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MECHANICAL PROPERTIES AND BIOACTIVITY OF TITANIUM HYDROXYAPATITE (Ti-HA) COMPOSITE COATING ON 316L-STAINLESS STEEL SUBSTRATE PREPARED BY THERMAL SPRAY

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ABSTRACT

This study was conducted to investigate the mechanical properties, characterisation and bioactivity of titanium-hydroxyapatite (Ti-HA) composite coated on stainless steel,SS using high velocity oxy-fuel (HVOF) spray technique. Hydroxyapatite, $Ca_{10}(PO_4)_6(OH)_2$ was synthesized by using different microwave irradiation that were 800, 900 and 1100 Watts. HA powder was sieved and undergone characterisation and morphology analysis. As the power increased, the peaks for impurities in x-ray diffraction (XRD) pattern decreased and at 1100 W all peaks are seen correspond with standard reference data HA. Meanwhile, field emission scanning electron microscopy (FESEM) morphology of HA powder showed that the HA particles have needle-like shaped and at some places the particles have agglomerated. Then, Ti-HA composite with different weight percentage, wt% of HA were deposited on SS using HVOF technique. The XRD analysis showed the presence of titanium (Ti), titanium oxide (TiO), titanium dioxide (TiO_2) phases in all samples. For Ti-5% HA and Ti-10% HA samples, peaks corresponding to HA, tricalcium phosphate (TCP) and calcium titanate ($CaTiO_3$) phases were also identified. FESEM micrograph of pure Ti coating appeared to be fully melt, homogeneous and seemed to be denser compared to HA containing coatings where well distributed pores were detected. The mechanical properties of Ti-HA composite coatings were determined by hardness, adhesive and wear test. For hardness test, coating with pure Ti showed the highest value of hardness and the values were decreasing subsequently with the addition of HA. Adhesion test showed that coating with pure Ti gave the highest adhesion strength compared to HA addition coatings. Whereas, the coefficient of friction of coatings showed that pure Ti coating gave high value of coefficient of friction. However, Ti-10 % HA showed the highest coefficient of friction value due to three-body abrasion that occurs during the test. The bioactivity of Ti-HA composite coating was investigated with simulated body fluid (SBF) by measuring the changes in pH values and in the Ca and P ions concentration. The reaction of coating surfaces with the SBF resulted in increased of pH values and ions concentration where the maximum value was observed at day three. Further immersion showed decrease of pH value and ions concentration. The FESEM and EDX analysis indicated that Ti-10% HA promoted more nucleation and formation of apatite on the samples surface. Furthermore, it is also observed that HA containing samples have resulted in a more uniform apatite growth compared to pure Ti coated samples.

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CHAPTER ONE
INTRODUCTION

1.1 BACKGROUND OF STUDY

Coating of titanium, Ti for surgical implants has been an active field of research in recent years. Ti materials are generally regarded to have good biocompatibility and also possess favourable properties, such as relatively low modulus, low density, and high strength (Niespodziana et al., 2006). It had been reported that high velocity oxy-fuel (HVOF) sprayed Ti formed a very dense coatings with high corrosion resistance. Such coatings are expected to act as an interlayer between the structural implants made of alloys such as titanium alloy Ti6Al4V or stainless steels and the bone (Kawakita et al., 2006).

In medical application, hydroxyapatite, HA can be use as bioceramics coating and bone fillers. HA is a preferred material for bone repair because of its stability under in vivo conditions, compositional similarity, excellent biocompatibility, osteoconductivity, and ability to promote osteoblasts functions. It also elicits specific biological responses at the interface, which results in the formation of a strong bond between the bone tissues and the material (Kalita and Verma, 2010). Unfortunately, because of poor sinterability, HA shows low strength and toughness, especially in wet environment under physiological condition (Banerjee et al., 2007). The poor mechanical properties of pure HA have limited its use in any load-bearing applications. Their medical applications are limited to small unloaded implants, powders, coatings and low-loaded porous block implants (Murugan et al., 2006).

Many investigation have been done in order to extract HA from bio products like corals (Xu et al., 2001), natural calcite (Herliansyah et al., 2007), bovine bone (Murugan et al., 2006), and eggshell (Arawi, 2015). These products which are considered as biowaste are rich sources of calcium in the form of carbonates and oxide (Sanosh et al., 2009). Eggshell was selected due to the high composition of calcium carbonate (94%) which is the starting material for HA extraction (Karlsson and Lilja, 2008).