

CHARACTERISTICS AND POTENTIAL OF THE ANODIC PLASMA-CHEMICAL TREATMENT OF TITANIUM IMPLANT SURFACES

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INTRODUCTION: Anodic plasma-chemical treatment (APC) of valve metals is a cost-effective process to modify surface topography and chemistry in a single coating step¹. The technique is suitable for coating complex three-dimensional devices and therefore an interesting alternative to conventional surface modification processes for titanium implants². The project aims at developing a composite calcium phosphate/titania coating in order to accelerate the ongrowth of bone tissue on the titanium implant surface. The surface coating process presented in this paper is based on a calcium- and phosphate-containing electrolyte at high pH stabilized by organic chelating agents. The resulting coating contains partially soluble, amorphous calcium phosphate phases embedded in a titanium oxide matrix with crystalline anatase components.

METHODS: CP titanium samples (disc-shaped, diameter: 15 mm, thickness: 1 mm) or medical implants are ultra-sonically cleaned in acetone for 20 minutes, rinsed with acetone, dried in air, etched in 2%HF / 10%HNO₃ for 2 minutes, subsequently rinsed with u. p. water and dried in air.

The samples are plasma-anodized galvanostatically (between 100 and 500 mA) in aqueous electrolytes for 90 seconds. The electrolyte contains Ca²⁺, PO₄³⁻, EDTA as chelating agent and sodium hydroxide to adjust the pH of the solution (EP 1 372 749). All chemicals are high purity grade and supplied by Fluka, Buchs, Switzerland. After coating, the samples are rinsed with u. p. water and dried in air.

The resulting surfaces are tested by standard surface analysis techniques as well as for their bio-performance.

RESULTS: Table 1 shows the dependence of the calcium-to-phosphate ratio in the coating on the pH of the electrolyte solution. This ratio increases with increasing pH. Fig. 1 shows two different surface topographies achieved by coating at different current densities. Dissolution experiments in a model electrolyte demonstrate the partial solubility of calcium and phosphate. No disadvantageous biological reactions could be found in cell and animal studies.

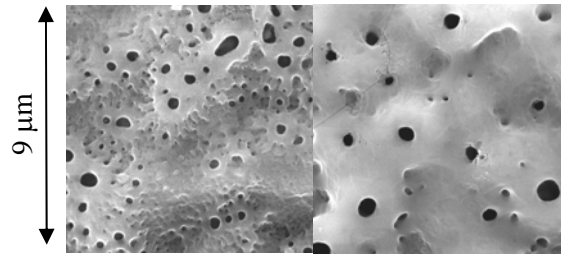


Fig. 1: Effect of current density on the topography of the coating. Low density (left), high density (right).

Table 1. XPS Ca/P-ratio [at%/at%] in the APC coating as function of pH in the electrolyte solution.

pH	6	11	14
Ca/P-ratio	0.6	0.7	1.3

DISCUSSION & CONCLUSIONS: The new high pH electrolyte system containing organic chelating agents allows us to produce coatings with substantial (>10 at%) proportions of calcium phosphate at high calcium-to-phosphate ratios. The dissolution experiments indicate that calcium and phosphate are partially dissolved without a major effect on the integrity of the anatase-based coating matrix. The animal studies showed the good biocompatibility and good ongrowth of bone tissue onto the APC-surfaces.

REFERENCES: ¹ G. P. Wirtz, S. D. Brown, W. M. Kriven (1991) *Materials & Manufacturing Processes* **6**:87-115. ²J. P. Schreckenbach, G. Marx, F. Schlottig et al. (1999) *J. Mater. Sci.-Mater. Med.***10**: 453-457.

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