CHAPTER 2

PURPOSES OF THE RESEARCH

Bone is a complex living tissue which has an elegant structure at a range of different hierarchical scales. It is basically a composite comprising an organic phase (based on collagen) in which calcium-containing inorganic crystals are embedded. Bone not only provides structural support and protection to bodily organs, but it is involved in the serves as a reservoir for minerals, particularly calcium and phosphate. Generally, bone has capability of self-regeneration or self-remodeling to a certain extent throughout the life without leaving scar. However, many conditions call for bone grafting owing to bone defects either from traumatic or from non-traumatic destruction (e.g. cancer). With reference to statistical reports, about 6.3 million fractures occur every year in the United States of America (USA) itself, of which about 550,000 cases require some kind of bone grafting. It was also noticed that the fractures occur at an annual rate of 2.4 per 100 population in which men seem to experience more fractures (2.8 per 100 population) than women (2.0 per 100 population). The most frequently occurring fractures are, in decreasing order, hip, ankle, tibia, and fibula fractures. It is reported that the total number of hip replacements was about 152,000 in the year 2000, which is an increase of about 33% compared to the year 1990 in the USA alone and it is expected to increase to about 272,000 by the year 2030, indicating that there is still a great need for synthetic bone grafts. According to a market survey conducted by Medtech Insight, bone grafts sales was found to exceed US$980 million in 2001 in the USA and about US$1.16 billion in 2002, which is also expected to double by 2006. In Europe, the number of bone grafting procedures was reported to be 287,300 in 2000 and it is expected that it could be increased to about 479,079 in 2005. In 2000, the worldwide use of bone grafts was estimated to be about 1 million, of which about 15% of the surgery had used synthetic bone grafts[2-4].

Several methods of reconstructing bone defects are available include using autograft or allograft, which is connected with several problems. The use of autograft substance involves additional surgery. Moreover, the autograft bone is available only in limited quantities. The major disadvantage of allograft bone implants is that they may be rejected by the human body and diseases may be transmitted together with the implant[2-7]. For these reasons, there is a growing need for fabrication of artificial hard tissue replacement implants. Metals have been widely used for major load bearing orthopedic applications. However, there are, various problems related to metallic materials in the human body due to corrosion, wear, and/or negative tissue reaction[4]. Therefore, several ceramic materials have been clinically applied. Among various ceramics that have been tested for their use in the human body, calcium phosphate based materials, especially hydroxyapatite (HA) is most favored by the scientific community because of their excellent biocompatibility and compositional similarities with human bone. Unfortunately, HA ceramic is limited in its use, since its mechanical properties are not sufficient for more demanding load application, such as fracture fixation, artificial bone and tooth[1-7]. Recently, nanoscale particle of HA (~10-100 nm) have received much attention because of their superior functional properties over their microscale counterpart[2]. It is reported that sinterability, densification, and mechanical properties of ceramics prepared from nanoscale powders can be improved by using nanocrystalline HA, which is expected to have better bioactivity than the coarser crystals. Nanocrystalline HA has the potential to revolutionize the field of hard tissue engineering from bone repair and augmentation to controlled drug delivery devices[2-3].

In the past 2 to 3 decades the synthesis of materials of which the properties and structure on the nanometer scale are the most characteristic started to advance, concomitant with the increase of chip technology. In the last few years the scientific community has cherished the potential of nanosized materials. These entities have distinctly different properties than bulk material because the number of atoms or molecules at their surface can become comparable to that inside the particles. Despite the high potential, very few applications have been developed so far using nanoparticles. The key limitation is the lack of large quantities of nanosized particles with closely controlled properties at a cost that will allow scientists and engineers to comfortably explore new practical applications of these particles as well the science of processing these new materials. Therefore research should be focused on developing the science and engineering that would allow the development of inexpensive technologies for manufacture of nanoparticles that can be densified into nanocompacts[30,51]. The synthesis and properties of nanomaterials is a very broad field, too broad to be totally discussed here. Therefore the specific nanomaterials of interest for this thesis will be dense hydroxyapatite based nanoceramic.

In this thesis, the fabrication of dense nanocrystalline HA ceramic is described. This title mentions 3 properties of the materials to be fabricated. First of all the HA is nanopowder and should be synthesized with simple method for the largely mass product in the shorting times. Second requirement is a density of sintered HA at least 95%. The third and most important one is the requirement of nanoscale dimensions for microstructure, theses mean grains of HA nanoceramic or nanocomposites should have structural feature with at least one dimensions in the nano-domain, whish is in between 1 and 100 nanometer.