RDU150394
Faculty of Chemical & Natural Resources Engineering

BUKU PROFIL PENYELIDIKAN SKIM GERAN PENYELIDIKAN GERAN UNIVERSITI JANGKA PENDEK / GERAN DALAM UMP (LAPORAN AKHIR)

Picture related to the research project

From waste to wealth: Utilisation of marine based shell waste in producing hydroxyapatite for biomedical applications

Name of Project Leader : Dr. Jun Haslinda Hj. Shariffuddin
Name of co-researchers:
Noor Ida Amalina Binti Ahamad Nordin
Sureena Binti Abdullah
Ruzinah Binti Isha

IPT/ Faculty / School/ Centre/Unit : Faculty of Chemical & Natural Resources Engineering

E-mail: junhaslinda@ump.edu.my
Field : Materials

ABSTRACT (120 words)

Bio-scaffold is referred to an artificial structure that being used alternatively as bone replacement for bone tissue regeneration. The ultimate objective of this study is to synthesis the bio-scaffold derived from the cockle shell waste. Main steps involved in the production of the scaffold including pre-treatment of cockle shells, synthesis of Hydroxyapatite (HAP) and synthesis of bio-scaffold. The scaffolds were then undergone physicochemical and mechanical characterization to identify their functional groups, surface morphology, elemental components and compressive strength. Bioactivity of scaffolds evaluated by immersing them in the simulated body fluid solution (SBF). Overall, it is feasible to produce $CaCO_3$ from cockle shell wastes as the results obtained shows the physicochemical characteristic of the cockle shell powder imitated the real $CaCO_3$. Furthermore, HAP also significantly produced from cockle shell waste since cockle shells are rich with calcium source. Then, it is proved that all the prepared scaffolds produced has similar properties as actual bone in term of physicochemical, mechanical properties and bioactivity.

1. INTRODUCTION

Bone defect and irregularities may cause by traumatic injuries or pathological condition such as osteoporosis and bone cancer. In today's medical practices, conventional treatment methods like autograft and allograft are still being used to treat the defect. However, these methods have some drawbacks such as insufficient bone donations, threat of donor-site morbidity and risk of disease transmission. Currently, biomimetic bone scaffold has been widely studied to treat bone injuries and irregularities. The scaffold serves as temporary template for bone cells attachment and regeneration while it gradually degrades to allow new bone tissue to form. This study is focused on the effect of bio-polymer and different types of bio-ceramics on the scaffold. Hydroxyapatite (HAP) and calcium carbonate (CaCO3) derived from cockle shells are raw materials that have been used together with sodium alginate.

2. RESEARCH METHODOLOGY

The process of developing the bone scaffold involved the preparation of RCS and S-HAP powders, followed by the fabrication of bone scaffold using different concentration of RCS and S-HAP powders where sodium alginate was used as the matrix. There were six samples of scaffolds with different powder concentration (C4 is RCS scaffold with 30wt%; C8 is RCS scaffold with 45 wt%; C12 is RCS scaffold with 55 wt% ; H4 is S-HAP scaffold with 30wt%; H8 is S-HAP scaffold with 45wt% and H12 is S-HAP scaffold with 55 wt%). Sodium alginate scaffold (S5) was used as control. The RCS and S-HAP powders were characterized using X-ray fluorescence (XRF), X-ray diffraction (XRD), Fourier transform infrared (FTIR), scanning electron microscope/ energy dispersive X-ray (SEM/EDX) and thermal gravimetric analysis (TGA).. The bone scaffolds properties were evaluated using XRD, FTIR, SEM/EDX, TGA, differential scanning calorimetric (DSC), compressive strength, porosity, swelling ratio, bioactivity and biocompatibility toward bone cells (hFOB 1.19).

3. LITERATURE REVIEW

HAP is a type of bioactive bio-ceramic. Although it is able to form bonds with the surrounding tissue and mimic bone, it does not have the same mechanical strength(Homma et al.,2005; White et al.,2007). This limits the use of HAP as a complete replacement for bone but its bio-compatibility is still utilized as a bone filler, as a coating for implants and as part of composites which can be used in implants(Carter et al.,2007). HAP has been used as artificial bones and tooth roots, powders for tooth paste, retarded of cancer cell and drug delivery agent. Other than being biocompatible HAP is wear resistant and can be lightweight, but it has a low tensile, strength, low toughness and is difficult to fabricate (Carter et al.,2007). HAP has also been widely used in various fields such as in wastewater treatment and water purification.(Islam M. et al.,2010; Bailliez S. et al., 2004; Barka S. et al.,2004; Bigi A. et al., 2004), and also in chromatography columns by taking advantage of its ability to selectively absorb protein and nucleic acids (Matsumoto T. et al., 2004). HAP is also used industrially as a fluorescent material, catalysts and catalyst support, ion conductors and chemical sensors (Yamashita K. et al., 1995; Gitting J.P. et al., 2009; Mahabole M. et al., 2005)

There are many methods that can be used to produce HAP powder, such as precipitation, solid-state synthesis, hydrolysis, hydrothermal and sol-gel method (Kweh SWK,1999). Due to the various applications of HAP, it is important that the method of synthesizing HAP provides the required properties based on the intended application. However, wet chemical precipitation method is the most often method used to produce HAP powder either by the reaction between diammonium hydrogen phosphate with calcium nitrate or the reaction between ortophosphoric acid and calcium hydroxide under a controlled pH and temperature of the solution. (Asaoka N, 1995; S Zhang , 1997).

4. FINDINGS

- This invention has undergone several analyses and testing chemically, mechanically and in vitro bioactivity. Chemically and mechanically, it is proved that this bioscaffold had the biomaterial (calcium carbonate & HAP) properties that is suitable for bone material.
- For bioactivity analysis, it showed the bioscaffold has ability in bone regeneration by observing the mineral deposited on it.
- This bioscaffold had proved to be bioactive towards simulated body fluid as some mineral has growth on this bioscaffold during immersion.
- The CaCO3 and HAP scaffolds show high cell viability of more than 75% which indicates higher cells attachment and proliferation. This suggest scaffolds have no cytotoxicity toward the osteoblast cell.

5. CONCLUSION

This work shows the possibility of synthesizing CaCO3 and HAP bone scaffold using cockle shell as the starting material. Increasing the HA powder concentrations improved the physicochemical, thermal, mechanical as well as bioactivity of the scaffolds. However, excessive CaCO3 HAP content could reduce the porosity of the scaffold and interrupt the nutrients and oxygen transport within the scaffold. In addition, this work not only demonstrates the preparation of low-cost bone material but could reduce environmental pollution by utilizing the cockle shell wastes.

ACHIEVEMENT

i) Name of articles/ manuscripts/ books published

1. Siti Hajar Saharudin, Jun Haslinda Shariffuddin, Noor Ida Amalina Ahamad Nordin. (2019). Fabrication of bone scaffolds from cockle shell waste. Chemical Engineering & Technology. https://doi.org/10.1002/ceat.201800518

2. Siti Hajar Saharudin, Jun Haslinda Shariffuddin, Aqeela Ismail and Ji Heng Mah. (2018). Recovering value from waste: biomaterials production from marine shell waste. Bulletin of Materials Science. 41:162, 1-8. DOI: 10.1007/s12034-018-1680-5

3. Siti Hajar Saharudin, Jun Haslinda Shariffuddin, Noor Ida Amalina Ahamad Nordin. (2017). Biocomposites from (Anadara granosa) shells waste for bone material applications. IOP Conference Series: Materials Science and Engineering. 257, 012061. https://doi.org/10.1088/1757-899X/257/1/012061

4. Hajar Saharudin, S., Haslinda Shariffuddin, J., Ida Amalina Ahamad Nordin, N., & Ismail, A. (2019). Effect of Aging Time in the Synthesis of Biogenic Hydroxyapatite Derived from Cockle Shell. Materials Today: Proceedings, 19, 1208–1215. https://doi.org/10.1016/J.MATPR.2019.11.124

ii) Title of Paper presentations (international/ local)

1. M.H.A. Zainal Abidin,S.Abdullah,J.H. Shariffuddin. Synthesis Of Hydroxyapatite Derived From Cockle Shells For Biomedical Applications: The Effect Of Calcination Temperature And Sodium Carbonate Addition. Proceeding, International Conference On Fluids & Chemical Engineering (FLUIDCHE2017).

2. S.H. Saharudin, J.H. Shariffuddin & N.I.A.A Nordin. Effect of biopolymers on cockle shell biocomposite for bone material applications. Proceeding, 4th International Conference on Mechanical Engineering Research (ICMER2017).

3. Siti Hajar, Saharudin, Jun Haslinda, Haji Shariffuddin , Noor Ida Amalina, Ahamad Nordin and Aqeela, Ismail (2018) Effect of aging time and stirring speed in the synthesis of biogenic hydroxyapatite derived from cockle shell. In: International Conference on Chemical Sciences and Engineering (ICCSE 2018), 7-8 November 2018, Melaka, Malaysia

4. Siti Hajar, Saharudin and Jun Haslinda, Haji Shariffuddin and Noor Ida Amalina, Ahamad Nordin (2019) Fabrication of Cockle Shell Based Bioactive Bone Scaffold. In: 7th International Symposium on Applied Engineering and Sciences (SAES2019). 11th – 12th November 2019. Serdang, Selangor, Malaysia

iii) Human Capital Development
Name of Student: Siti Hajar binti Saharudin (PhD Student)
ID Matric No: PKC16016
Faculty:FKKSA
Semester enrolled :6

Name of Student: Muhammad Hazim Aiman Bin Zainal Abidin
ID Matric No: KC12062
Faculty:FKKSA
Thesis title: Synthesis Of Hydroxyapatite Derived From Cockle Shells For Biomedical Applications: The Effect Of Calcination Temperature And Sodium Carbonate Addition
Graduation Year: 2016

Name of Student: Aqeela Binti Ismail
ID Matric No: KA13166
Faculty: FKKSA
Thesis title: Utilization of Marine Based Shell Waste In Producing Hydroxyapatite for Biomedical Applications: Investigate The Effect of Reaction Time and Mixing Speed on Producing Hydroxyapatite From Cockle Shells

Graduation Year: 2016

Name of Student: Mah Ji Heng
ID Matric No: KA13166
Faculty: FKKSA
Thesis title: Utilization of Marine Based Shell Waste in Producing Hydroxyapatite for Biomedical Applications: Investigating The Types of Shell Waste
Graduation Year: 2016

iv) Awards/ Others

1.Special Award in the CIGIF 2016, Seoul, Korea 5 November 2016 "From Waste To Wealth: Transformation of Cockle Shells Into HAP For Bone Regeneration"

2016 Korea Cyber International Genius Inventor Fair (CIGIF2016).

2.Gold Award in the CIGIF 2016, Seoul, Korea 5 November 2016 "From Waste To Wealth: Transformation of Cockle Shells Into HAP For Bone Regeneration".

3.Gold Medal Award in the Creation, Innovation, Technology & Research Exposition (CITREX) 2016, Universiti Malaysia Pahang, "From Waste To Wealth: Transformation of Cockle Shells Into HAP For Bone Regeneration".

4. Grand Prize in the International Festival Innovation on Green Technology (i-FINOG 2016), "From Waste To Wealth: Transformation of Cockle Shells Into HAP For Bone Regeneration".

5.Gold Prize-International Festival Innovation on Green Technology (i-FINOG 2016) "From Waste To Wealth: Transformation of Cockle Shells Into HAP For Bone Regeneration".

5.Citrex 2016- Bronze Medal

6. Silver Medal Award in the 2nd Advanced Innovation & Engineering Exhibition AINNEX2017), UMP, May 2017, " Waste to Wealth : Transformation Of Marine Based Shell Into Bone Materials Product"

7. Gold Medal in ITEX 2018 for invention entitled : Recovering Value From Waste : Development Of Bioscaffold From Cockle Shell For Dental Biomaterials

8. Gold Medal Award in the Creation, Innovation, Technology & Research Exposition (CITREX) 2018, Universiti Malaysia Pahang, "Recovering value from waste: Development of biocomposite from cockle shell for dental biomaterials".

9. Best Invention Universities/Educatioal Ins. in ITEX 2018 for invention entitled : Recovering Value From Waste : Development Of Bioscaffold From Cockle Shell For Dental Biomaterials

10. Gold medal in iENA2018 for invention entitled : Recovering Value From Waste : Development Of Bioscaffold From Cockle Shell For Dental Biomaterials

v) Others

Intellectual property. Invention title: Recovering Value From Waste : Development Of Bioscaffold From Cockle Shell For Dental Biomaterials. (PI2018000691)

REFERENCES

[1] ……………………………………………………………………………………………………

[2] ……………………………………………………………………………………………………

[3] ……………………………………………………………………………………………………

APPENDIXES