Characteristics and Biological Responses of Novel Coatings Containing Strontium by Micro-Arc Oxidation

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1.Abstract

The micro-arc oxidation (MAO) is an effective method to improve biocompatibility of titanium. This study aimed to investigate the coatings containing different contents of strontium. The physicochemical characteristics and cell behavior were assessed. The results indicate that strontium incorporated into MAO coatings did not change the physicochemical characteristics but exhibited an effect on biological responses.

2.Introduction

Titanium and its alloys are widely used in dental and orthopedic fields. The MAO process is easily control the coatings properties to improve the metal surface properties. Recently, strontium-substituted calcium phosphates have been developed. It is known that strontium is beneficial for biological applications for bone regeneration due to the strontium ranelate [1]. It was seldom reported about the strontium-containing coating on the surface of metal substrate. This study is to prepare titanium oxide coatings containing strontium, calcium, and phosphorus on the titanium surface by MAO. The biological properties were evaluated by *in vitro* tests, in term of the cell morphology and cell proliferation.

3.Materials and Methods

Medical grade titanium (CP-Ti, Grade 2, ASTM F-67, S-Tech, Tainan, Taiwan) was selected as substrate. The MAO coatings were constructed in a two-electrode electrochemical cell. The samples were treated with applied voltage at 350 V for 1 min. The physicochemical characteristics were evaluated by thin film X-ray diffraction (TF-XRD), scanning electron microscopy (SEM), energy dispersive X-ray spectrometer (EDX), and surfcorder. Cell behaviors of human fetal osteoblastic cells (hFOB) were assessed by MTT assay and cell morphology.

4.Result and Discussion

By SEM observation, Fig. 1 shows the MAO coatings morphology. The rough and three-dimensional structures with open pores were observed on the four kinds of specimens. The similar average pore size, 1.04 μm in diameter, was observed at the surface of four kinds of specimens. The surface roughness is indicated that the average roughness was sub-micron meter level in all specimens surface. The EDX indicated that the strontium element in electrolytes can incorporate into MAO coatings. The cross-sectional morphology of MAO coatings was uniformly and continuously formed on surface of substrate. The XRD patterns of specimens showed the three kinds of phases, anatase (TiO_2), rutile (TiO_2), and titanium. Although strontium, calcium, and phosphorus are TF-XRD undetectable in MAO coatings, it could be inferred to titanium oxide composition containing Ca-Sr-P-O amorphous phase.

Fig. 2 shows the effect of strontium content on the viability of hFOB cells after culturing for 1, 7 and 14 days, respectively. The increases in cell number were found for all kinds of specimens from 1 to 14 days. It was reported that low concentrations of strontium have been shown to stimulate bone formation, but high concentrations have deleterious effects on bone mineralization [2]. After 1 h of culture, the cell morphologies on MAO coatings containing different contents of strontium results indicated that the effect of strontium content did not influence the initial cell attachment.

5.Conclusions

In this study, the various electrolytes have been applied to produce coatings with Sr-Ca-P phase embedded in the TiO_2 matrix. By TF-XRD analysis, anatase and rutile phases were identified in four kinds of MAO coatings. The average thickness of all MAO coatings is form 3.74 to 3.79 μm, and the surface roughness of all specimens is from 0.31 to 0.34 μm. *In vitro* test, cell morphology was not significant influence with the MAO coatings containing different contents of strontium, but MAO coatings containing low strontium contents provided a preferential surface for cell proliferation. Consequently, the optimal content of strontium in MAO coatings should be studied *in vivo*.

References

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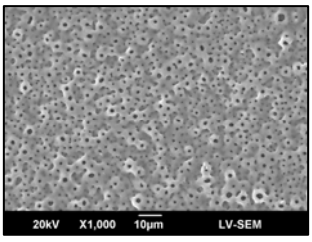

Fig. 1 The MAO coatings containing Sr 1% morphology.

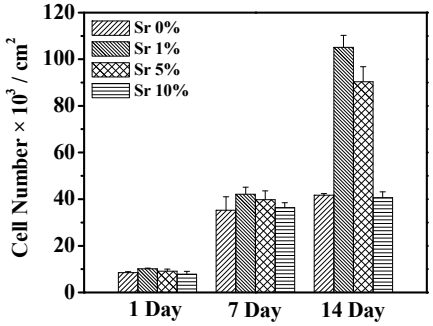

Fig. 2 The cell proliferation assay of MAO coatings.