Microstructure of Hydroxyapatite from Waste Eggshell Synthesized under Different Temperature

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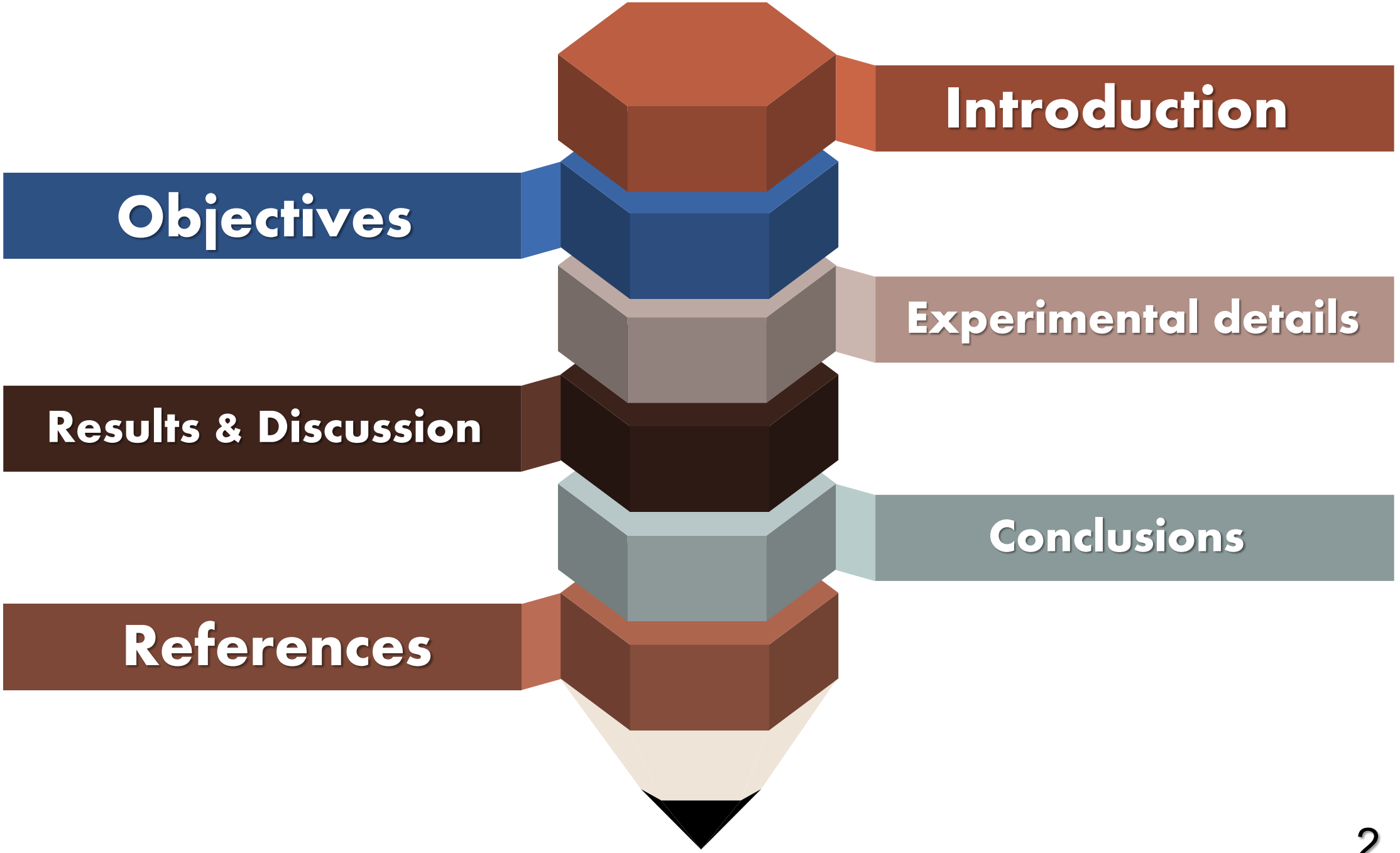
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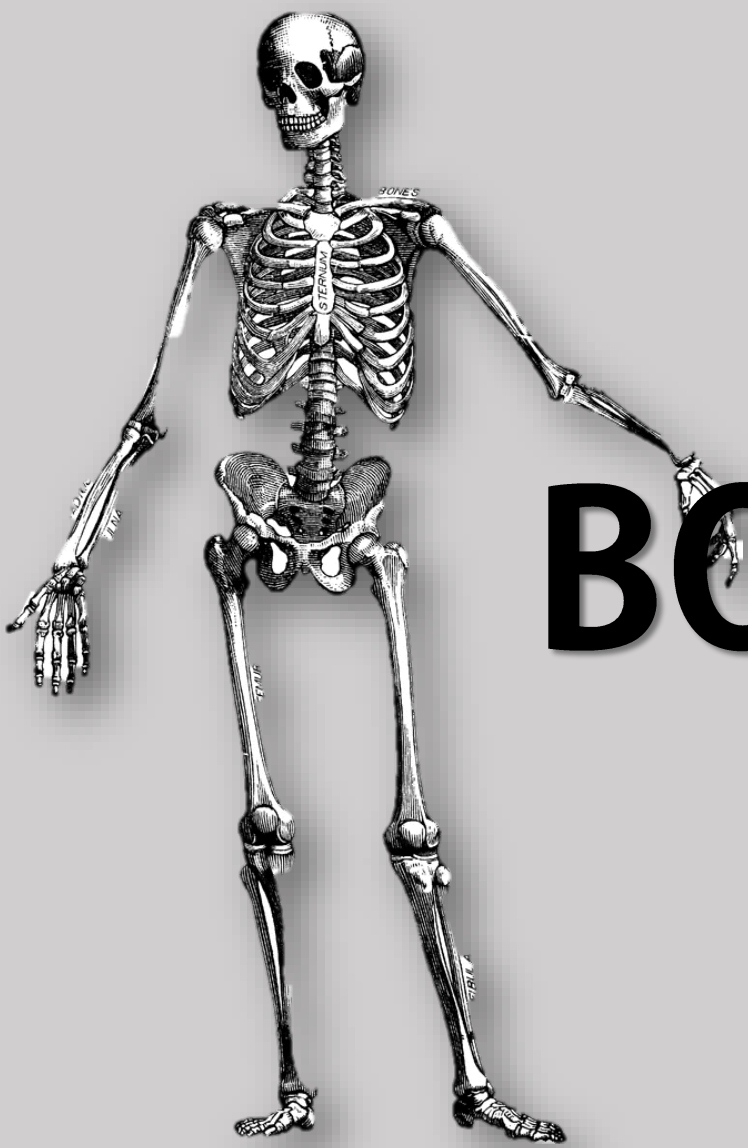
Introduction

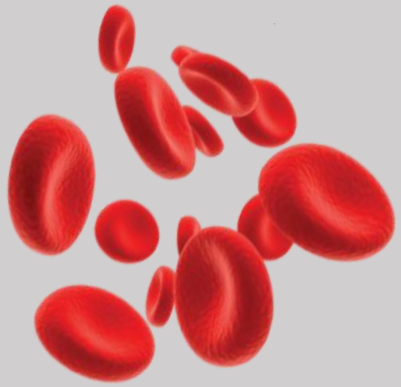


BONE

Support

Protection

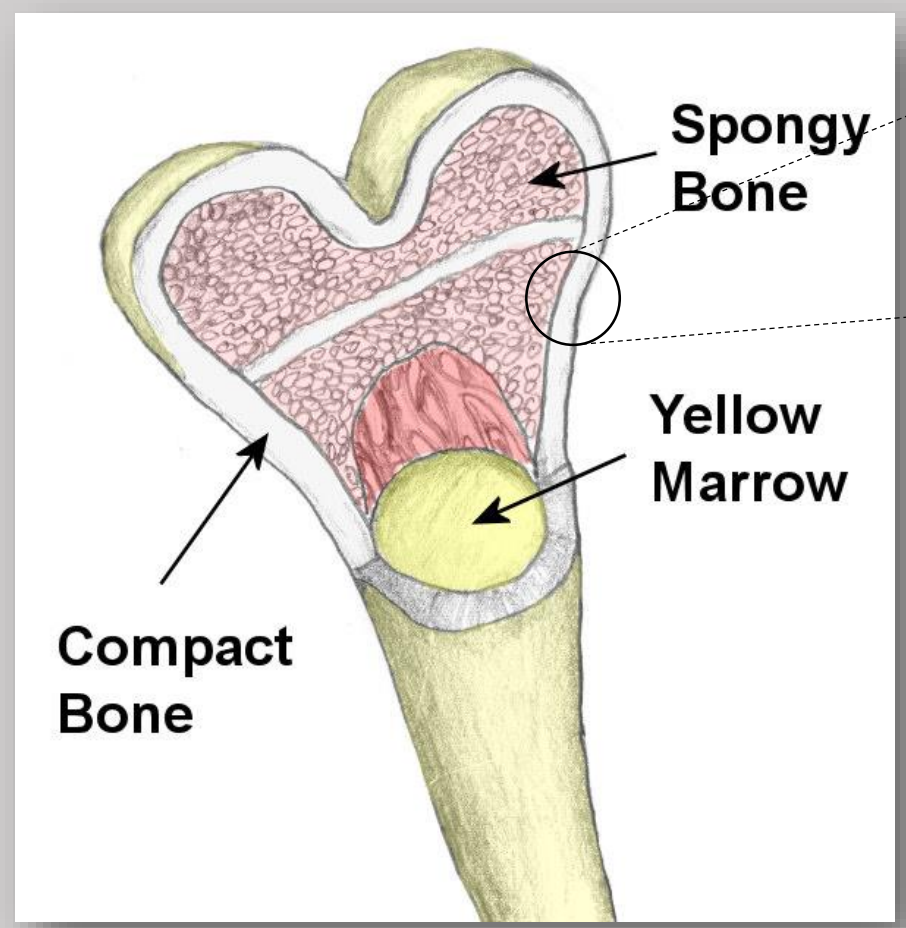
Movement

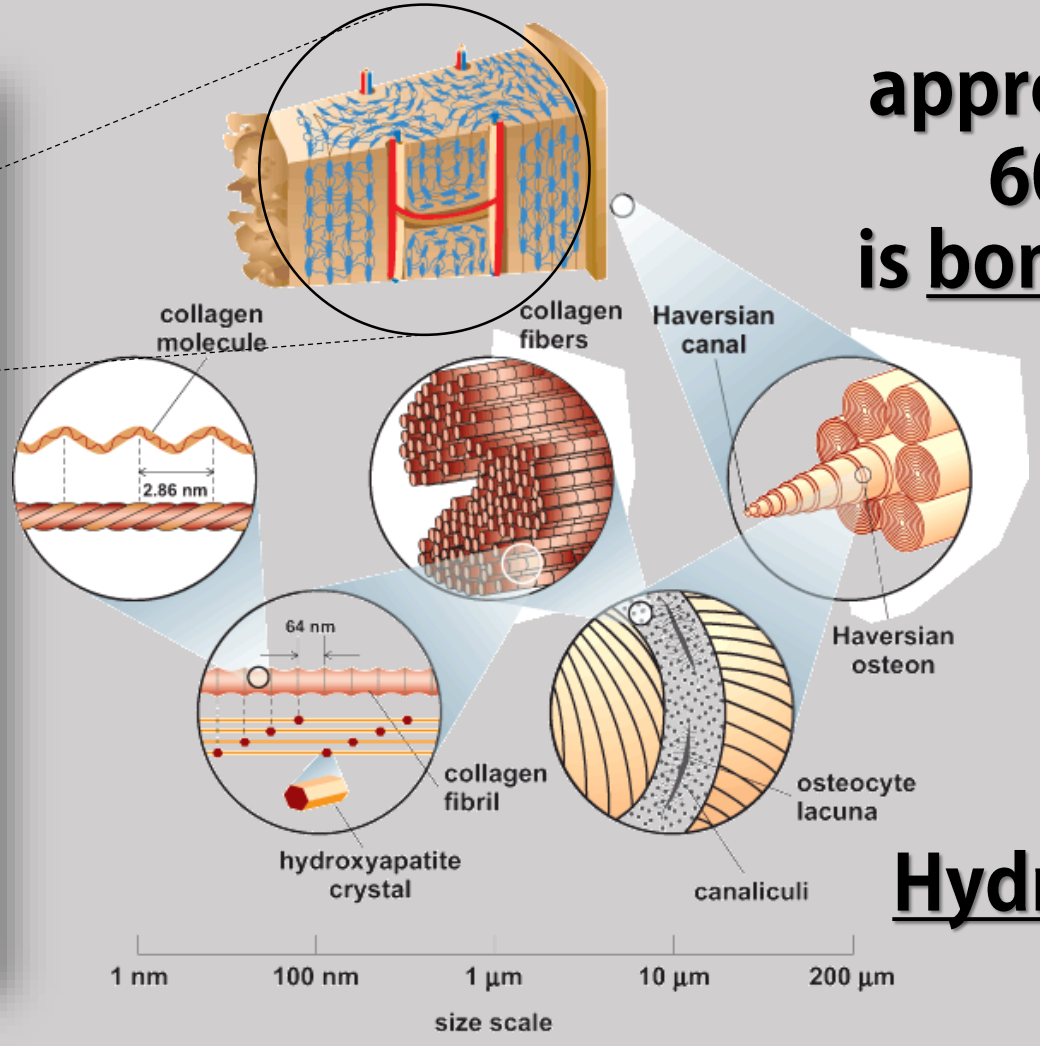


Blood Cell Production

Introduction

Bone structure





approximately 60-70% is bone mineral

↓

Calcium phosphate

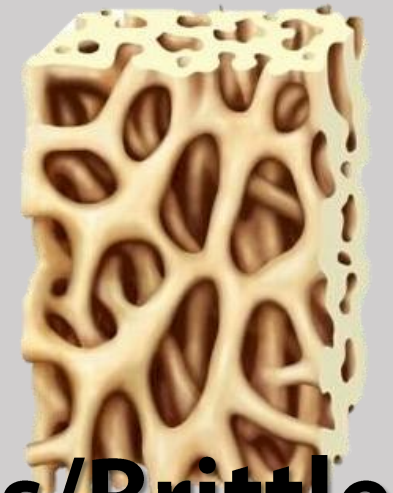
↓

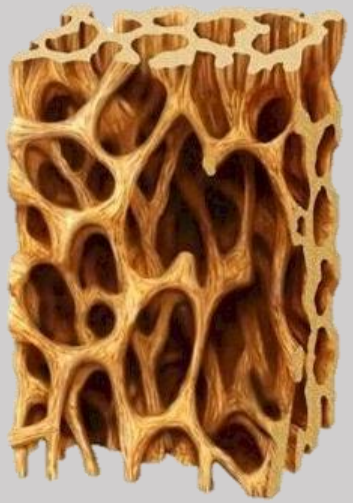
Hydroxyapatite

Introduction

Broken bone
loss bone

Accident





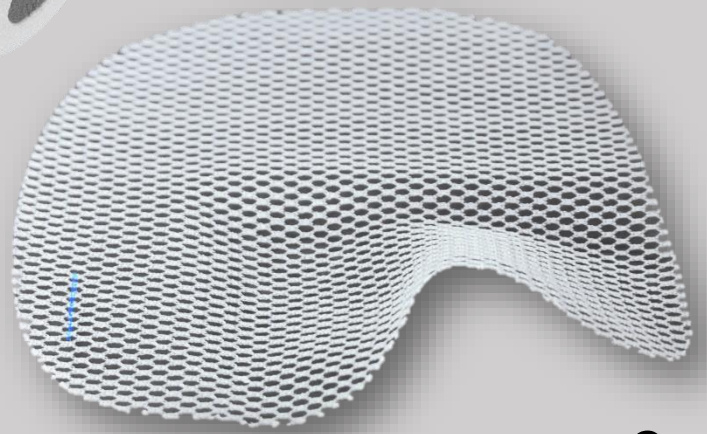
Porous/Brittle bone

Introduction

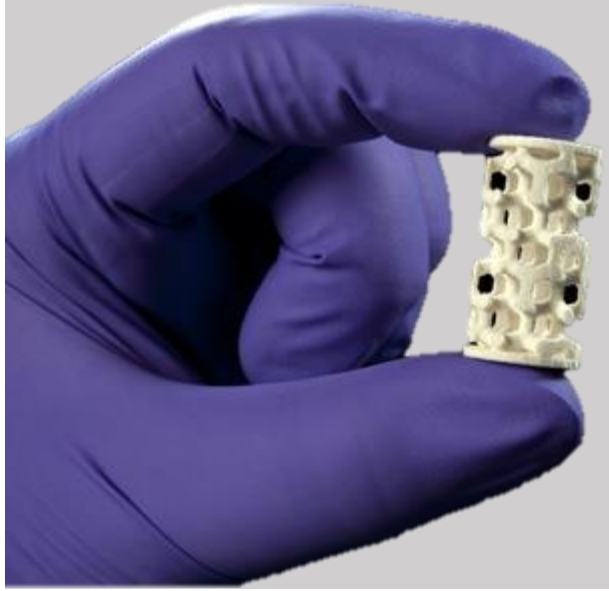
Bioinert

Bioactive

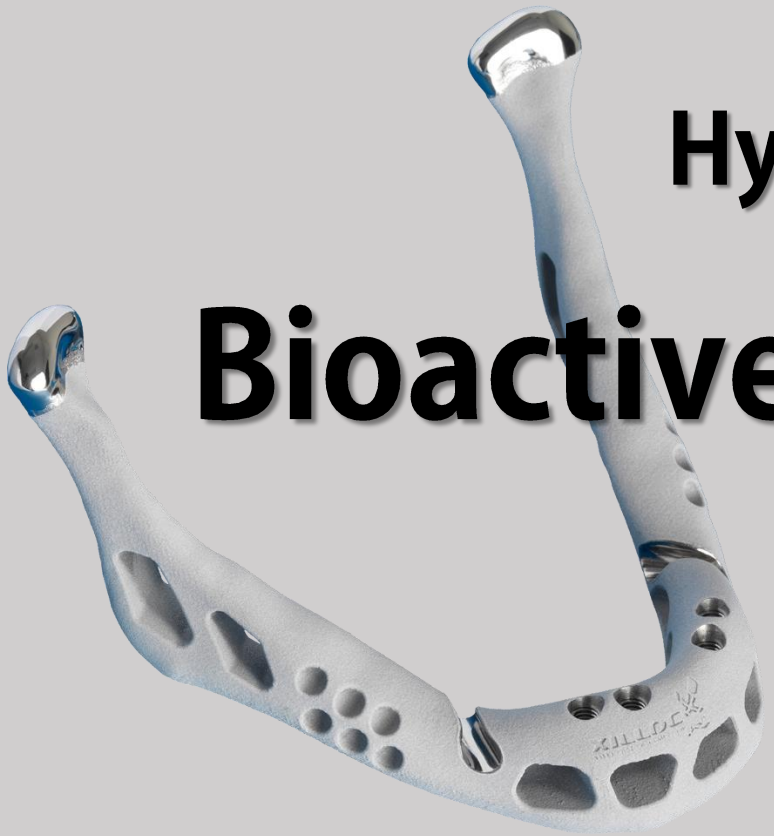
Bioresorbable



Bone replacement material



Introduction

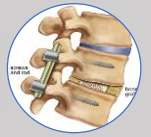


Bioactive

Hydroxyapatite

- Inorganic Mineral
- $Ca_{10}(PO_4)_6(OH)_2$
- Bone and Teeth
- Biocompatibility
- Bioactive ceramic

Applications

- Alveolar ridge augmentation 
- Maxillofacial reconstruction 
- Orbital implants 
- Spine fusion 
- Repair of bones defects 

Human bone contains 60%-70%

Introduction

Hydroxyapatite synthesizing

Hydroxyapatite

Calcium phosphate

Calcium ions

Phosphate ions

Sea shell

Coral reef

Bovine bone

Eggshell

Introduction

Why the eggshell can be used for synthesizing hydroxyapatite?

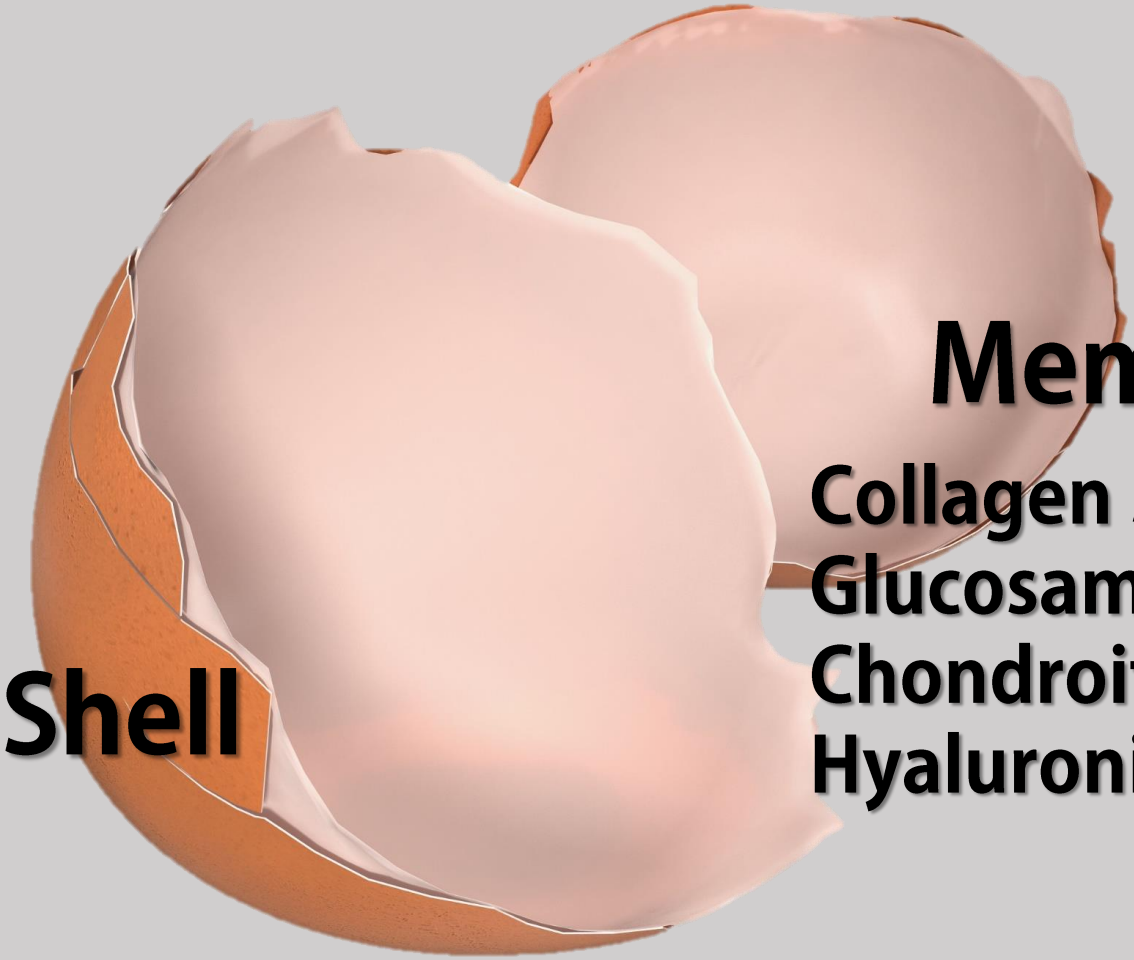
Calcium 95%

$CaCO_3$ 94%

$Ca(PO_4)_2$ 1%

Magnesium 1%

Organic 4%



Shell

Membrane

Collagen 35%
Glucosamine 10%
Chondroitin 9%
Hyaluronic acid 5-10%

Introduction

Some method to synthesis the hydroxyapatite

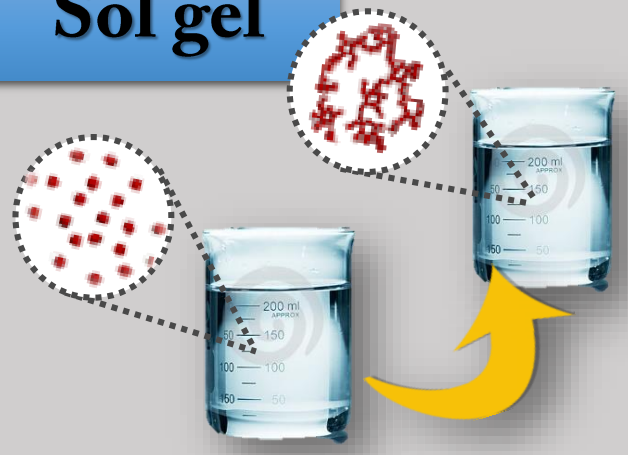
Solid state

Very low cost

Lack of purity

large particle

Sol gel



Small particle

20 - 50 nm

High cost of precursors

Wet chemical

Small particle

low cost

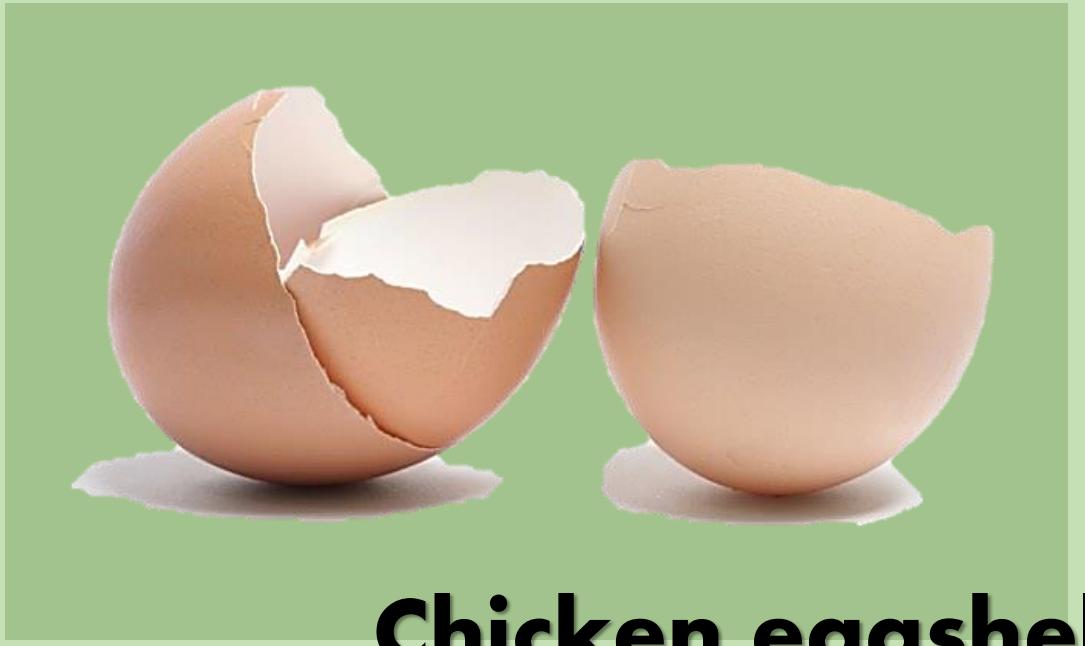
Easy to control

Objectives

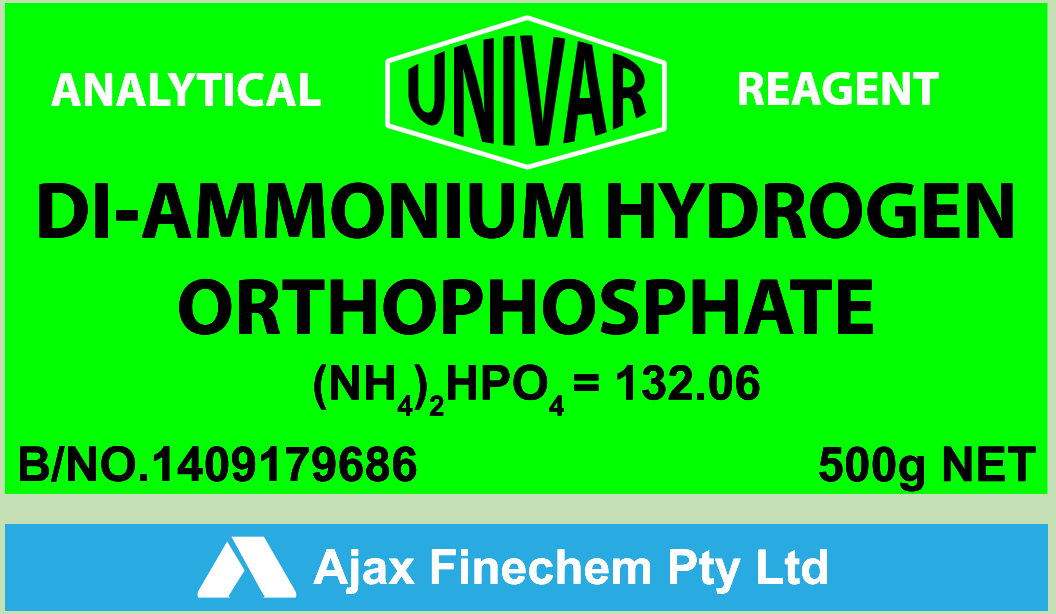
- To synthesis hydroxyapatite from waste eggshells.
- To study the effect of hydroxyapatite synthesizing under different temperature.
- To study the temperature effect on hydroxyapatite from waste eggshell.

Experimental details

Chemical precursors



Chicken eggshell



Experimental details

Hydroxyapatite synthesizing

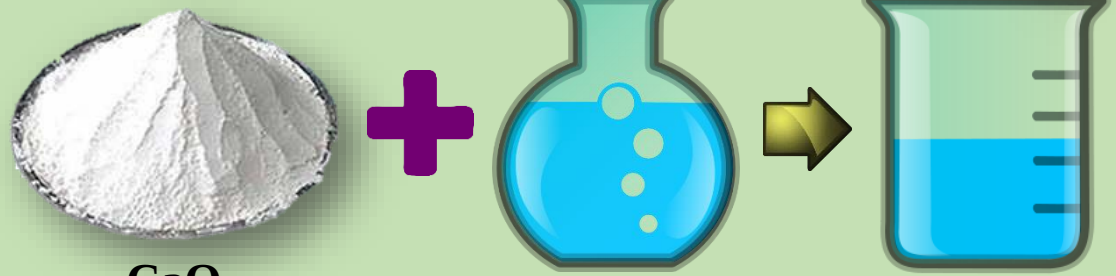
Heat at 1300˚c

$$CaCO_3 \rightarrow CaO + CO_2$$

Di-ammonium hydrogen orthophosphate

Di water

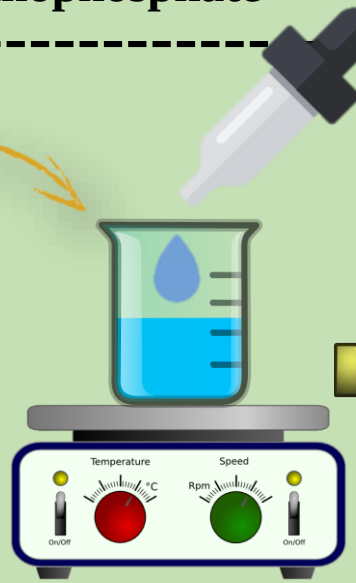
PO_4^{3-} Solution



CaO

DI water

$Ca(OH)_2$ Solution



Stir 30 min

Keep at 200 - 700ºc
4 H
Dried at 80 ºc
48 H

Hydroxyapatite

Experimental details

Sample characterization

All of sample

Heat at 200-800˚c

Furnace

XRD

FESEM

FTIR

Results & Discussions

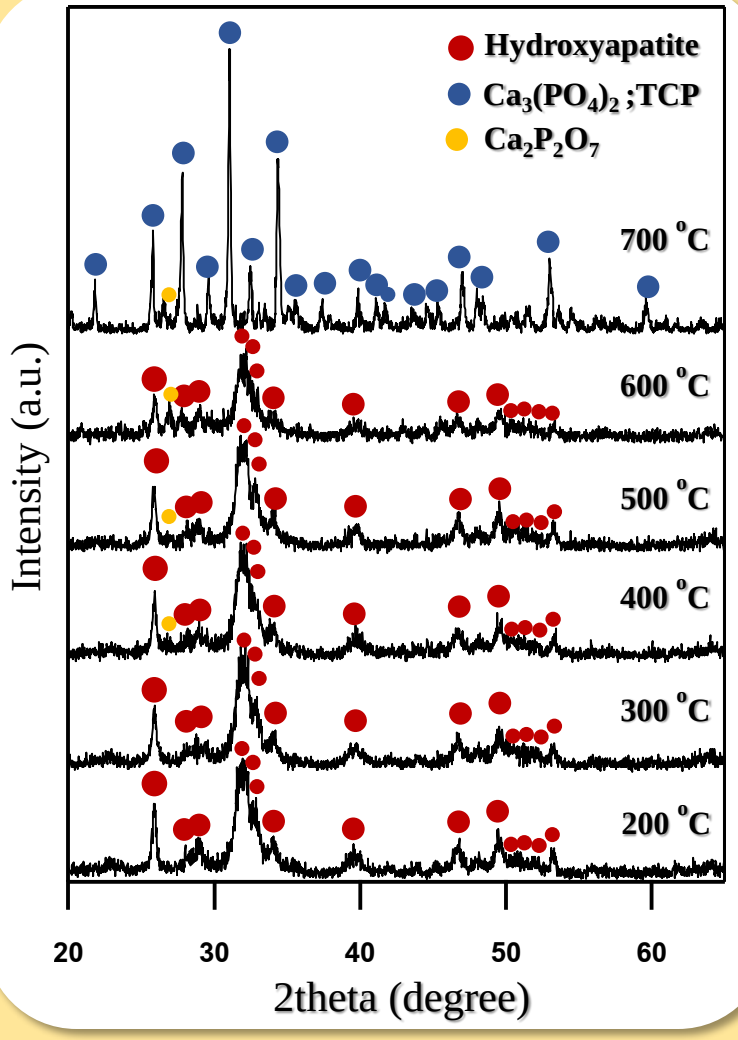


Figure 1. XRD patterns of hydroxyapatite were synthesized at various temperature.

Hydroxyapatite synthesizing

$$10Ca(OH)_2+6(NH_4)_2HPO_4 \rightarrow Ca_{10}(PO_4)_6(OH)_2+12NH_3+18H_2O$$

Hydroxyapatite decomposition

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

Wave number (cm^{-1})	Function Group
562 - 1095	(PO_4^{3-})
631	(OH^-)

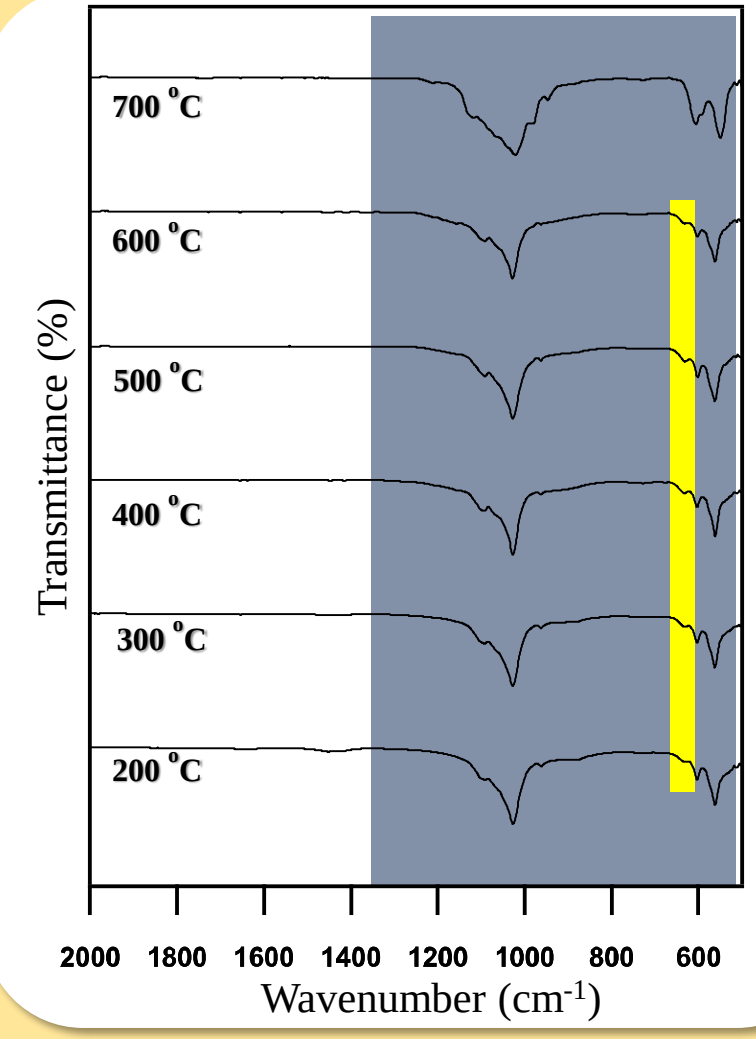


Figure 2. FTIR spectra of hydroxyapatite were synthesized at various temperature.

Results & Discussions

FESEM images of hydroxyapatite various synthesizing temperature.

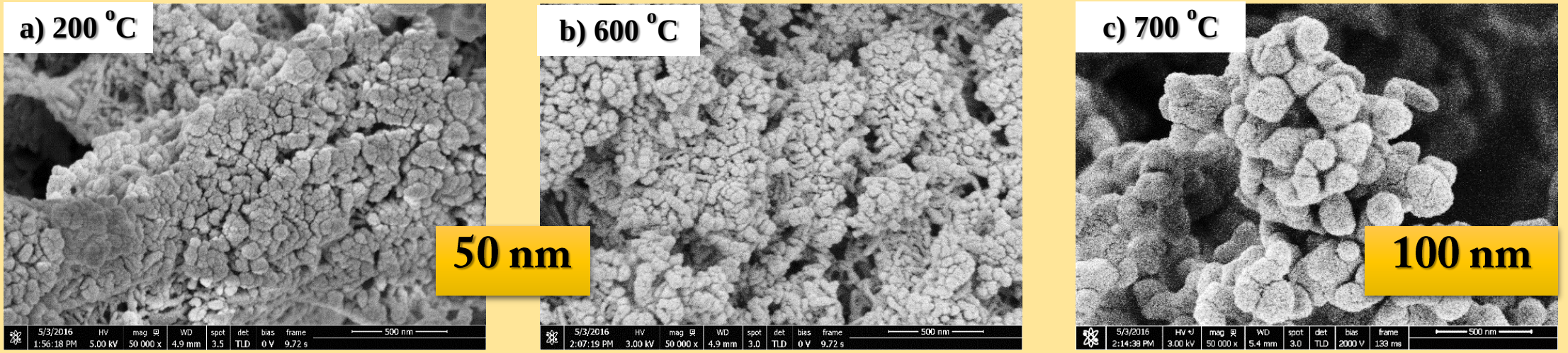


Figure 3. The FESEM images of sample powder were synthesized at various temperature.

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Results & Discussions

Temperature effect of Hydroxyapatite from chicken egg shell

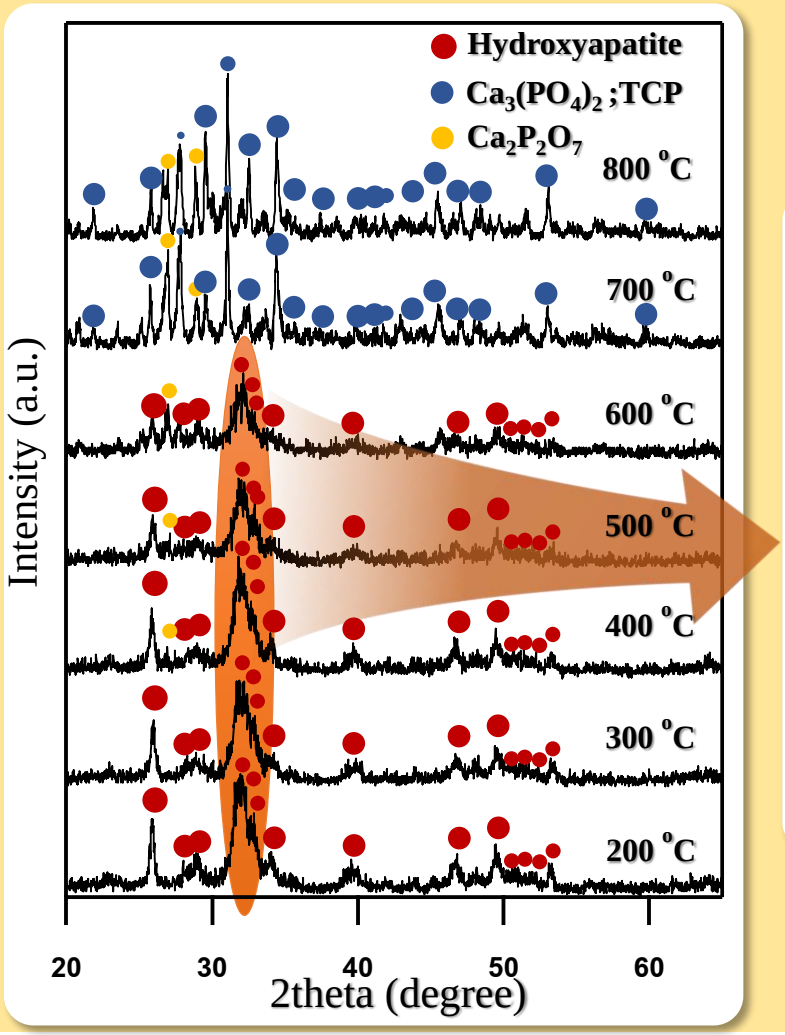

Figure 4. XRD patterns of hydroxyapatite were heated at various temperature.

$$D = \frac{0.9\lambda}{\beta \cos\theta}$$

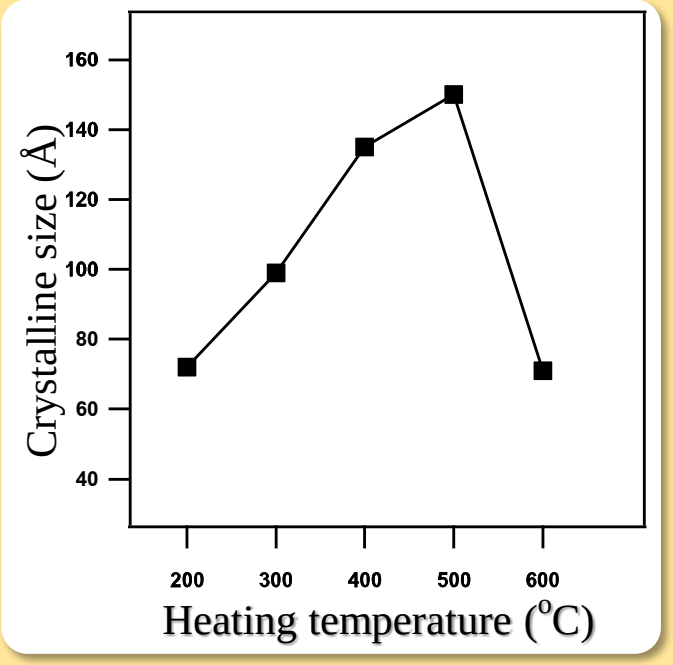

Figure 5. The crystal size of hydroxyapatite were heated at various temperature.

Conclusions

- Hydroxyapatite can be synthesized from waste eggshells by reaction of $Ca(OH)_2$ and $(NH_4)_2(HPO)_4$
- Hydroxyapatite transform to tri-calcium phosphate ($Ca_3(PO_4)_2$) at 700°c of synthesizing temperature.
- The particle size of hydroxyapatite synthesized from waste eggshells is around 50 nm.
- The crystalline size of hydroxyapatite increase with increasing the heating temperature and hydroxyapatite transform to $Ca_3(PO_4)_2$ after heat over 700°c.

References

1. Ghazanfari, S.M.H. and Zamanian, A., 2013, "Phase Transformation Microstructural and Mechanical Properties of Hydroxyapatite/Alumina Nanocomposite Scaffolds Produced by Freeze Casting", **Ceramics International**, Vol.39, pp. 9835-9844
2. Bigi, A., Foresti, E., Gandolfi, M., Gazzano, M. and Roveri, N., 1995, "Inhibiting Effect of Zinc on Hydroxyapatite Crystallization", **Journal of Inorganic Biochemistry**, Vol.58, pp. 49-58.
3. Elliott, J.C., Wilson, R.M. and Dowker, S.E.P., 2002, "Apatite Structures", **Advances in X-ray Analysis**, Vol. 1, pp. 172-181**.**
4. LeGeros, R.Z. and LeGeros, J.P., 1993, "Dense Hydroxyapatite", in **An Introduction to Bioceramics**, Hench, L.L. and Wilson, J., 2nd ed., World Scientific, Singapore, pp. 139-180.
5. Seo, H. J., Cho, Y.E., Kim, T., Shin, H.I. and Kwun, I.S., 2010, "Zinc May Increase Bone Formation Through Stimulating Cell Proliferation, Alkaline Phosphatase Activity and Collagen Synthesis in Osteoblastic MC3T3-E1 Cells", **Nutrition Research and Practice**, Vol.4, No.5, pp 356-361.


Thank you!