GSJ: Volume 6, Issue 10, October 2018
ISSN 2320-9186

Global Scientific JOURNALS

PREPARATION OF HYDROXYAPATITE FROM NATURAL RESOURCES LITERATURE REVIEW

Ola Saleh Mahdi
engoulasaleh.alsaffar@yahoo.com
University of Babylon ,College of Materials Engineering , Department of Ceramic Engineering and Building Materials

Abstract

Bone defects healing stay in orthopedic and trauma surgery, hard problem. The difficulty comes from partial obtainability for material of bone toward defect seal and aid growth of bone. A ready biomaterial hydroxyapatite (HA) , that near toward mineral constituent of bones chemically, and in animals the solid tissues, so as a sealer it can be used to alteration, bone cracked or as a grafts layer to assistance bone in growing grafts when used in applications of dental ,orthopedic, and maxillofacial.
The aim of review focuses on preparation HA from biological resources identical bones animal, eggshells, wood, etc. Also displays properties, for example particle size, morphology, stoichiometry, thermal constancy, also occurrence of drop ions , deference by primary substantial and process done. Additionaly, review also highpoints the important of natural resources to prepare HA , and make available future opinions to the researcher, so that biological resources for extracted HA can be used clinically as a esteemed biomaterial.

Keyword: Hydroxyapatite, Fishbone, heat treatment, particle size , Biogenic.

1. Introduction

Bone deficiency from long-lasting disease, or shock quiet leftovers a task for clinicians healing. Indeed the usage synthesis biomaterial for defect bone repairs, became more needing ,(Sakka et al, 2013).As reasons for the, limited provided, of autologous bone and the risk of thinkable infection by allograft, lead to prepared, biomaterial or xenograft, a bone part from unlike animal types(Chaari et al, 2009).Positive effects as results ,for using xenogenous, bone which is actual like in construction and morphology to hominid bone. Bones of bovine, sheep, or fish xenografts involved trace quantity identify ions, that give to much, amount and requirement minute-care giving. Calcination steps made to confiscate constituents and to finish pathogens; the residual ash comprises bone elements of the bone(Bohner, 2000).The entirely transformed, of bovine ash bone to HA may supplied as far as(1.2 to kg 2) kg of hydroxyapatite from of dense bone. This removed HA involves trace ions value, that exihipted, a central part in the bone formation route, then recognized the speed of synthase process. (Gutierres et al, 2007).Mixing of more than one ions into the procedure of prepared HA is not simple, and as a outcome ion-replaced HA many ways was more exclusive than easy HA. HA is a imitation biomaterial that has significant results for many decades because of its likely to the animal hard tissue(Carrodeguas et al, 2011).Bone and tusks of animal are built from , Ca (23.5), P (11), proteins (20) wt%, and trace quantity of elements like Na^{2+}, Zn^{2+}, Mg^{2+}, K+, Si^{2+}, Ba^{2+}, F^-, $CO_3^{\,2-}$, etc. These elements trace exhibited, a chief part in the life series of bones; hence, inventers invented several methods to evolve the helpful ions into the building of prepared hydroxyapatite to instruct it with well osteoconductive properties (Ribeiro et al, 2012).However, all competition with the mineral constitutes, in animal hard tissue became a remains converses. To get a lots of matches with the mineral constituent of bone, biomaterials sources ..A general categories of biological resources for the abstraction of HA and their raw materials shows in **Fig. 1** (Jaramillo et al, 2010).

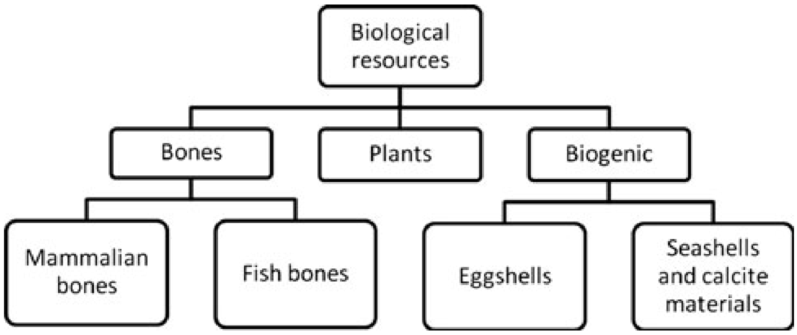

Figure 1 Categorize of naturaly resources, for the abstraction of HA and their raw materials.

2. Hydroxyapatite synthesis from natural sources :

2.1 Mammalian bones as a resources to prepared hydroxyapatite

There are several ways to ,synthesis HA from wide range of different raw materials, that need more interesting to the procedure factors, to get high-excellence HA. Prepared HA is a stoichiometric material with calcium to phosphor ratio of 1.67, whereas the HA got from mammalian bone is a no stoichiometric material as result for the,trace ions took place and the effect of careful potential material for bone graft drives(Ramesh et al, 2007). HA crystallites, frequently created in more microstructure shapes are usually prepared as of, moreover natural bone cool or, after chemicals prepared. The properties, effectiveness, phase clarity, and size provided of HA created from natural sources mainly as bones be contingent on many aspects like, elimination method, heat of calcination, and bones nature .Generally all bones of the animals are cleaned carefully, boil slowly by distilled water, washing by(NaOH) to remove the proteins and any others foreign bodies, on the bones surface. Next bones are respectively cut pieces or ball ground for unequal, periods that in get also effect on the particle size and morphology of the last produce(Fathi et al, 2008). For calcination procedure by put bones in the furnace heated at several temperatures among 550°C and 1300°C to absolutely eliminate the living substance from the bone and supply HA. A calcination system invented sensibly to improve the HA crystallinity, though evading the last ,product thermal decomposition of HA(Cai et al, 2009). Also, treatment of calcination damage the pathogens, which are probable diseases to patient transmission(Noh et al, 2010). HA created in biological arrangement grown obviously in an living medium of protein fragments with exact methods. Thermally pure HA steady phase, was created by calcinating bovine bone, and chicken femur bone among 650°C and 1200 °C (Jaramillo et al, 2010). Escalation in calcinations temperature to 1100 °C augmented the HA crystallinity , but this great calcination temperature caused in the development of beta –tricalicum phosphate. HA from bovine bone removed has been accustomed make hydroxyapatite/collagen , scaffolds for tissue engineering drive X-ray, measures of heat treatment bone coordinated with the typical XRD outline of crystal-like HA cards. Mammalian bones, are important, source of ion-fixed HA expressly the bovine bones, therefore, have been used by the scientists to prepar HA(Smolen et al, 2013).

2.2 Marine/river sources

High ratio of the world whole fish ingesting, comes from marine/river . Fish and shellfish ingesting lead to, accrual of huge quantity of Ca- and HA-rich waste. So, several bioactive composites made from marine waste . (Ozawa et al, 2002). Caught fish used to offer, naturally fish meat, fish oil, and several little economic manures. Nevertheless, current investigation trainings have known the occurrence of some CP salts in these bases; so, they became used to prepare bioactive mixtures (Lee et al, 2003). Prepare HA from, fish bones as a result, in considering it as ironic source of calcium, phosphate, and carbonate. These bioactive combinations can be created by diverse modest to multipart methods. Normally, using fish bones to get calcium for several products, however tiny efforts have been ended to create HA from these normal sources for biological use(Kannan et al, 2006). Acceptable to alter fish bones or linked sources into HA, these bones cleaned with warm water or several alkaline resolutions to eliminate proteins layers. Later the elimination of protein frame the bones are exposed to great temperature calcination to supply HA(Ooi et al, 2007). Carbonated HA was prepare from bone by alkaline hydrolysis , and calcination thermally at 700 °C for 5 hours. According to the TGA consequences , writers informed that HA ready from tuna bone was thermally steady up and about to 1100 °C, advanced than the HA ready from additional sources such as pig or bovine bones(lvarez-Lloret et al, 2010). XRD investigation of no preserved bone showed the occurrence of mineralized unwell crystal-like HA implanted in organic ground. Although the Xray configurations of basic preserved and calcined bone models exposed that the particle size and crystallinity were augmented because of the resultant c-HA treatments (Lombardi et al, 2011). Fish bones were firstly calcined at 850 °C for 3–8 h trailed by the devastating of bones with ball grind for 1 - 5 hours. SEM examination showed that the crushing time effect on the size of spherical particles. X-ray configuration established the change of aragonite phase to brushite phase, and HA at temperature of hydrothermal at 155 °C and under, whereas pure HA phase was made at 170 °C then upstairs. Fish bones are too a decent basis to provide micron-sized c-HA with decent biocompatibility. (Li et al, 2012).

2.3 Plant sources

Through the latter little years, important efforts resulted in to the creation, of the similarity the bone structures scaffolds. Some porous constructions by moral grade of porosity have been recently got.

Constructions with decent grade of porosity and interrelated pores are essential for cell vascularization and ingrowth nonetheless, the chief problematic related with these structures is the absence of correct biophysical reply, which can lone be exposed by scaffolds able with a in height grade of hierarchy (Landi et al, 2003). Contemporary labors are deficient to produce biomimetic and very prepared hierarchal structures. However, investigators are unceasingly annoying to present novel usual resources to create HA powder. Scientists have currently absorbed their courtesies near natural sources alike wood and calcite-ironic plants and algae as their hierarchically structures can be used to provide, biomedical scaffolds(de Paula et al, 2004). Wood is collected of extremely prepared similar resonating tubes and cellular microstructures that have great strength, toughness, and little density so, it may be used to project bone scaffold templates. Certain marine species like algae and corals are collected of $CaCO_3$ that are like in sponginess and interconnectivity to human bones and, then can be used to produce HA structures . Preparation of biphasic HA needing little pressure and finaly, the manufacture of HA by hydrothermal process. Xray investigation exhibited, the creation of pure crystalline HA phase, although the FTIR consequences showed , the carbonate replacement in the HA arrangement(de Paula et al, 2010).

2.4 Biogenic sources

Each year lots of eggshells appeared as waste substantial. A great quantity of eggshells is created as waste from restaurants, houses, etc. Also, a lot of quantity of sea shells and extra calcite supplies are too current (Thamaraiselvi et al, 2006). The structure of, eggshell calcium carbonate (93), CP (1)%, and organic substances (4 %) (Shariffuddin et al, 2010). Being low-cost and , eggshells appeared, a rich source of calcium precursor important for the production of HA .Typically by sintering at high temperature HA prepared both porous or dense .Mechanical properties are dignified by order the several views similar sintering temperature, period of sintering, and conformation of the ceramic substantial used(Wu et al, 2011). Considering the sea shells and eggshells, an improved selections to create ,excellence biomaterials as they look like the humanoid hard tissues. Around Molluscs shells well nanoscale symmetry, mechanical properties, and compression strength than mutual inorganic crystals (Wu et al, 2011).To eliminate CaO the shells are washed by boiling water or steam to completely removed the layers and then the shells are broke to powder by heating system at high temperature to got CaO. This CaO can be responded with phosphorous precursors to make hydroxyapatite as appear in the next reaction (Zhang et al, 2011).

$CaCO_3 \rightarrow CO_2 + CaO$…………….(1)

$3Ca_3(PO3)4+ 2CaO + H_2O \rightarrow Ca_{10}(PO_4)_6(OH)_2$……………(2)

Carbonated HA proved that , the inorganic portion of enamel, tusks, and bones and its varieties a insufficient part in weight(Kumar et al, 2012) . The effects of combination CO_3 ions in the structure of apatite lead to , enhanced the morphology, and gave well biochemical reactivity of bone minerals (Wu et al, 2013).Therefore, CO_3 substituted HA nanoparticles explained the remains important, chosen for bone and dental requests . Hydroxyapatite and beta tricalcium phosphate, were successfully made by recycled eggshells and phosphoric acid There is no crushed washed eggshells , calcined on 850 °C to removed the organic substance. The eggshells that calcined by ball milled aimed at 24 hours,trailed by calcination to 800 °C for 2 hour, to offer HA with calcium to phosphor ratio of 1.65. The earlier clarity phase formations rest on the ratio of calcium oxide come from, acid of phosphoric add to eggshells (Goloshchapov et al, 2013).

3. Summary

Because of excellent views that HA showed, in more medical branches, evaluation papers have been focuses on the preparation of HA , and gave more interested to it is applications and preparation methods. However, widespread resulted displays the preparation of HA using, the natural unused supplies or additional natural materials. Due to its development needing, important of applications in different sides, carry out a complete study, give attention to ways of synthesis , phase purity, and stability in thermal treatment, as an example for its production from, natural sources and natural unused materials. Several resources hydroxyapatite can be created from like, eggshells, bone of diverse animals, seashells, and plants, considered Search displays many studying for the natural sources can be a accepted for synthesis, HA or, the ability to present Ca and P precursor for making of pure phase ,and thermally steady HA.

Additionally, the natural waste or raw materials can be used, to prepare HA, be more benefits as it offers ions, that, helped in the formation of, biological HA. Hydroxyapatite come from, bovine bone similarity to the HA current in the animal bones but, the occurrence of trace elements is rarely stated. There is usually a danger of HA resulting as of biomaterials sources being polluted with, noxious ions, particularly HA improved from, sources about the manufacturing area. Besides, sure ethical issues will constantly be, involved to the HA improved from animal sources, these moral matters will no hesitation will boundary the practice of others HA.

The review has emphasized that, bovine bones and fish are an esteemed chosen for the construction of pure HA phase, while use of biogenic and plant as a sources incline to provided thermally unstable HA, which could be because of the partial change of, to HA or owing to the existence of ions of carbonate in the raw materials. This carbonate considered a results of , uncompleted, calcination process for calcite, or as a result of interest of CO_2 from air or water. Preparation limits such as grinding time, calcination period, and procedure, heat too effect to the segment pureness of the previous production.

4. References

Bohner, M .," Calcium orthophosphates in medicine: from ceramics to calcium phosphate cements". Injury 4:37–47,2000.

Cai, Y., Zhang, S., Zeng, X., Wang, Y., Qian, M., Weng, W., " Improvement of bioactivity with magnesium and fluorine ions incorporated hydroxyapatite coatings via sol–gel deposition on Ti6Al4V alloys". Thin Solid Films 517:5347–5351,2009.

Carrodeguas ,R.,G., Aza, S.,D., "a-tricalcium phosphate: synthesis, properties and biomedical applications". Acta Biomater 7:3536–3546,2011.

Chaari, K., Ayed ,F.B., Bouaziz J Bouzouita K "elaboration and characterization of fluorapatite ceramic with controlled porosity". Mater Chem Phys 113:219–226 ,2009.

de Paula, R., Ramakrishna, S., "Crystallographic study of hydroxyapatite bioceramics derived from various sources". Crys Growth Des 5:111–112,2004.

de Paula, S.,M., Huila, M.,F.,G., Araki, K., Toma, H.,E., " Confocal Raman and electronic microscopy studies on the topotactic conversion of calcium carbonate from Pomacea lineateshells into hydroxyapatite bioceramic materials in phosphate media". Micron 41:983–989,2010.

Fathi, M.,H., Hanifi, A., Mortazavi ,V.," Preparation and bioactivity evaluation of bone-like hydroxyapatite nanopowder". J Mater Process Tech 202:536–542,2008.

Goloshchapov, D.,L., Kashkarov ,V.,M., Rumyantseva, N.,A., Seredin, P.,V., Lenshin, A.,S., Agapov, B.,L., Domashevskaya, E.,P., "Synthesis of nanocrystalline hydroxyapatite by precipitation using hen’s eggshell". Ceram Int 39:4539–4549,2013.

Gutierres, M., Dias, A.,G., Lopes, M.A. , Hussain ,N.S., Cabral, A.T., Almeida, L., Santos ,J.D.," Opening wedge high tibial osteotomy using 3D biomodelling bonelike macroporous structures: case report". J Mater Sci Mater Med 18:2377–2382,2007.

Jaramillo ,C.,D., Rivera, J.,A., Echavarrı´a, A., O'byme ,J., Congote, D., Restrepo, L.,F.," Osteoconductive and osseointegration properties of a commercial hydroxyapatite compared to a synthetic product". Rev Colomb Cienc Pecu 23:471–483,2010.

Kannan ,S., Rocha, J.,H.,G., Ferreira, J.,M.,F., "Synthesis andKumar ,G.,S., Thamizhavel ,A., Girija ,E.,K ., "Microwave conversion of eggshells intoflower-like hydroxyapatite nanostructure for biomedical applications". Mater Lett 76:198–200,2012.

Landi, E., Celotti ,G., Logroscino, G., Tampieri, A., " Carbonated hydroxyapatite as bone substitute'. J Eur Ceram Soc 23:2931–2937,2003.

Lee, S.,J., Oh ,S.,H., " Fabrication of calcium phosphate bioceramics by using eggshell and phosphoric acid". Mater Lett 57:4570–4574,2003.

Li ,S., Wang, J., Jing, X., Liu, Q., Saba ,J., Mann, T., Zhang, M., Wei, H., Chen, R., Liu, L. " Conversion of calcined eggshells into flower-like hydroxyapatite agglomerates by solvothermal method using hydrogen peroxide, N, N-dimethylformamide mixed solvents". J Am Ceram Soc 95:3377–3379,2012.

Lombardi, M.,P., Palmero, P., Haberko, K., Pyda, W., Montanaro, L., "Processing of a natural hydroxyapatite powder: from powder optimization to porous bodies development". J Eur Ceram Soc 31:2513–2518,2011.

lvarez-Lloret ,P., Rodrı´guez-Navarro, A.,B., Falini, G., Fermani, S., Ortega-Huertas ,M., "Crystallographic control of the hydrothermal conversion of calcitic sea urchin spine (Paracentrotus lividus) into apatite". Crys Growth Des 10:5227–5232,2010.

Noh, K.,T., Lee, H.,Y., Shin, U.,S., Kim, H.,W., " Composite nanofiber of bioactive glass nanofiller incorporated poly(lactic acid) for bone regeneration". Mater Lett 64:802–805,2010.

Ooi, C.,Y., Hamdi, M., Ramesh, S., "Properties of hydroxyapatite produced by annealing of bovine bone". Ceram Int , 33:1171–1177,2007.

Ozawa, M., Suzuki, S., " Microstructural development of natural hydroxyapatite originated from fish-bone waste through heat treatment". J Am Ceram Soc 85:1315–1317,2002.

Ramesh ,S., Tan ,C.,Y.,, Sopyan I., Hamdi ,M., Teng, W.,D.," Consolidation of nanocrystalline hydroxyapatite powder". Sci Technol Adv Mat 8:124–130,2007.

Ribeiro, D.,C., Figueira, L.,deA., Issa ,J.,P.,M., Cecina, C.,A.,D., Dias, F.,J., Cunha ,M.,R.,D "Study of the osteoconductive capacity of hydroxyapatite implanted into the femur of ovariectomized rats". Microsc Res Tech 75:133–137,2012.

Sakka ,S., Bouaziz ,J., Ayed, F.B., "Mechanical propertiese of biomaterials based on calcium phosphate and bioinert oxides for applications". Advances in biomaterials science and biomedical applications in Biomedicine. Intech, Rijeka, p 23–50, 2013.

Shariffuddin, J.,H., Jones, M.,I., Patterson, D.,A., " Greener photocatalysts: hydroxyapatite derived from waste mussel shells for the photocatalytic degradation of a model azo dye wastewater".,2010.

Smolen ,D., Chodoba, T., Iwona, M., Kedzierska, K., Lojkowski ,W., Swieszkowski W., Kurzydlowski ,K.,J., Mierzynska, M.,K., Szumiel, M.,L .,"Highly biocompatible, nanocrystalline hydroxyapatite synthesized in a solvothermal process driven thermal stability of sodium, magnesium co-substituted hydroxyapatites". J Mater Chem 16(3):286–291,2006.

Thamaraiselvi, T.,V., Prabakaran ,K., Rajeswari, S.," Synthsis of hydroxyapatite that mimic bone mineralogy". Trends Biomater Artif Org.; 19: 81-83,2006.

Wu ,S., C., Tosu, H.,K., Hsu, H.,C., Hsu ,S.,K., Liou ,S.,P, Ho, W.,F., "A hydrothermal synthesis of eggshell and fruit waste extract to produce nanosized hydroxyapatite". Ceram Inter. doi:10.1016/j. ceramint.,2013.

Wu ,S.,C., Hsu ,H.,C., Wu, Y.,N., Ho ,W.,F., "Hydroxyapatite synthesized from oyster shell powders by ball milling and heat treatment'. Mater charact 62:1180–1187,2011.

Zhang ,Y., Liu, Y., Ji, X., Banks, C.,E., Zhang, W., " Conversion of egg-shell to hydroxyapatite for highly sensitive detection of endocrine disruptor bisphenol ". J Mater Chem 21:14428–14431,2011.