利用低溫電漿化學改質鈦金屬表面

Chemical Modification of Titanium Surface by Glow Discharge

中文摘要

良好生物相容性是植體的首要要求，而植體材料的本質及其表面特質決定其生物相容性，尤其是與宿主組織直接接觸的材料表面。雖然目前對於植體表面與組織之間的反應、其長期穩定性及在臨床上的顯著性仍無定論，但已知植入後最早的生物反應爲組織液蛋白質在植體表面的吸附，這層緊密吸附的蛋白質直接決定接下來宿主對植體表面的細胞反應，所以爲了提昇植體與組織間整合，可藉由控制界面反應，吸附特定蛋白質，進而導引有利之組織癒合。因此本研究利用低溫電漿來活化鈦金屬表面以進一步連接白蛋白，企圖改變鈦金屬表面化學性質，發展一種能鍵結已知生物活性分子到鈦金屬表面的技術。鈦金屬圓片先以氬氣電漿去除表面污染物，來產生可重複取得的清潔表面，接著用丙烯胺電漿處理，使丙烯胺聚合在鈦金屬表面，再以交鏈劑戊二醛將白蛋白與丙烯胺的胺基(-NH2) 鍵結。樣本以掃描式電子顯微鏡(SEM)及原子力顯微鏡（AFM）觀察表面形態變化，以能量分散光譜儀(SEM-EDS)進行表面元素變化之定性分析，使用 X 光光電子能譜儀(XPS)檢測表面化學鍵結與元素變化作定性分析與半定量分析，並以膠樣金免疫標示法(colloidal gold immunolabeling)配合使用場發射鎗掃描式電子顯微鏡(Field Emission Scanning Electron Microscope, FEG SEM)，觀察鈦金屬表面白蛋白連接情形作定性分析與定量分析。經 SEM 及 AFM 觀察得知，氬氣電漿處理的時間與表面潔淨度及表面粗糙度有正相關，此結果顯示經電漿解離的氬離子與原子具清潔及離子轟擊(ion bombardment)鈦金屬表面的功能；丙烯胺的聚合厚度隨著丙烯胺電漿作用時間的增加而增加，另外鈦金屬表面形態除了氬氣電漿處理組與丙烯胺電漿處理組相似外，其他組別也隨著處理程序展現不同變化。SEM-EDS 的結果顯示在未經任何處理及經氬氣電漿清潔後的鈦金屬表面，偵測到主要爲鈦元素，丙烯胺電漿處理後，即可測到氮元素；戊二醛作用後表面有氧元素的出現；白蛋白處理後即可測得碳及氧元素。XPS 更進一步證實，氬氣電漿只有清潔鈦金屬表面的作用，並不會改變其表面化學組成；其餘各組的鈦、碳、氮、氧的比例及鍵結能量隨著處理程序而改變，可知表面上有化學組成之改變，且隨不同處理程序所得到表面元素之百分比及鍵結能量，與預期的表面披覆物元素百分比及鍵結能量相近。在膠樣金免疫標示觀察結果發現，經電漿表面處理再使用戊二醛交鏈劑作用，連接白蛋白到鈦金屬表面的密度，已多於預期可引發生物活動的數目。因此使用電漿處理技術可達到鈦金屬表面胺基化，加上交鏈劑戊二醛的處理後，可使鈦金屬表面接上白蛋白產生表面改質，確可提供一個鍵結已知生物活性分子到鈦金屬表面的方式，以期植體植入後能引導及促進組織復原。

英文摘要

Biocompatibility is the prime requisite for implant material and is determined by the bulk properties and especially the surface of implant which directly contacting the host tissue. Even though the relationships and reactions between the surface of implant and tissue and their long-term integrity and clinical efficacy are still not well understood, the first biological reaction known to occur after implantation of a biomaterial is the adsorption of tissue fluid proteins onto its surface and this tightly proteins strongly influences subsequent interactions of cells with the surface. In order to optimize the integration of implants, it is desirable to control interfacial reactions such that nonspecific adsorption of proteins is minimized and beneficial molecules are selectively adsorbed onto biomaterials prior to their implantation. In this regard, our goal is to develop a glow-discharge method to functionalize titanium surfaces by the covalent immobilization of bioactive organic molecules. Titanium plate first was cleaned by glow Discharge using argon plasma to eliminate surface contaminants and to produce a consistent and reproducible titanium oxide surface layer. Then an intermediary allylamine deposition was covalently linked to the oxide layer by glow discharge, followed by the covalent binding of albumin to the free terminal NH2 groups using glutaraldehyde as a coupling agent. Surface morphologies were observed by scanning electron microscopy (SEM) and atomic force microscopy (AFM). Analyses of surface composition were performed by scanning electron microscopy energy dispersive spectroscopy（SEM-EDS) and X-ray photoelectron spectroscopy (XPS), and Surface coverage by bound albumin was evaluated by field emission scanning microscope (FEG SEM) visualization of colloidal gold immunolabeling. The SEM and AFM result showed that the surface contaminants and roughness were decreased as the treating time of Argon plasma increased. The deposition thickness of allylamine was increased with the treating time. The surface textures were changed following different procedures except allylamine groups and it means that the 30 min deposition thickness of allylamine is too thin to change the surface contours. The SEM-EDS showed that the content of surface elements was changed after treated with glutaraldehyde or albumin indicated that argon plasma only had surface cleaning effect and did not change surface composition and the allylamine deposition thickness was too thin to show the difference in SEM-EDS findings. The XPS results confirmed the argon plasma cleaning effect and revealed that the ratio and the binding energy of surface elements changed with different treatment procedures and were similar to what expected to coat on the titanium surface. The binding density of immunolabeling for albumin suggests that the surface coverage of albumin is in excess of what expected for inducing biological activity. So the surface characteristics was successful

modified on the titanium plates by glow discharge technology and this method could offer the possibility of covalently linking selected molecules in order to guide and promote the tissue healing that occurs during implant integration in bone and soft tissue.