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The Effect of Sodium Alginate on the Properties of Hydroxyapatite

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Abstract

The aim of this research is to investigate the effect of sodium alginate on the physical, mechanical and morphology of non-sinter of hydroxyapatite. The ceramic based materials as hydroxyapatite and natural polymer as sodium alginate composite materials are investigated based on their application of bone implants in biomedical fields. Precipitation method was performed to prepare HA/SA powder. The hardness and fracture toughness was identified by using Vickers Hardness Test. The density of compacted powders was increased and attained highest density at 97/3% (HA/SA) about 1.46g/cm^3.The Vickers indentation was used to determine the fracture toughness of brittle materials by measure the crack of the sample due to the ease of sample preparation and simplicity of this test. The morphology, particle size and distribution of microstructure surfaces were characterized by using a Field Emission Scanning Electron Microscope (FESEM). The powder characterization is important to identify the crystalline composition that exists in the mixed powder. Hydroxyapatite (HA)/sodium alginate (SA) are characterized through XRD. The crystallinity of XRD powder can be identified by testing the lattice parameter that existed in the various parameter.

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1. INTRODUCTION

Bone tissues engineering promote a better way in regeneration and repair of defects bones. Variety material has been proposed for used in bone tissues engineering. One of the materials that promote success in bone tissues engineering are the hydroxyapatite. Hydroxyapatite (HA) are the major component for tooth and bone mineral that constituent similarity to a composition in hard tissues. The stoichiometry are represented by the formula $Ca_{10}(PO_4)_6(OH)$ which consist of calcium and phosphorus with the ratio (Ca/P) of 1.67. Hydroxyapatite (HA) is a bioactive group that widely used especially in biomedical field for bone implant applications due to its biocompatibility, non-toxicity and osteoconductivity. This can be prepared as dense ceramic, ceramic coating, powder and porous ceramic which required for specific applications (Ramli et al., 2011, Sharifah Adzila et al., 2013,

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Lala et al., 2016, Kantharia et al. 2014). Hydroxyapatite is an inorganic element of bone that widely used due to it characteristic while, alginate (Alg) is a natural polymer that is synthesis from brown algae and it prefer to be used in biomedical application due to it characteristic such as biocompatibility, low cost and low toxicity (Ilie et al., 2016).

The application of hydroxyapatite as bioceramic in the biomedical fields such as orthopedic and dental fields are limited to a load-bearing area due to its characteristic which is brittle and low fracture toughness between 0.8-1.2MPam$^{1/2}$.Vickers indentation is more prefer to be used to determine the fracture toughness test of brittle materials such as ceramic. This is due to simplicity, quick and inexpensive of a test. The small sample of materials can be used to test the fracture toughness and the preparation are easy due to only polished samples are needed to be clearly seen the diamond shape (C.B.Ponton et al., 1998).

Among the bioceramic group, composites are more prefer to be used due to its characteristic which can fulfil the mechanical properties required in the biomedical field. The development of composites materials are important in implants application as their physical and mechanical strength is close to the strength of bone which exhibits a high fatigue resistance of load such as corrosive resistance and fracture toughness (Orlovskii, Komlev, and Barinov 2002).The most useful approaches are to enhance the strength and reduce the brittle of HA ceramic is by adding or mixed with polymer materials to form a composites materials.

Based on this research, calcium phosphate based ceramic-hydroxyapatite (HA) and a natural polymer-sodium alginate (SA) are employed. The precipitation method was used to prepare the HA and HA/SA to enhance the densification and hardness of composite materials. Densification behavior is investigated based on the physical and mechanical properties of composites materials. The physical and mechanical properties are investigated to improve the composite materials and produce the high strength of bone that can be used in load bearing area for implants applications.

2. EXPERIMENTAL METHOD

Two precursors used in the preparation of hydroxyapatite/ sodium alginate (HA/SA) were commercially available HA nanopowder $Ca_{10}(PO_4)_6(OH)_2$ (99.5%, Emory) and sodium alginate NaC_6H_7O (Sigma-Aldrich). The sample ratio were from 100/0%, 99.5/0.5%, 97/3%, 95/5%, 92/8% and 90/10% (HA/SA). The HA powder was used to mix with distilled water under constant stirring in hot-plate for 2 hours and another 2 hours by pouring the SA powder. After mixing process, the suspension was left overnight for 24 hours to precipitate the solution. The precipitate solution was filtered and dried for 24 hours at 80˚C.

The phase existence in the mixed powders is analyzed by using the X-ray diffraction (XRD) (Shimadzu XRD 6000 diffractometer) under ambient conditions using Cu-Ka (λ= 0.154056nm) as radiation source at current 40mA with voltage 40kV. The spectra of XRD are recorded at 2Θ= 10˚ to 80˚ at a scanning speed 1˚/min and step size at 0.02˚. The XRD peaks that obtained were compared with standard reference Joint Committee of Powder Diffraction Standards (JCPDS) file for HA. Morphologies of HA and HA/SA composite were observed and characterized by using Field Emission Scanning Electron Microscope (FESEM). The sample was coated with gold at 20 milliampere at 60s with 15kV voltage**.**

The prepared mixed powders were compacted into pellets by using uniaxial pressed in a steel die of 13mm at about 2.5MPa load at 5 minutes. Density was measured based on Archimedes principle by using distilled water as an immersion technique. By analysed varies parameter of the sample, the bulk density was measured and recorded with using Mettler Toledo Densitometer. The surface of samples was grinded and polished before indentation is performed on the samples at 0.2HV testing loads with an indentation time of 10s. The hardness of samples was determined by using Vickers hardness under HMV,Shimadzu. The hardness and fracture toughness analyses of HA and HA/SA composites were carried out by using an optical microscope. The fracture toughness (K_{IC}) of samples was identified the crack of each sample which has five indentations and the average was measured and recorded. The indentation of fracture toughness was determined through the Niihara equation.