

## EXTRACTION OF PLASMA SPRAYED TITANIUM THROUGH A BONE CEMENT USING ELECTROCHEMICAL TECHNIQUES.

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**Introduction:** Titanium and titanium alloys are widely used as orthopedic implants because of their favorable mechanical properties and good biocompatibility. However, some specific cases are known, where highly loaded cemented implants made from Ti alloys produced unsatisfactory results in clinical practise (e.g. 1). Prior *in-vitro* experiments showed that micromotion alone could not explain debonding and osteolysis reported for such cemented implants (2). Electrochemical test on samples of cement + titanium revealed the ability of the polymer to transport electrical charges in the polymer – metal interface (3).

The cement is an ionic conductor and therefore participates in the corrosion process. The corrosion phenomenon is in this case accompanied by titanium cation diffusion into the electrolyte and chloride anions towards the titanium through the cement. In the present study, we have evaluated the corrosion behavior of titanium vacuum plasma spray coating (Ti VPS) with and without bone cement. Electrochemical extraction tests were carried out, with ICP-MS analysis of the electrolyte, in order to verify the ionic permeability of the polymer.

**Materials and methods :** A layer of CEMEX® bone cement, approximately 0.9 mm thick, was manually pressed onto Ti VPS sample discs of diameter 11 mm.

The quantities of titanium in the electrolyte, extracted from the samples by cyclic and potentiostatic voltametry, were determined by the technique of ICP-MS.

After the tests, we eliminated part of the cement on the disc to check for the presence of chloride ions using EDX analysis.

**Results and discussion :** Figure 1 shows the sweeping curves corresponding to the first and last (#48) cycle recorded during cyclic. The measured current is of the order of a few hundred nano-amperes.

For the second technique used are displayed in Figure 2 the potentiostatic curves of the ten cycles at 650 mV SCE.

The concentrations of titanium cations found in the electrolyte by ICP-MS were smaller than 0.5 µg/L in both tests.

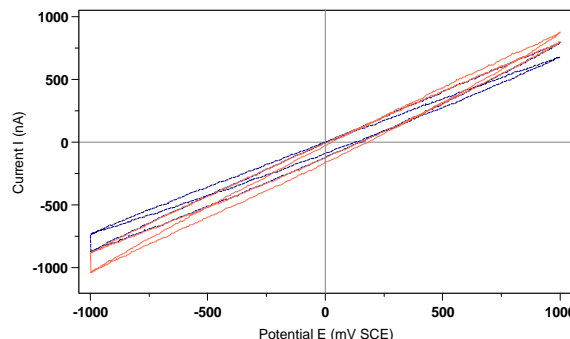


Fig.1 Potentiodynamic curves obtained by the cyclic voltametry technique. First cycle and the last, # 48 .

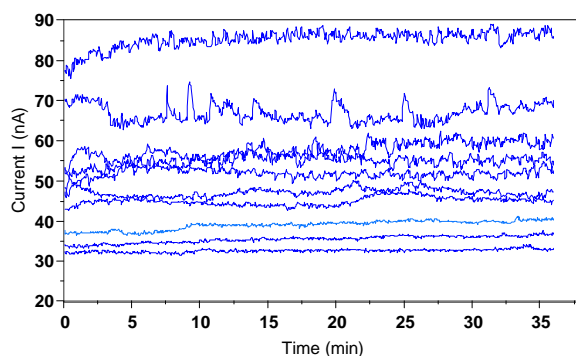


Fig. 2 Potentiostatic curves recorded during 36 minutes, number of cycles, 10 / level

The total quantity of charge recorded during the extraction test was 6106, 6 °C. Based on Faraday's law, which assumes that all the measured electrical charge is used to extricate the  $Ti^{2+}$  cations from the disc sample through the membrane of bone cement into the electrolyte, we expect a theoretical quantity of 1.515 µg of titanium in the solution, corresponding to a titanium concentration of 75µg/liter. This theoretical concentration by far exceeds the measured quantities of less than 0.5 µg/liter. This indicates that most of the electrical charges are consumed in the cement by other ions (sodium and chloride), and probably also by the growth of the titanium oxide layer. After the extraction test, we find indeed chloride ions on the surface of the sample disc using EDX analysis.

The presence of titanium in the solution and of chloride on the sample surface confirms the suggested transfer mechanism (Fig.3).

**Conclusion:** From our results we conclude that the bone cement is permeable for titanium cations, leading to a corrosion process of the titanium underneath the cement. The corrosion process comprises the formation of titanium cations as well as the growth of the titanium oxide layer.

**References:**

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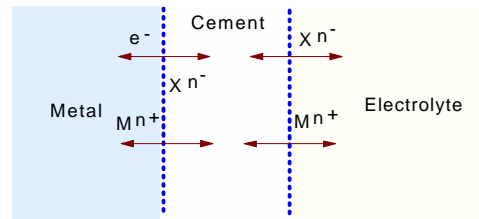


Fig. 3 Schematic representation of the exchange process between the metal - cement – electrolyte.