CHAPTER 11

CONCLUSIONS AND FUTURE WORKS

11.1 Conclusions

The vibro-milling method was successfully provided a simple route for synthesis nanocrystalline HA powder from natural bovine bone with high quality, low cost, reproducible and high mass productivity. It was found that the vibro-milling time slightly affects the crystallite size of the HA nanopowders. However, the optimum period of vibro-milling time of about 2-4 hours can separate and disperse the HA nanocrystals from its parent bone structure. Moreover, the as-prepared powders are confirmed to be pure nanocrystalline HA powder with their Ca/P ratio close to that of stoichiometric HA. The vibro-milling method is also found to be the beneficial process to produce the silica nanopowders of high purity, low cost and high mass productivity.

The agglomeration problems limit the high densification of HA nanoceramics. However, maximum bending strength of 69.3±5.7 MPa with porosity of 21±0.07% was achieved in the sample fabricated by the nanopowders obtained from of 2 h vibro-milling times and 1200°C sintering temperature, with about 2 times higher than that of the sample which fabricated by microsized HA powder having the equal amount pores. In addition, the high porosity of this sample is expected to have great benefit to permit the circulation of the physiological fluid flow throughout such a scaffold device.

The rate controlled sintering is effective technique that could both improve the sinterability and mechanical properties of nanocrystalline HA cereamics. The sintered samples at 1200°C were nanocrystalline HA materials which possesses high strength and fracture toughness. The values are found to lie in the range of the mechanical properties of human cortical bone. The increased toughness and strength are mainly attributed to crack deflection bridging, pull-out phenomena and grain boundary sliding in microstructure of the nanocrystalline HA cereamic.

The optimum conditions for fabrication the dense nanocrystalline HA ceramic in this study found at 1200°C of sintering temperature for 3h by rate-controlled sintering method. Fracture toughness of 1.8±0.3 MPa.$m^{1/2}$ with bulk density of 95.2% of the theoretical density of HA was achieved. These properties ensure the most appropriate materials for hard-tissue replacement. This optimum sintering condition was used in the fabrication of craniotomy flap fixation device and nanoporous HA ceramic, having high mechanical strength that can be used for bone implants and drug delivery applications. Moreover, nanostructured HA biomaterials promise the promotion of osteoblast adhesion and proliferation, osseointegration and the decomposition of calcium containing mineral in the surface of these materials.

11.2 Future work

1. The progress of animal and clinical trial.
2. Improvement of mechanical properties of the HA bases materials for hip replacement.
3. Fabrication of some bone implant fixation such as plates and screws.