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Advances in Electrochemical Corrosion of Metal Materials Used in Oral Prosthodontics

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Abstract

Oral cavity is an extremely complex electrolyte environment, and the metal corrosion in oral cavity is mainly electrochemical corrosion. Metal materials are the most commonly used materials in the field of dental prosthodontics, and the study of electrochemical corrosion of metal materials has always played a very important role in the field of dental prosthodontics and dental materials. Metal corrosion not only affects the quality and service life of the repair body, but also leads to adverse reactions. The electrochemical corrosion, ion precipitation and biological effects of metals are reviewed in this paper.

Keywords

Oral Repair; Metal Materials; Electrochemical Corrosion; Service Life; Ion Precipitation; Biological Effect.

1. Mechanism of Electrochemical Corrosion of Metals

Electrochemical corrosion is refers to the metal surface and the ion electrochemical reaction between conductive medium (electrolytes) that cause damage. Corrosion process occurs mainly on the interface between the metal and conductive medium. It is generally believed that corrosion starts from the surface of the metal. Once the oxide film on the metal surface is damaged by mechanical or chemical erosion, the corrosion speed of the metal will be accelerated and the degree of corrosion will be deepened[1]. In the process of electrochemical reaction, metal ions were precipitated at the anode, and the reaction process was as follows: M→M ++ NE -, while the reaction process at the cathode was as follows: O2+ 4E -+2H2O→4OH- in neutral or alkaline solution; In acidic solution, the reaction process is 2H++ 2E →H2↑, O2+4H++ 4E -→2H2O, so the electrochemical corrosion principle of metal is consistent with the reaction principle of galvanic cell[2].

2. Detection of Electrochemical Corrosion of Metals

After electrochemical experiments, scanning electron microscopy (SEM) can be used to observe the site, scope, morphology and types of corrosion on the surface of metal materials, as well as the occurrence process of corrosion of metal materials. When metal materials are corroded, pitting corrosion will occur at the beginning, and then initial corrosion fatigue cracks will be initiated at the grain boundary of corrosion. The cracks transform from intergranular to transgranular, and the main cracks will be formed, and their continuous expansion will lead to instability fracture of metal materials.

X-ray photoelectron spectroscopy (XPS) is a surface analysis method. Experiments are carried out on a photoelectron spectrometer. Its basic principle is the photoelectric effect, which can detect all elements except hydrogen. Provide important information on the composition and chemical states of various elements on the sample surface and oxide film. Because XPS usually contains chemical information, also known as chemical analysis electron spectroscopy, more advanced applications of XPS can yield more detailed information about the chemical composition of the material surface[3]

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and formation, with detection sensitivity up to 0.002 atomic layers. XPS can be combined with secondary ion mass spectrometer (SIMS) or Auger electron spectroscopy (AES) to study the composition of material surface, which can have high detection sensitivity and spatial resolution (up to 0.1μm), and even provide molecular information[4]. At present, element sensitivity factor method is mostly used in quantitative analysis of materials. This method uses spectral line intensity of a specific element as a reference standard to detect the relative spectral line intensity of other elements, and then obtain the relative content of each element. Most analytical methods use empirical calibration constants, the element sensitivity factors, derived from standard samples. For example, if the sensitivity factors of two elements I and J in a solid sample are known to be Si and Sj respectively, and their specific spectral line strengths Ii and Ij are detected, the ratio of their atomic concentrations is ni: Nj = Ii/ Si: Ij/ Sj.

3. Influencing Factors of Electrochemical Corrosion Behavior of Dental Metals

Through research, it is generally believed that the corrosion resistance of precious metals is better than that of non-precious metals[5]. Meerakker et al.[4]found that precious metals such as Au and Pd have the lowest sensitivity to corrosion reaction, while non-precious metals Ni-Cr-Be alloy has the highest sensitivity to corrosion, while co-Cr-Mo-Ni-Cr (excluding Be) and stainless steel have the sensitivity between the two.

Huang[6] analyzed the electrochemical corrosion behavior of six ni-Cr-Mo alloys with different components in acidic artificial saliva, and the results showed that the corrosion resistance of Ni-Cr-Mo alloy was related to the formation and composition of surface passivation film. After electrochemical treatment, the surface composition of the alloy was analyzed by XPS, including NiOH2, NiO, Cr2O3 and MoO3.

Cobalt chromium alloy compared with nickel chromium alloy, cobalt chromium alloy corrosion resistance is better, The good corrosion resistance of cobalt-Chromium alloy is due to the formation of an oxide film structure containing Cr-O and CroH on the surface of the alloy, which inhibits the precipitation of cobalt ions and chromium ions Khamis E et al.[7] found when studying the influence of metal elements in the alloy on its corrosion resistance: The alloy containing cobalt or platinum can significantly improve its corrosion resistance, and high temperature melting and repeated casting does not affect its corrosion resistance.

Sun et al.[8] pointed out in their study that the corrosion resistance of precious metals is relatively high, which is mainly due to two reasons: on the one hand, it contains a high content of precious metals, and on the other hand, the submicroscopic composition of precious metals is relatively stable.

The corrosion resistance of cast pure titanium titanium is superior, mainly because its surface is especially easy to form a layer of dense oxide film that can prevent the metal anodic dissolution process and firmly adhere to the metal surface. Its main ingredient is titanium dioxide, which forms even in acidic conditions.[9]Kuphasuk et al. [12]studied the electrochemical corrosion behavior of six titanium alloys in artificial saliva. The photoelectron diffraction spectra showed that tiO2-Ti-5Al-2.5Fe was covered on the surface of all titanium alloys after electrochemical experiments, and the oxide film formed on the alloy surface was mainly composed of the mixture of TiO2 and Ti9O17. The main composition of oxide film on NiTi alloy surface is the mixture of TiO2 and Ni2Ti4O.

4. Detection Method for Metal Ion Precipitation

At present, the detection methods of ion precipitation mainly include atomic absorption spectrometry, electrochemical method, atomic emission spectrometry and inductively coupled plasma spectrometry[10]. Aas can be divided into flame aAS, graphite furnace AAS and hydride generation AAS. It has the advantages of fast, sensitive, accurate, good selectivity, less interference and simple operation. It can quantitatively detect many metal elements and some non-metal elements, and its detection limit can reach 10-9 g /mL order of magnitude below[11]. Its principle is based on the radiation from the light source to produce the characteristic spectral line of the element to be measured,

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through the sample vapor is absorbed by the ground state electron of the element to be measured in the sample vapor, according to the degree of the radiation characteristic spectral line is weakened to detect the content of the element to be measured in the sample[12].

5. Expectation

At present, due to the improvement of living standards, people's awareness of oral health care is gradually strengthened, and patients' multiple prostheses will lead to the coexistence of two or even multiple metal prostheses in the oral cavity of many patients. Relevant clinical reports have found that patients with oral prostheses with multiple metal materials, Oral mucosal diseases, contact gingivitis, delayed hypersensitivity and other adverse reactions have a high probability of occurrence. The biological effects of metal ions precipitated from metal materials in oral prostheses have been paid much attention. Some scholars research report points out that the restoration of the precipitation of metal ions on oral mucosal cell and the distribution of the sample cell DNA damage and induce the apoptosis of role, people began to study at the molecular level of metal ions to stimulate the reaction mechanism of action of poor oral tissue cells, the research remains to be further research.

To sum up, domestic and foreign studies on the products of electrochemical corrosion between implants and the upper repair structure in different environments have not been completely concluded, and the biological effects of the products need further study.

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