THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
Nº. 3 - 2015, ISSN 1453 – 083X

RESEARCH ON THE BEHAVIOUR OF THE TOOTH - CROWN ASSEMBLIES MADE OF DIFFERENT METAL MATERIALS IN SOLUTIONS SIMULATING THE ORAL ENVIRONMENT

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ABSTRACT

One of the basic principles of restorative dentistry is the conservation of the hard dental structure, while satisfying both aesthetic and functional requirements. Complying with this principle will minimize the harmful effects caused by the diversity of works and materials. There are numerous studies that aim to determine the behavior of different types of materials in the complex environment of the oral cavity, but a small number are those that relate to the changes that occur in the underlying dental hard tissues represented by dental abutments. Experiments were performed on extracted teeth prepared by grinding. On the polished abutments, crowns of three alloy types were made, namely: Cr- Co, Cr-Ni, and copper alloys. The crowns were cemented onto the abutments with a glass ionomer cement and subsequently immersed and maintained in solutions simulating the specific conditions of an oral environment (also called artificial saliva) of the type: Ringer Fusayama-Mayer and citric acid. After a period of six months, the ablation of crowns was achieved and comments were made on the changes in the abutments and also in the crown envelopes.

KEYWORDS: hard dental tissue, dental alloy, artificial saliva, metal crowns

1. Introduction

Progress over time in restorative dentistry art and science can be largely attributed to the dynamics of materials development and evaluation of interaction between material and oral tissues [2, 3, 6]. Numerous research studies are focused generally on the knowledge and enhancement of physical, chemical and mechanical properties of the dental materials, but how they interact with the environment of the oral cavity has yet many unknown aspects. The fixed prostheses, so-called connectives, play a role in the reconstruction of the affected dental crowns and in the replacement of a limited number of absent teeth [3-5].

They are secured by cementing them to the abutments, previously processed by grinding, and are made from metal, acrylics, ceramics or mixed materials.

Micro prostheses of crown cover (envelope) type are all made of materials using different technologies and techniques; the non- physiognomic metal prostheses are made of different alloys and the metallic or physiognomic ones are made of ceramic, composite materials or acrylic resins [14]. Mixed crowns [11, 12, 14-16, 18, 19] combine the advantages of both materials, are the most often used and, depending on the veneering material, can be metal-ceramic, metal-composite, metal-acrylic or made of ceramic on zirconium support.

The dentist choses between a restorative prosthesis or another, depending on the type of restoration. Moreover, from his dental practice, the dentist notices that there is a significant difference in the macroscopic appearance of the dental hard tissues in different patients, even when prosthetic restoration was done with the same material and at the same time [6, 7, 11].

By removing the prosthetic work, it can be clinically seen that sometimes weaker materials in terms of their general characteristics, such as copper based alloys or acrylic resins, have a greater influence on the dental abutments than others. Therefore, there is the question of taking into account both issues such as the preparation, marginal closing or the type of cement chosen as major factors responsible for the success of prosthetic restorations [12, 19]. Studies on the behavior of different types of metal materials in

the complex environment of the oral cavity are considering how salivary pH requires choosing a particular material for restoration [17, 20]. On the other hand, there are a lot of clinicians, and they should be paid attention to, who noticed that after the ablation of partially fixed dentures, the hard dental structures were affected, putting it on account of the material the prosthetics is made of.

2. Materials and experimental conditions

We used prosthetic restoration materials commonly used for coronary restoration by envelope micro prosthesis restoration. The study conducted over a period of 6 months sought to identify changes in the morphological aspect of the dental hard tissues and alloys in the metal parts under the influence of the oral environment.

Extracted natural teeth were prepared by grinding. After preparing the abutments, metallic crowns (Table 1) were cemented to the abutments and the assembly was then immersed into three types of artificial saliva. After a period of 6 months since the cementing, the crowns were removed and the changes were studied. The morphologic appearance and the surface details of the dental structures and crown envelopes were highlighted using stereo microscope AxioCam ERC5s [6, 7] and microscopy analysis.

Table 1. *Chemical composition of the alloys studied [%]*

Chemical Composition / Alloy	Ni	Cr	Mo	Si	Fe	Cu	Al	Mn	Zn
Ni-Cr (Niadur)	58-64	22-27	10 -12	1.6-2	1.4-1.6	-	-	-	-
Cu alloy (Orcast)	4.5	-	-	-	3	81.5	7	2	2

3. Experimental results and discussion

Microstructural aspects of the alloys studied in their marketing type/state are shown in Figure 1.

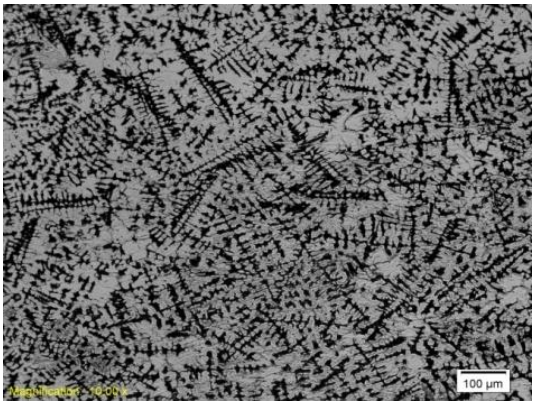
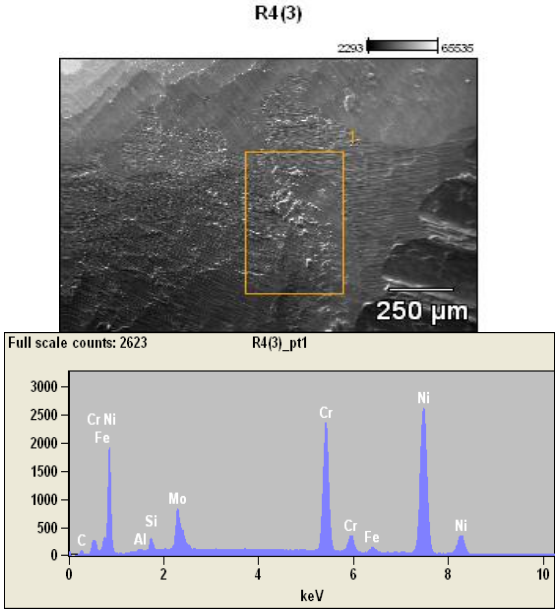


Fig. 1. *Microstructural Aspect of the Ni-Cr Alloy/Niadur (X100)* [6]



Weight %

Elements /R4(3)	C-K	Al-K	Si-K	**Cr-K**	Fe K	**Ni K**	Mo L
P. (1)	3,29	0,25	1.04	**24,78**	1,34	**61,91**	7,39

Fig. 2. *X-ray spectroscopic analysis of Ni-Cr Alloy (the marketing state / delivery conditions state)*

After grinding in the dental center**,** the teeth have been brought to the dental laboratory for the crown envelopes to be made. The abutments and crowns made of metallic materials are shown in the figure below (Fig. 4).

a. **b.**

Fig. 4. *The aspect of dental abutments after polishing and crown envelopes of Ni-Cr alloy(a) and copper based alloy(b)* [6]

For cementing purpose, the same type of cement was used, compatible for cementing all types of crowns, namely a glass ionomer, the most common type of cement used in dentistry due to its qualities in cementing metal crowns of Cr-Co, Cr-Ni and copper based alloys and nonmetallic ones of acrylic resin and zirconium oxide.

The ensemble represented by the teeth and metal crowns was immersed into solutions that simulate various conditions of the oral environment (artificial saliva prepared at the Dental Materials Laboratory of the Faculty of Medicine and Pharmacy of UDJ Galati) whose composition and pH are as follows [8]:

- **Saliva Riger (SR)**: pH of 6.6;
- **Saliva Fusayama Meyer (SFM)**: pH of 5.0;
- **Citric Acid (AC)**: 0.5 M $C_6H_8O_7$ (citric acid) with pH of 1.81.

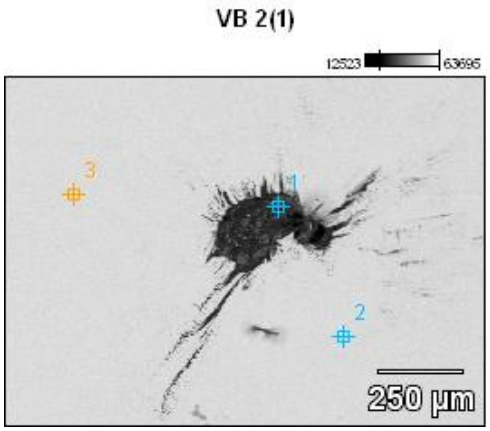
The teeth - crown assembly was maintained for 6 months in the saliva indicated above. The observation after the maintenance of the sediment indicates a slight disintegration, particularly in the citric acid solution. Incidentally, the largest amount of dissolved material derived from dental cement (and maybe from the dental tissue) was obtained as a white precipitate as a result of the chemical reactions between the solution and the components of the tooth - crown assembly occurring in the environment considered to be the most aggressive, namely the citric acid solution.

Discolouration is visible (shading), particularly with copper based alloys, and is higher in citric acid solution.

Fig. 5. *Tooth – crowns assembly after 6 months of maintenance in citric acid solution*

The main modification is the presence of cement film of variable thickness and aspect / consistency according to the type of artificial saliva and the type of crown shell/envelope.

EDS analysis (Fig. 6, 7) of the samples taken from crown envelopes reveals, especially in the case of the copper based alloys, the presence of impurities (mainly oxide inclusions) but they were also highlighted in the case of Ni-Cr or Co-Cr alloys, proof of the long presence of the alloy in contact with the atmosphere during the melting-casting operations.



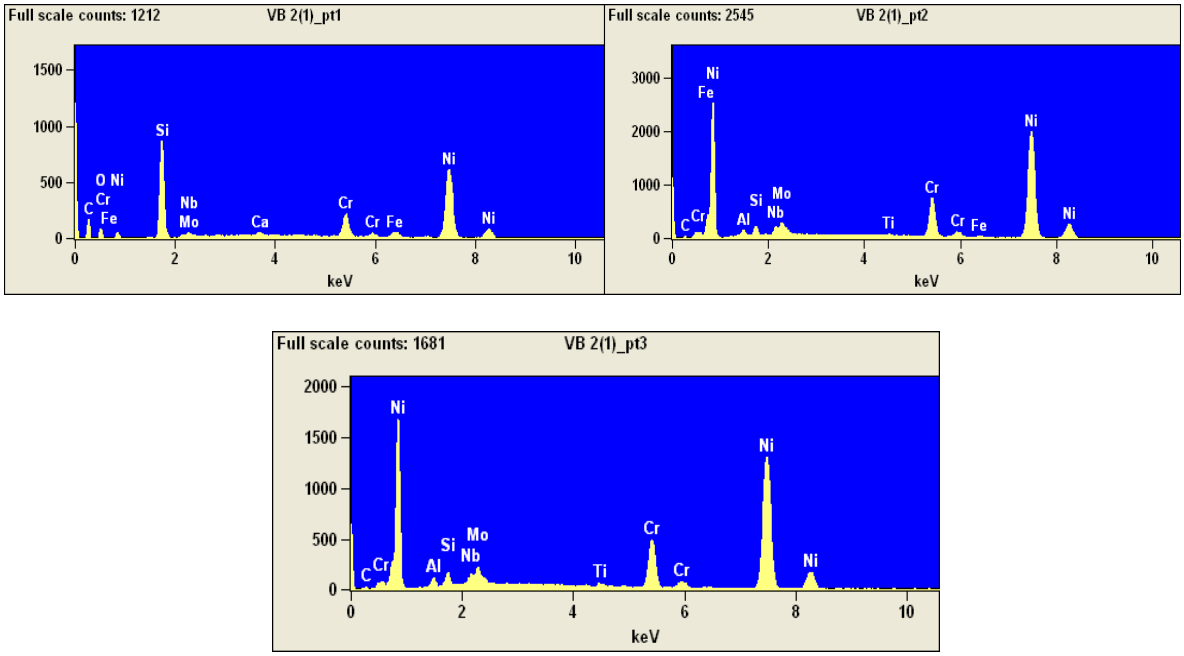
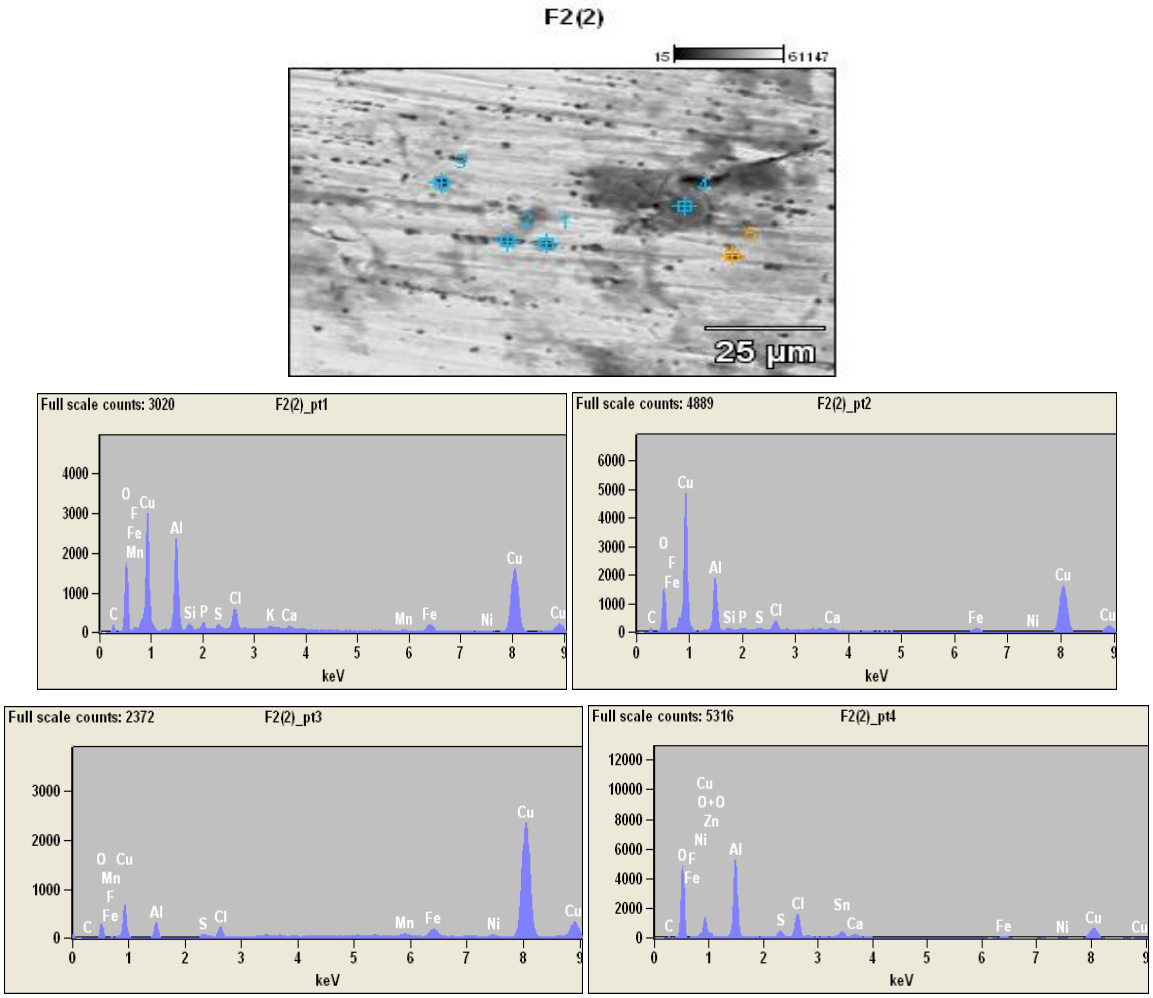


Fig. 6. *X-ray spectroscopic analysis of Ni-Cr Alloy (Samples of metal crown)* [11]



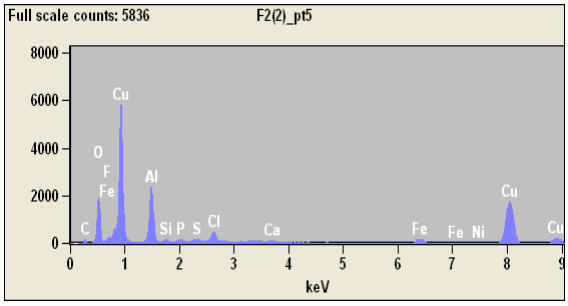


Fig.7. *X-ray spectroscopic analysis of the chemical composition of samples of Cu-alloy (Samples of metal crown)*

Table 2. *The chemical composition of the Copper Alloy, (%)*

F2(2)	C-K	O-K	F-K	Al-K	Si-K	P-K	S-K	Cl-K	K-K	Ca-K	Mn-K	Fe-K	Ni-K	Cu-K	Zn-K	As-K	Sn-L
_pt.1	6.49	28.69	0.26	10.48	0.72	0.70	0.39	2.19	0.48	0.43	0.37	2.23	0.66	45.92			
_pt.2	5.67	24.94	0.82	10.12	0.39	0.48	0.33	1.45	-	0.40	-	1.85	0.69	52.86			
_pt.3	1.33	6.31	0.11	2.57	-	-	0.37	0.86	-	-	0.65	2.52	0.96	84.33			
_pt.4	2.84	**51.45**	0.95	**15.05**	-	-	1.17	4.89	-	0.36	-	1.57	0.84	**16.20**	**0.84**	0.64	3.21
_pt.5	5.63	**26.74**	0.61	**10.88**	**0.32**	0.35	0.39	1.66	-	0.23	-	2.44	0.75	**49.99**	-		

There are also present microporosity and solidification shrinkage voids, casting system defects which are transmitted to the crown envelopes affecting its strength and the assembly as a whole.

EDX spectroscopy analysis (Fig. 6) shows high contents of oxygen, silicon and aluminum (Pt.1) in areas where the proportion of basic elements (Ni and Cr) decreases significantly. The analysis performed within the matrix indicates the initial composition of the alloy in the range indicated by the manufacturer (Pt.2 and pt.3)

4. Conclusions

The paper presents an important subject in restorative dentistry practice. The research studies made show the lack of rigor in the processing of the alloys, by highlighting defects (oxidation) that can affect the quality of conjunct fixed prostheses built from different metal materials. The study of changes recorded on the abutments under prosthetic bridges composed by crowns made from different alloys but also the metal crown, ended with the conclusive results that firstly confirm the influence of oral environment on materials (shading) and secondly the importance of respecting technological conditions of processing for achieving the metal component without defects. It was highlighted the different behavior of restoration materials under the influence of pH saliva (the most acid saliva determined accentuated color changes to metallic materials, particularly visible in copper alloys). EDX spectroscopy analysis on samples taken from the crown, from all alloys (but especially copper based alloys) confirms the presence of impurities (mainly oxides), proof of the long-standing contact with the atmosphere of the alloy during processing.

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