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The comparison of the corrosion resistance of advanced ferritic stainless steels by Mott-Schottky approach

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Abstract – Ferromagnetic stainless steels (SS) have been investigated as potential candidates for dental prosthesis applications in replacement of magnetic attachments made of noble and expensive alloys. In order to be used as biomaterials, their corrosion resistance has to be appropriate. The corrosion resistance of passive materials is related to the characteristics of the passive film formed and this property might be investigated by Mott-Schottky procedure. The capacitance of passive films formed during 2 days of immersion in a Phosphate Buffered Solution (PBS), at room temperature on PM2000, DIN 1.4575 and 17-4 PH ferritic stainless steels (SS) was studied by Mott-Schottky approach. A commercial alloy was also analyzed for comparison reasons. The results showed that films on tested materials behave as both, n-type and p-type semiconductors and the PM2000 presented the highest corrosion resistance among all materials studied.

Prosthesis retained by magnets play an important role in dental implants applications [1], such as dental combination prosthesis [2], and orofacial prosthesis [3]. The magnetic force necessary for retaining dental prosthesis can be obtained by use of a small magnet and ferromagnetic attachment. This attachment is mainly made of noble alloys as EFM alloy or special soft magnetic stainless steels (SS) of high production costs. The replacement of the EFM alloy by other more economical SS is of great importance and ferromagnetic materials have been tested as potential alternatives. PM 2000 is one of the potential candidates. This is produced by mechanical alloying and presents high corrosion resistance being used in high temperature applications. 17-4 PH is a precipitation hardenable martensitic SS manufactured by powder injection, a net-shape forming process with the advantage of shape complexity and high final density, commercially used in orthodontical brackets. The high corrosion performance DIN 1.4575 ferritic stainless steel is commonly used in chemical, paper and desalinization industries. The phase precipitation behavior of this stainless steel has been largely investigated and its possible utilization as biomaterial has been already proposed. In this study, the passive behavior of these alloys was compared to that of the commercial EFM alloy. The samples were immersed in phosphate buffer solution (PBS) naturally aerated, at room temperature and pH 7 and the Mott-Schottky diagrams were taken after 2 days of immersion.

The results showed that the passive films formed on all SS analyzed behave as n-type, above the flat band potential, and p-type semiconductors, below the flat band potential. These results confirm the duplex character of the passive films formed on the SS surface, being the film formed on chromium, a p-type, and the iron oxides, an n-type semiconductor. The Mott-Schottky approach also shows the doping density (number of donors and acceptors) of the passive films. Smaller the doping density, higher is the corrosion resistance of the material. According to Table 1, the passive films formed on all SS studied in this work have smaller doping density than the commercial EFM alloy. However, the PM2000 has the smallest number.

Table 1: The doping densities of the passive films formed on 17-4 PH, DIN 1.4575 and PM2000 SS surfaces. The doping density of the EFM alloy is shown for comparison.

Material	Donors (cm^{-3})	Acceptors (cm^{-3})
17- 4 PH	7.25 E+19	6.36 E+18
DIN 14575	1.05 E+20	3.16 E+18
PM 2000	6.51 E+17	2.16 E+18
EFM alloy	-	1.01 E+20

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