OVERVIEW TO HYDROXYAPATITE NANOPARTICLES AND THEIR APPLICATIONS

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Hydroxyapatite (HA) is a naturally occurring phosphate mineral with the formula,$Ca_5(PO_4)_3(OH)$. However, the crystal unit cell of HA contains two entities and hence generally written as ($Ca_{10}(PO_4)(OH)_2$).The OH^- ions of HA crystal can be replaced by fluoride, chloride or carbonate, producing fluorapatite or chlorapatite. It crystallizes in the hexagonal crystal system with (a = 9.41 A, b = 6.88 A, z = 2) unit cell parameters. Crystal structure of HA clearly indicate in Figure 01. Pure HA powder is white in color and naturally occurring apatite has different colors such as brown, yellow, or green colourations due to the incorporation of the various metal ions into the HA crystal lattice.

HA nanoparticles are the major and most abundant material in human bones and teeth. As a result, synthetic HA nanoparticles that mimic natural HA are extensively synthesized to repair and substitute human bones. The composition, grain size, large surface area-to-volume ratio, and crystallinity of synthetic HA nanoparticles are very similar to biological apatite. Hence, synthetic HA nanoparticles have exceptional biocompatibility and superior bioactivities such as osteoconduction and osteointegration. HA nanoparticles are mostly used as a coating material in manufacture of biocompatible metallic implants since it is able to control the removal of metallic ions from the metallic implant to the human body. Furthermore, HA nanoparticles can easily be combined with biodegradable and non-degradable polymers, so HA nanoparticles are used to prepare large number of polymer nanocomposites such as collagen/HA,Poly(lacticacid)/collagen/HA, alginates/collagen/HA, chitozan/HA, gelatine/HA, Poly(caprolactone)/HA, Poly(lactic acid)/HA, Poly(ethylene)/HA, Poly(urethane)/HA, Poly(tetrafluoroethylene)/HA, Poly(methyl methacrylate)/HA and so on. These nanocomposites are used as drug delivery systems as well as to prepare bone cement for biomedical applications. Therefore, HA nanoparticles are one of the highest value in biomedical field (Murugan and Ramakrishna, 2005).

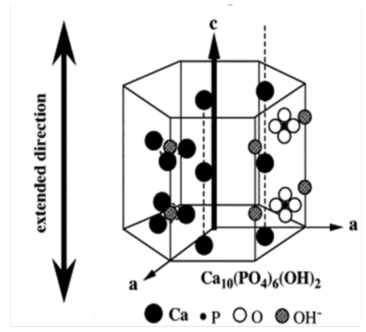
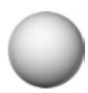
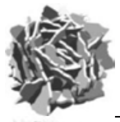
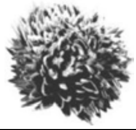


Figure 01- Crystal structure of the Hydroxyapatite

There are a large number of available methods to synthesize HA nanoparticles including mechanochemical synthesis, electrochemical deposition, sol-gel technique, chemical precipitation from aqueous solutions, combustion and hydrothermal methods. Furthermore, various morphologies of HA have been recorded by different researches and it may vary with their preparation methods as given in Table 01. Needle-like and spherical shapes of HA nanoparticles are the most common applicable morphologies of HA (Sadat-Shojai *et al.*, 2013).

Table 1. Different shapes of HA nano-particles and their appropriate preparation methods.

Shapes of HA nano-particles	Morphology	Preparation methods*
	irregular, formless, sphere	ss, mch, cc, hl, sg, hth, em, sch, ht, bs, cp
	sphere, microsphere, nanosphere, ball	mch, cc, sg, hth, em, sch, ht, bs, cp
	rod, needle,	cc, hl, hth, bs, cp

	plate, flake, sheet	cc, hl, hth, bs, cp
	leaf, flake, sheet, plate	hth, em, bs, cp
	flower	cc, hl, cp
	Dumbbell	hth, cp

We, at physical chemistry research laboratory, Department of chemistry, University of Peradeniya have synthesized pure HA nanoparticles with needle-like and spherical shapes (Figure 02) using dolomite and apatite (at Eppawala, Sri Lanka) as raw-materials with novel, simple and economical methods. Those isolated HA nanoparticles can be used in Biomedical applications.

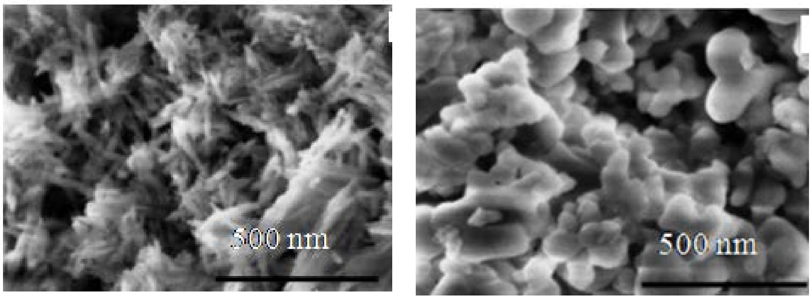


Figure 02. SEM images of (a) Needle-like HA nanoparticles (b) spherical shape HA nanoparticles.

Where, ss: solid-state synthesis, mch: mechanochemical method, cc: conventional chemical precipitation, hl: hydrolysis method, sg: sol–gel method, hth: hydrothermal method, em: emulsion method, sch: sonochemical method, ht: high-temperature processes, bs: synthesis from biogenic sources, cp: combination procedures.

References:

Murugan, R., and Ramakrishna, S. (2005). Development of nanocomposites for bone grafting. *Composites Science and Technology*, *65*(15), 2385-2406.

Sadat-Shojai, M., Khorasani, M. T., Dinpanah-Khoshdargi, E., and Jamshidi, A., (2013). Synthesis methods for nanosized hydroxyapatite with diverse structures. *Acta biomaterialia*, *9*(8), 7591-7621.