STAINLESS STEEL 316L-HYDROXYAPATITE COMPOSITE VIA METAL INJECTION MOULDING: PROPERTIES STUDY

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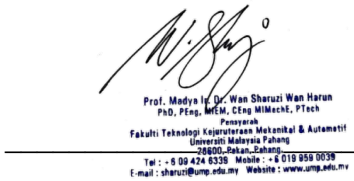

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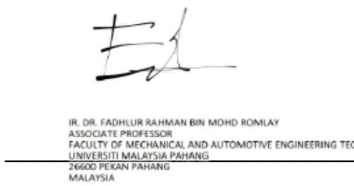

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

College of Engineering

UNIVERSITI MALAYSIA PAHANG

MAY 2021

ACKNOWLEDGEMENTS

The completion of this undertaking could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. It is my pleasure to acknowledge the roles of several individuals who were instrumental in the completion of my research.

First and foremost, my deep gratitude goes to my respected supervisor, Professor Madya Dr. Wan sharuzi, the one who expertly guided me through my research and who shared the experiences and excitement. His unwavering enthusiasm for mechanical study kept constantly engaged with my research, and his personal generosity helped makes my time in finishing this research enjoyable. It is my pleasure for having Prof. Madya Dr. Wan Sharuzi as my advisor for this research and having the golden opportunity to learn from him.

Secondly, my appreciation also extends to my co-supervisor Dr. Fadhlur Rahman bin Mohd Romly, senior lecturers: Dr Juliana Alias, Dr.Tedi Kurniawan who are either directly and indirectly had helped towards the success of this research and for mentoring and encouragement have been especially valuable. The success of this research will not be achieved without their generous input and passionate participation. Also thank to technical staffs from UMP and DRB Hicom University for their willingness to help me.

The special thanks also go to my laboratory colleagues from Green Research for Advanced Materials Laboratory (GRAMSlab) whose helped sustain a positive atmosphere in which to do research and their early insights launched the greater part of this dissertation. They always give a hand during my difficulties in completing the task.

Above ground, I am indebted to my family, whose value to me only grows with age especially to my mother Puan Hajah Zainab binti Hassan and my late father Allahyarham Haji Johari bin Abd. Majid (Al-Fatihah). Finally, I acknowledge my husband, Muhammad Khalil bin Majid, who is my champion and who blessed me with a life of joy for give unbeatable support and encouragement to me through my years of study. This accomplishment would no have been possible without them.

Thank you all.

ABSTRAK

Hydroxyapatite amat dikenali sebagai seramik yang bio-aktif dan mempunyai pertalian biologi dengan tisu tulang yang mana ia terpilih sebagai bahan yang digunakan dalam pebedahan tulang. Persamaan fasa antara komposisi dan kimia keatas fasa organic dalam tulang menjadikan seramik HA sebagai biokompatibiliti yang terbaik. Walau bagaimanapun, HA mempunyai sifat mekanikal yang rendah dan terbatas penggunaanya sebagai bahan implant. Logam tahan karat 316L (SS 316L) telah berkembang sebagai logam yang paling baik digunakan dalam bioperubatan kerana ciri-ciri mekanikal dan tahan karat. Idea menggabungkan seramik HA bersama bahan yang lebih tinggi sifat mekanikal iaitu logam tahan karat 316L untuk menghasilkan bio-komposit SS 316L/HA dilihat sebagai satu alternative terbaik untuk membentuk bahan yang berharga dan boleh diterima untuk implant pada badan manusia. Komposit SS 316L/HA dengan tambahan nisbah HA dihasilkan melalui teknik Pengacuan Suntikan Logam (MIM). Bahan komersial HA dihasilkan daripada Kalsium-Fosfat dan Sistem Pengikat pula terdiri daripada Polipropilena (PP), Stearin Acid (SA) dan pengikat utama Paraffin Wax (PW). Nisbah berat HA yang berbeza iaitu 0, 5,10 dan 15 % berat disediakan untuk menghasil kajian pada komposit SS 316L/HA. Semua sampel dijalankan proses sintering pada suhu 1350C dan selama 3 jam masa rendaman. Sifat mekanikal komposit SS 316L/HA diselidik dengan dikaji tahap mikro-kekerasan ujian tegangan. Manakala, sifat kehakisan ditentukan melalui eksperimen elektrokimia. Melalui penyelidikan pada serbuk logam tahan karat SS 316L dan seramik HA, purata saiz zarah 11.2μm and 70.3μm mencatatkan nilai Sw pada tahap 2.0 dan 2.0. Ini menunjukkan bahawa taburan agihan saiz zarah kedua-dua jenis serbuk yang luas dan sesuai untuk disuntik ke dalam acuan dalam proses pengacuan. Kadar ketumpatan dan pengecutan meningkat seiring dengan peningkatan nisbah berat HA pada komposit. Manakala, kekuatan tegangan dan tahap kekerasan menurun dengan jumlah HA meningkat. Walaubagaimanapun, kadar karat meningkat apabila jumlah HA meningkat. Pemerhatian terhadap mikrostruktur melalui kajian mikrostruktur optic (OM) menunjukkan peningkatan nisbah HA pada komposit membawa kepada peningkatan porositi pada sampel kajian. Disamping itu, pemerhatian ini juga menunjukkan sempadan porositi berkurangan apabila jumlah berat HA bertambah. Selain itu, pemerhatian dari segi mikstruktur juga menunjukkan kecenderungan kepada perubahan bentuk liang pada permukaan sampel daripada bentuk yang bulat kepada bentuk yang tidak teratur. Walaubagaimanapun, ini menunjukkan peningkatan terhadap sifat sampel itu sendiri yang membawa kepada penurunan bacaan mekanikal pada bahan sampel sekaligus menarik lebih dekat dengan ciri-ciri mekanikal tulang manusia. Oleh itu, dapat disimpulkan disini bahawa peningkatan nisbah berat serbuk hydroxyapatite pada komposit adalah parameter yang penting dalam meningkatkan sifat mekanikal yang baik dan nisbah berat antara 5 % ke 10 % berat HA adalah nisbah yang terbaik untuk menghasilkan composite SS 316L/HA.

ABSTRACT

Hydroxyapatite (HA) is well-known as bio-active ceramic and biological affinity with bony tissue which appointed as a selected material applied in bone surgery. The similarity of phase composition and chemical to inorganic phase in bones makes the HA ceramic as the best biocompatibility of all orthophosphates. However, HA has low mechanical properties which limits it to be use as implant materials. Stainless steel 316L (SS 316L) metallic biomaterial has blossomed as the most favorable metal used in biomedical application due to excellent mechanical and corrosion properties. Uniting HA with higher mechanical properties of metallic biomaterials 316L stainless steel (SS 316L) to produce a SS 316L/HA bio composite has been as the best alternative to form an acceptable mechanical property for human implants. The SS 316L/HA composite would have credited vital to current implant materials such as low Young's modulus, high biocompatibility and bio-inertless. This research investigated the mechanical, physical and corrosion properties of the SS 316L/HA composite by additive of HA via metal injection moulding technique (MIM). Commercial HA was produced from calcium-phosphate. While, Polypropylene (PP), Stearin Acid (SA) and primary binder, Paraffin Wax (PW) utilized as binder system. The composite of SS 316L/HA was prepared at different weight ratio of HA (0,5,10 and 15 wt.%). All compacts were sintered at 1350 ^{o}C for 3 hours of soaking time. The physical properties of SS 316L/HA sintered compact were investigated by the shrinkage and relative density study. The mechanical properties of the sintered SS 316L compacts were determined by the microhardness and tensile testing. While, the corrosion properties were characterised by electrochemical experiments. The investigation indicated on SS 316L and HA powders showed an average particle size were 11.2µm and 70.3µm which recorded the Sw values of 3.0 and 2.0 respectively. This showed that metal and ceramic powders broad particle size distribution and fit for moulding. The shrinkage and density increased as the increase of HA amount. While, the tensile strength and hardness decreased with the additive of HA in composite compacts. While, The corrosion rate increased as the HA amount increased. The observation on microstructure by optical microstructure study (OM) showed the additive of HA on composite compacts routed the porosity amount increased. While, the grain boundaries decreased as the additive of HA increased. Microstructure observation revealed the circular pore formation tendencies which changed to irregular shape as the HA additive. Moreover, this shows the improvement on sintered compact properties which brought the decreasing of mechanical properties as it routes closer to the human bone mechanical properties. Hence, it can be concluded that with powder ratio of HA wt.% additive is critical parameter for improving mechanical properties and with 5 to 10 wt. % of HA additive showed the best ratio of SS 316L/HA biocomposite.

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