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CORROSION RESISTANCE OF DENTAL ALLOYS

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ABSTRACT
Metals and metallic alloys are unavoidable materials in everyday dental use for the making of fillings, cast cores and post systems, individual crowns, implantants' suprastructures, dentures and orthodontic devices. They still belong to the vital materials in dentistry. Applied alloys in a mouth are exposed to the influence of chemical, biological, mechanical, thermal and electrical forces which can have a negative impact on a very therapeutic work or surrounding tissue. Electrochemical corrosion is the most important damaging factor of dental works. The corrosive resistance of metal is its important characteristic during implantation into a mouth. Therefore precious alloys are the most suitable for dental use. However, due to economic reasons, nonprecious alloys are frequently used, while corrosive resistant precious metals have been used less frequently. Based on studying different literature, the purpose of this work was to give and overview of the existing dental metals and alloys in contexts with their anticorrosive characteristics.
Keywords: corrosion resistance, dental alloys

1. INTRODUCTION
Today a number of different alloys are used in dentistry for fillings, fixed and mobile prosthetic works, orthodontic devices and dental implants.
A combination of two or more dental alloys in the oral environment can react and form diverse compounds, which could lead to oral problems. Corrosion is one of the phenomena occurring in the oral environment [1].
In the oral environment, all materials (ceramics, metals, alloys, cement…) can react with the saliva and form different metallic, organic or mineral compounds. Saliva is more or less aggressive in relation to its composition and its pH, which varies during the day and from patient to patient.
Generally, precious metal alloys have a higher resistance to corrosion than non-precious metal alloys [2].
Applied alloys in a mouth are exposed to the influence of chemical, biological, mechanical, thermal and electrical forces. These forces have a negative effect on functional and esthetic characteristics of dental works and they substantially lessen their durability. Electrochemical corrosion is the most important damaging factor of dental works [3]. Corrosion is the unintentional wearing down of the metal surfaces, and damage to the outer and inner layers of their surface caused by exposure to chemical or electrochemical reaction of the surrounding area [4]. Electrolyte is needed for electrochemical reaction. Saliva, as well as soft and a hard tissue, has the role of electrolyte in the

mouth. Saliva is a media of strong corrosive affect. The corrosion potential of saliva increases as its pH factor decreases and as chloride concentration increases. Corrosion stops on the very surface by creation of a surface oxide layer which is good protection from further corrosion. Two different protective layers are formed in the mouth: an oxide layer and a biofilm.

Corrosion affects all materials and induces dissolution of materials, more or less significantly according to their resistance to corrosion. The material which is the least resistant will be more corroded because it is submitted to a higher electrical potential than its characteristic electrical potential. Indeed, when a metallic material is immersed in a conductive media, it is possible to measure its electrical potential.

If we dip one or more metals in the mouth, the metal tends to ionize. Because of the difference in alloy potentials, alloy ions tend to convert to electrolyte and by this action metal melts. By absorption of oxygen an oxide film is formed on the surface of the alloy which prevents further melting of the rest of the alloy's components.

Biofilm is a surface layer that covers all surfaces in the mouth, and is formed by precipitation of proteins and glycoproteins from saliva. Therefore, the corrosive endurance of dental alloys depends on the chemical component of saliva, first and foremostthe organic components [5]. Biofilm influences the ion conversion between the alloy surface and the surrounding area [6]. The most frequent is sulfide biofilm, which forms as a result of silver or copper sulfide formation.

In spite of the oxide layer and biofilm formation, corrosion in the mouth continues. Because of the constant circulation of saliva, melted ions react in contact with new saliva and alloy releases the new ones, which provoke further corrosion.

2. DENTAL ALLOYS AND CORROSION RESISTANCE

Due to economic reasons, non-precious dental alloys are used more frequently. These are mostly Co-Cr and Ni-Cr alloys which are considerably cheaper than gold. They have higher tensile strength, their modul of elasticity is higher and they have less density. The negative characteristics in comparison with precious alloys are: the higher melting point, harder to shape, higher loss of shine and inclination to oxidation and corrosion. Also, Ni alloys frequently provoke allergic reactions. Application of these alloys in the mouth results in discoloration, a metal taste and resorption of damaging corrosive products through the gastrointestinal tract. Messer and Lucas [7] investigated different nickel alloys. Some of the alloys showed a high inclination towards corrosion and cytotoxicity, although such results were not shown by all nickel alloys.

Pd is also an allergen. Pd-Cu alloys show allergic reactions, while such symptoms do not show with other Pd alloys. Berzins and co-workers confirmed clinical results by a higher tendency towards corrosion of Pd-Cu alloys than other Pd alloys [8].

Angellini [9] demonstrated on Pd dental alloys that identical alloys in the same corrosive media can show a different tendency to corrosion, depending on technical conditions, for instance temperature and melting duration, reheating, cooling period and so on. The presence of fluoride in saliva can also increase the tendency to corrosion. Guglielmino [10] showed that the presence of NaF in saliva does not change corrosive activity of Pd alloys, but increases the corrosion of titanium alloy.

2.1. Titanium

Due to its electrochemical characteristics, titanium, as the most biocompatible metal, is frequently used in modern dentistry-in implantation as well as in prosthetics [11]. Spectro-electrochemical researches of titanium alloys in vitro have showed the formation of quality protective oxide film on the alloy surfaces. Comparing the stability of titanium in different corrosive baths, with the results obtained with other alloys, the authors conclude that titanium has undoubtedly the highest corrosion resistance. However, in combination with different metals, it can form strong galvanic cells. Some authors belive that precious metals (An, Ag, Pd) in combination with titanium practically do not form galvanic currents, while in combination with Cr-Mo and Ni-Cr, weak galvanic currents are formed. In combination with Ni-Cr-Be these currents are important, so those alloys have to be avoided. Venugoplan, however, considers these currents as unimportant [12,13].

3. BIOCOMPATIBILITY AND CORROSIVE RESISTANCE

Alloy biocompatibility is closely linked with corrosive resistance. The damaging influence of alloy on the organism starts with the dissolving of its toxic components, which occurs as a result of corrosion [14-16].

Although many dental alloys do not have a high corrosive resistance compared to titanium, this does not mean that they should not be used. If one compares the toxic level of a certain element with the quantity that dissolves daily in the mouth as a result of corrosion, quite often one would have to wait for the whole crown to dissolve in order for a toxic dose to be released. Precious alloys can also be corrosive, although much less than the non precious ones.

Several investigations have attempted to find a solution on how to produce nonprecious alloys that are corrosively more stable in a chemically aggressive media [17,18]. By adding Pd and Au to an alloy, the corrosive resistance of Ag-Mn alloy is increased. By adding Pd to the same alloy the corrosive decrease is considerably greater than by adding Au [19]. Syverud and co-workers [20] showed in vitro that by adding Cu to a Pd alloy its corrosion increases, as well as its cytotoxicity. This is also proved by the clinical results of the appearance of gingivitis around the implanted alloy. Wataha and Lockwood [21] investigated the corrosion resistance of Au, Ag, Pd and Ni alloys, and proved that Au-Pd alloys have the highest corrosive resistance, while Au-Ag-Cu alloys have the lowest.

A higher level of corrosive resistance in nonprecious alloys could be achieved by covering them with protective layers [22-25].

4. ANTICORROSIVE PROTECTIVE FILMS AND DENTAL ALLOYS

Co-Cr alloys plated with a thin ZrO2 layer showed a considerable increase in corrosive resistance, as well as good quality of bonded hardness between the alloy and film, and for that reason they were recommended for widespread use. New, amorphous corrosive resistant alloys came on the market which could also be used for protection against dental alloys corrosion [26].

It is considered that by usage of such protective films, corrosive nonresistant non precious alloys could be satisfactory in replacing expensive precious alloys [27].

5. CONCLUSION

The corrosive resistance of metal is its important characteristic during implantation into a mouth. Therefore precious alloys are the most suitable for dental use. However, due to economic reasons, nonprecious alloys are frequently used. Because of its physical-chemical characteristics, titanium has been the material of choice during the implantation of nonprecious alloys. By plating nonprecious alloys with corrosive resistant alloys, the choice of implanted nonprecious alloy could also spread to other economic alloys.

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