STUDY ON THE PERFORMANCE ENHANCEMENT OF BIOMEDICAL IMPLANTS: *IN VITRO* TEST UNDER UV IRRADIATION OF TITANIUM ANODISED IN MIXED ELECTROLYTE

SALEH S SALEH ELFALLAH

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ABSTRACT

Titanium (Ti) recently has widely been used in the biomedical applications due to its high performance. Therefore, surface modifications of titanium have attracted a lot of interest to provide better osseointegration. Ti was subjected to anodic oxidation process and *in vitro* testing to assess the bioactivity of titanium oxide (TiO_2) coating. TiO_2 coating has been anodised at room temperature in different electrolyte; in sulphuric acid (H_2SO_4); phosphoric acid (H_3PO_4); and a mixture of H_2SO_4 and H_3PO_4 acids. The parameters used in anodization were: concentration of the electrolytes, applied voltage and current density. The coated surface is then evaluated using different testing techniques; the microstructure using scanning electron microscope (SEM); the elemental analysis using Energy-dispersive x-ray spectroscopy (EDX); mineralogical and crystal structure using x-ray diffraction (XRD); absorption analysis using Fourier transform infrared spectroscopy (FT-IR); and the hydrophilicity using water contact angle (WCA). TiO_2 was then subjected *in vitro* testing to assess the bioactivity of TiO_2 surface; that is the apatite formation ability. The apatite formation of the TiO_2 coating was precipitated by using simulated body fluid (SBF) in the dark and under the ultraviolet (UV) irradiation to mimic the reactions that may occur with the human bone-like cells layer. The testing was done to evaluate the apatite's microstructure, mineralogy, elements and absorption. From the results it was found that higher apatite was obtained with the increased of the immersion time; higher apatite formation and crystallization was found at earlier time of immersion for the TiO_2 that was immersed in SBF under the UV; higher apatite was obtained on the TiO_2 coatings that were anodised in H_2SO_4, H_3PO_4 and mixture electrolyte at lower electrolyte concentration. The increased apatite on these coatings can be related to the strong $Ti\text{-}O^-$ functional groups on the coating surface. The highest apatite was obtained on the TiO_2 coating that was anodised in a mixture electrolyte that has obtained Ti-OH functional group. The UV has resulted in the increased $Ti\text{-}O^-$ and Ti-OH groups, thus higher apatite precipitation ability.

ABSTRAK

Kebelakangan ini Ti telah banyak digunakan dalam aplikasi bioperubatan disebabkan oleh prestasinya yang sangat baik. Oleh yang demikian, ubah suai permukaan Ti telah menarik minat ramai untuk menghasilkan sifat biologinya yang lebih baik. Ti adalah telah dilakukan kepada proses pengoksidaan anodik dan ujian *in vitro* untuk menilai bioaktiviti salutan TiO_2. Salutan TiO_2 telah dioksidakan pada suhu bilik di dalam larutan elektrolit yang berbeza iaitu; H_2SO_4, H_3PO_4 dan campuran asid H_2SO_4 dan asid H_3PO_4. Pemboleh ubah yang digunakan dalam pengoksidaan anodik adalah: kepekatan elektrolit, voltan dan ketumpatan arus. Permukaan salutan kemudiannya di analisis menggunakan teknik pengujian yang berbeza; analisis mikrostruktur menggunakan SEM, analisis kandungan elemen menggunakan EDX, struktur hablur dan mineralogi menggunakan XRD, analisis penyerapan menggunakan FT-IR dan hidrofilik menggunakan WCA. Seterusnya ujian *in vitro* dilakukan untuk menilai aktiviti biologi permukaan salutan TiO_2. Penilaian aktiviti biologi pada permukaan TiO_2 dilakukan dengan menggunakan SBF yang dilakukan di dalam keadaan gelap dan di bawah UV untuk menyerupai tindak balas yang mungkin terjadi terhadap lapisan sel seperti tulang manusia. Ujian ini dilakukan untuk menilai mikrostruktur apatit, mineralogi, elemen dan penyerapan. Daripada keputusan ujian tersebut dapat disimpulkan bahawa banyak apatit dan tumpat mendap pada lapisan TiO_2 yang direndam di dalam SBF di bawah sinar UV berbanding salutan yang direndam di dalam SBF dalam keadaan gelap terutamanya pada permulaan eksperimen. Penyinaran UV juga telah mempercepatkan penghabluran apatit. Semua salutan memperolehi nisbah Ca/P apatit tulang dalam julat di antara 1.02 dan 1.57. Didapati juga fungsi bumpulan Ti-O menyumbang kepada peningkatan pembentukan apatit dan penghabluran untuk salutan oksida dalam larutan elektrolit H_2SO_4 dan H_3PO_4. Manakala fungsi kumpulan Ti-OH dan campuran ion S dan P dalam salutan telah menyumbang pembentukan apatit dan penghabluran yang lebih tinggi.

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