Surface Modification on Titanium Alloy for Biomedical Applications

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1 Introduction

The use of biomaterials has witnessed extensive applications, especially within the medical field associated in supporting internal and replacing tissues, for instance, implantation for orthopedic cases, as well as replacement of dental roots and joints. Nonetheless, the aspect of biocompatibility has been emphasized so as to ensure the longevity of these biomaterials for prolonged functional. With that, the term 'biocompatibility' is defined as 'the capability of a selected material in performing a certain function with a suitable host (Uwais *et al.*, 2017). In fact, some biomaterials that have been employed in the medical field are composite, polymer, ceramic, and metals. For instance, some metals that have been extensively applied as implants to function as artificial joints in the orthopedic are Ti alloys, stainless steel (316LSS), and alloys based on Co-Cr (Gibon *et al.*, 2017). Nevertheless, some limitations of these metals are the process of wear, osseointegration, and corrosion. Hence, the technique of modifying surface serves as an approach to address several issues, aside from enhancing the operational of tribological and the biomedical material in term of its mechanical features, (Shah *et al.*, 2017). In fact, the typical approaches employed as methods for treating surfaces in the biomedical field for implant cases are Chemical Vapor Deposition (CVD), Ricci *et al.* (2017), Physical Vapor Deposition (PVD) Shah *et al.* (2016a,b), ion implantation Qin *et al.* (2017), coating with plasma spray, Sathish *et al.* (2011), nitriding, Cassar *et al.* (2010), application of sol gel, Ayu *et al.* (2017), as well as thermal-based oxidation, (Sun *et al.*, 2016). With that, this paper describes materials and biomaterials for implantation, several problems concerning looks into Ti alloys, biomaterials, and titanium, as well as the approach of modifying the surface of titanium alloy.

2 Implant Biomaterials

In 1969, the inception of biomaterials was initiated at the Clemson University location at South Caroline. In fact, the notion 'biomaterial' denotes a material that is either natural or artificial used to form implant structure for replacement of certain biological frame so as to restore or to maintain its functional (Geetha *et al.*, 2009). Apart from that, biomaterial can also be referred as a material that responses towards biological frame in treating, examining or substituting organs, tissues or even functions of the body (Williams, 2009). As such, the biomaterials applied for implants are categorized as transient and permanent, based on reaction time towards the host. **Table 1** presents some biomaterial implementation for implant purposes.

Besides, the classification of biomaterials is of four types, as given in the following:

i) Polymers with covalent bond (silicone, nylon, polyester, rubber, and polytetrafluoroethylene),
ii) Metals with metallic bond (Au, stainless steel, Ag, titanium and its alloys, as well as Co-Cr alloys),
iii) Ceramics with ion bond (alumina zirconia calcium phosphates that are comprised of carbon and hydroxyapatite),
iv) Composites with polymer and ceramics combined or non-artificial elements such as ivory, bone, and wood (bone cement with fiber reinforcement, and wire that is carbon-carbon, (Müller *et al.*, 2008).

Table 2 shows both benefits and drawbacks, including biomaterial usage, in implant cases.

Since past these few decades, biomaterials that are based on metals have been extensively applied in implantology and orthopedic implant due to their maintain mechanical and biocompatibility in bone healing period (Shadanbaz and Dias, 2012). Basically metallic biomaterials widely used for implant materials are cobalt chromium (Co-Cr) alloys, stainless steel (316 L), and titanium and its alloys. However, Cobalt chromium and steel release metal ions such as Cr, Co, and Ni due to the corrosion of the implant subjected to body fluids. Besides having metal ions release, steel and Co-Cr have a higher elastic modulus than bone, which can lead to stress shielding and loosen of an implant, (Nakai *et al.*, 2011). In this case, the bone density is decreased using implant that promotes stress shielding through elimination of normal stress on bone. **Fig. 1** show the attributes of biomedical alloys based on elastic modulus. Besides, due to some features, such as having higher strength, lower density, hiked resistance for corrosion, being inertive towards bodily fluids, higher biocompatibility, lower modulus, and ease of being attached other tissues; the alloys of titanium have appeared to be a material with high potential for implant purposes, (Fukuda *et al.*, 2011; Suresh *et al.*, 2012; Wei *et al.*, 2011).

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