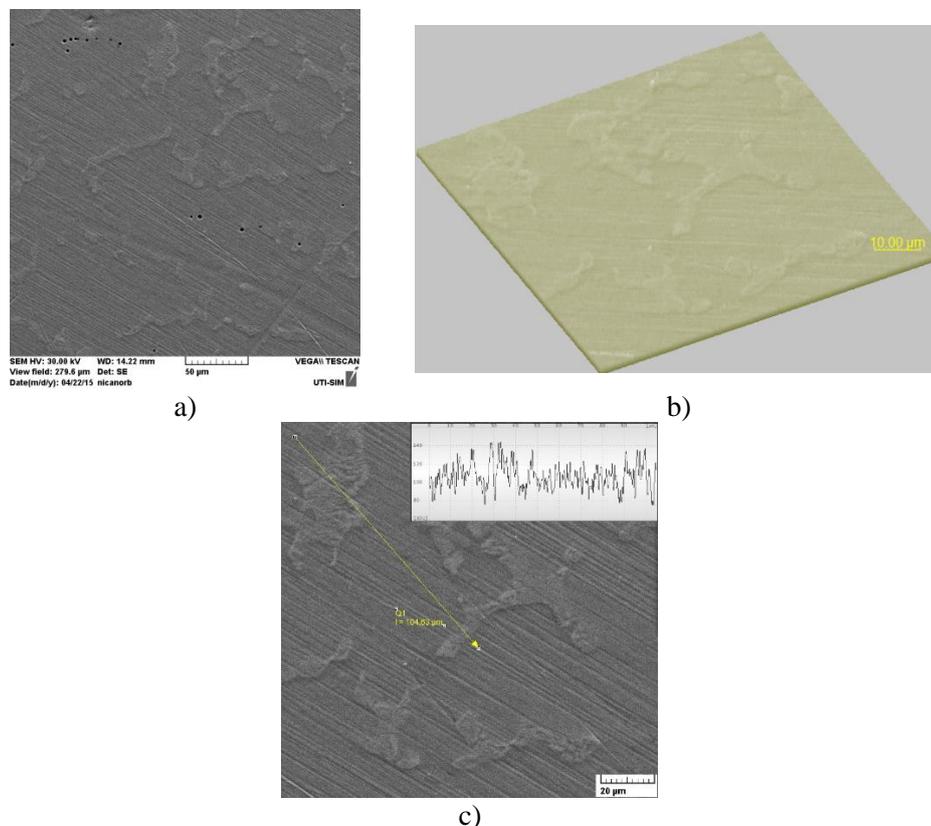


Figure 1. SEM microscopies of Ugirex alloy before the electrochemical corrosion test a) 2D image, b) 3D image and c) variation of light intensity at surface level.

The analysis of these images shows the existence of a monophasic matrix having a dendritic aspect. In the spaces between dendrites there may be particles of inter-metal compounds that may produce a pronounced increase of hardness at the level of the dendritic formations.

On the surface of the analysed samples we could see pores of 1-2 μm . the formation of pores is the result of the casting and plastic deformation processes of the alloy under study.

As for the variation of light intensity at the level of the sample surface, it has a uniform character with values between 50 and 60 ADU.

After they were subjected to the electrochemical corrosion tests in solution of Fusayama-Mayer artificial saliva, the surface of samples was analysed by microscopy (SEM), figure 2.

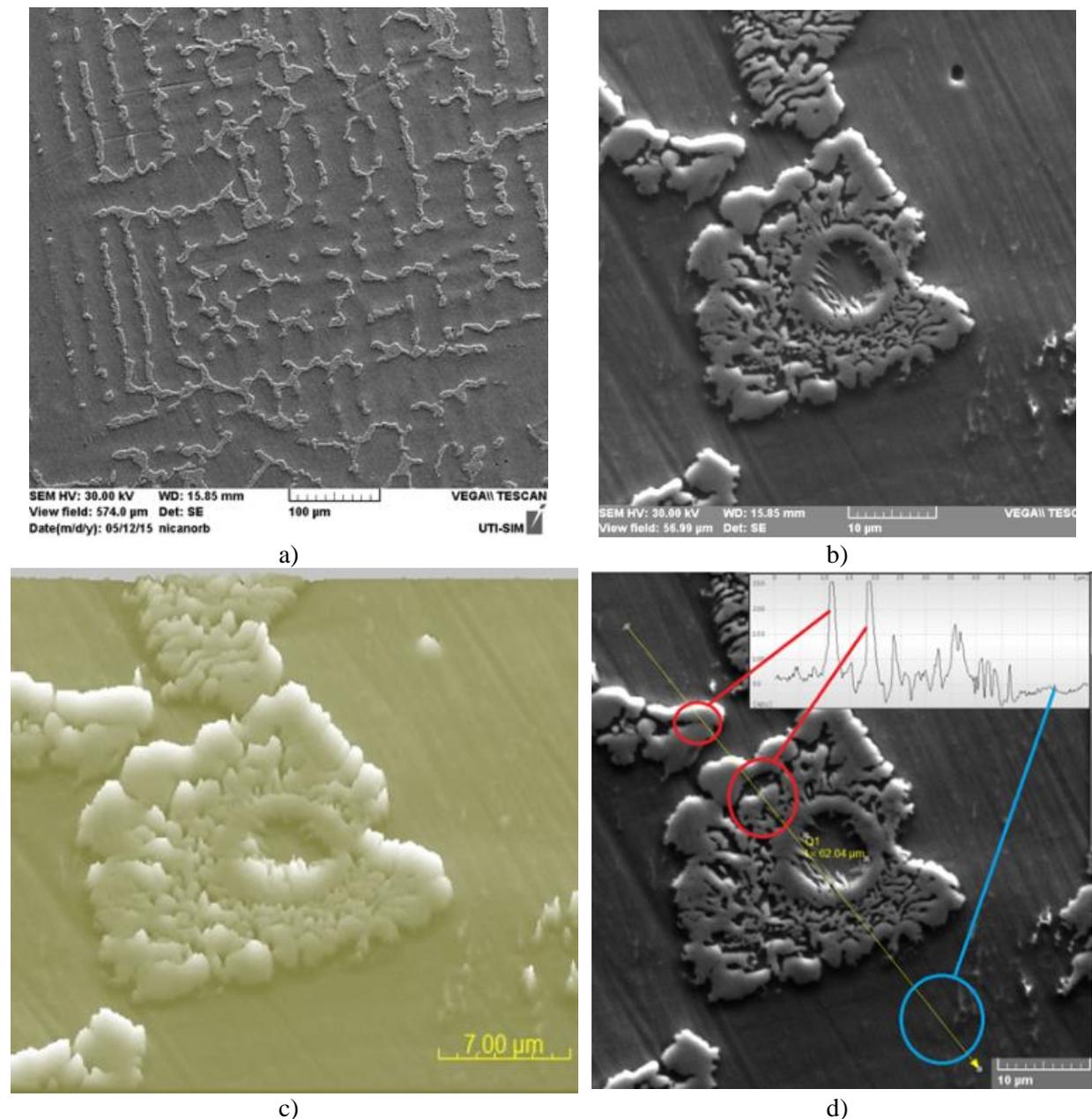


Figure 2. Images of Ugirex alloy surface after the corrosion test: a) 2D image (500:1), b) 2D image – (5000:1), c) 3D image and d) variation of light intensity at surface level.

The running of electrochemical corrosion tests had an effect similar to the attack of the metal surface by a chemical reagent. The final structural characteristics of Ugirex III alloy (Ugin dentaire, France), and some particular aspects resulted as an effect of the electrochemical processes are shown.

We consider that the microstructure is made of monophasic metal matrix having a dendritic aspect. Due to the very low hardness, the corrosion phenomenon primarily affected the matrix as small craters due to material extractions similar to the “pitting” phenomenon. The areas having a dendritic structure have a pronounced hardness and they are less affected by electrochemical corrosion.

From the viewpoint of variation of the light intensity, we may notice clear differences between the values registered for this parameter in the areas of corroded metal matrix (below 50 ADU) and in the areas having a dendritic structure (about 200 ADU).

At the level of the surface subjected to electrochemical corrosion tests, the presence of initial pores resulted following the technological processing is maintained even if the sizes of some of them were affected by the corrosion process.

5. Conclusions

We studied the behavior to electrochemical corrosion of a non-noble Ni-Cr-Mo dental alloy of Ugirex III type (Ugin dentaire, France) used for fixed dental prosthetics.

The tests were run in a solution of Fusayama-Mayer artificial saliva having the pH=7.

We performed investigations via electron microscopy (SEM) of the surfaces of the metal samples in initial state and after the electrochemical corrosion tests.

The initial microstructure is made of a monophasic matrix having a dendritic aspect at the level of which we may see pores resulted following the technological processing processes.

The corrosion tests affected the light intensity of the sample surfaces (especially in the area of monophasic matrix) and they facilitated the appearance of some “craters” following the extractions of the material.

6. References

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