PREPARATION OF BIOACTIVE SURFACE VIA GEL OXIDATION ON TITANIUM FOR BIOMEDICAL APPLICATION (HIP JOINT REPLACEMENT)

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ABSTRACT

Titanium and its alloys are widely used as implant in biomedical applications. They have good mechanical and chemical properties, biocompatibility and biointegration with human body, but they have no ability to bond directly to natural bone. Therefore, alkali and heat treatments (gel oxidation) were introduced to improve the bioactivity of titanium by forming a mixture of sodium titanate and rutile on the surface of titanium. This method enables titanium to possess a bioactive surface which is essential to induce the apatite formation. This study aims to investigate the effects of alkali, sodium removal and heat treatments on *in vitro* bioactivity of titanium. UV light irradiation was used to study the effect on *in vitro* bioactivity of titanium. Alkali-treated titanium subjected to heat treatment in air have shown better overall *in vitro* performance than those treated in argon atmosphere. Therefore, the sodium removal treatment (dilute hydrochloric acid (HCl) treatment) was introduced to convert sodium titanate into anatase to improve the bioactivity of titanium treated in argon atmosphere. Thus, four samples (AT-0.5-HT500R, AT-0.5-HT600R, AT-5-HT500R and AT-5-HT600R) with different ratios of anatase to rutile were produced by varying the concentration of HCl acid treatment and heating temperature in argon atmosphere. It was found that the incorporation of sodium removal treatment has reduced two times the duration of apatite formation as compared with the conventional alkali and heat treatments. In order to further enhance the bioactivity, these samples were subjected to six different conditions of ultraviolet light irradiation and followed by *in vitro* bioactivity test. As a result, AT-5-HT500R (82.2% anatase and 17.8% rutile) was proven to deliver the best performance. It was confirmed that UV light irradiation enhances the bioactivity by removing hydrocarbon, inducing superhydrophilicity and forming OH groups. It was discovered that the duration of apatite formation was shortened to 7 days. Furthermore, the continuous UVA irradiation during *in vitro* test resulted in the acceleration of bonelike apatite formation in 3 days. It can be concluded that the sodium removal treatment and UV light irradiation give very significant impact to the formation of bonelike apatite on the titanium surfaces for biomedical applications.

ABSTRAK

Titanium dan aloi merupakan bahan implant yang popular dalam bidang bioperubatan. Titanium mempunyai sifat mekanikal dan kimia yang bagus dan serasi dengan badan manusia. Namun demikian, titanium tidak dapat dilekatkan kepada tulang manusia. Oleh itu, perawatan alkali dan haba (pengoksidaan gel) telah diperkenalkan untuk meningkatkan bioaktiviti dengan pembentukan natrium titanate dan rutil atas permukaan titanium. Cara ini membolehkan titanium memiliki permukaan yang bioaktif yang penting untuk membantu pembentukan apatite dalam ujian *in vitro*. Tujuan kajian ini dijalankan adalah untuk menyiasat kesan-kesan perawatan alkali, penyingkiran natrium dan perawatan haba terhadap bioaktiviti titanium. Kajian ini juga menyiasat kesan radiasi ultra ungu terhadap bioaktiviti *in vitro* titanium. Kajian ini telah membuktikan bahawa titanium yang menjalani perawatan alkali dan haba dalam atmosfera udara adalah lebih baik berbanding dengan atmosfera argon dari segi prestasi *in vitro*. Untuk itu, rawatan penyingkiran natrium (rawatan pencairan asid HCl) diperkenalkan untuk menukarkan natrium titanate kepada anatase untuk meningkatkan bioaktiviti titanium yang menjalani perawatan alkali dan haba dalam atmosfera argon. Oleh itu, empat sampel yang mempunyai nisbah anatase kepada rutil yang berlainan telah dihasilkan, iaitu AT-0.5-HT500R, AT-0.5-HT600R, AT-5-HT500R dan AT-5-HT600R dengan menggunakan kepekatan asid HCl dan suhu perawatan haba dalam atmosfera argon yang berlainan. Penggabungan dengan perawatan penyingkiran natrium telah berjaya memendekkan masa pembentukan apatite sebanyak dua kali ganda berbanding dengan perawatan alkali dan haba yang biasa. Untuk meningkatkan lagi bioaktiviti titanium, sampel telah dipancarkan dengan radiasi ultra ungu dalam enam keadaan yang berbeza dan diikuti dengan ujian bioaktiviti *in vitro*. Hasilnya, AT-5-HT500R (82.2% anatase dan 17.8% rutil) adalah sampel terbaik dalam ujian *in vitro*. Ini telah dibuktikan bahawa radiasi ultra ungu telah berjaya menambah baik prestasi dengan cara penyingkiran hidrokarbon, peningkatan hidrofilik (superhydrophilicity) dan pembentukan kumpulan OH. Ia turut

didapati bahawa masa pembentukan apatite seperti tulang telah dipendekkan lagi kepada 7 hari. Tambahan lagi, radiasi UVA yang berterusan semasa ujian *in vitro* dapat mempercepatkan masa pembentukan apatite seperti tulang kepada 3 hari. Kesimpulannya, perawatan penyingkiran natrium dan radiasi ultra ungu membawa impak yang penting kepada pembentukan apatite atas permukaan titanium untuk bidang bioperubatan.

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