Introduction of hydroxyapatite and simulation analysis of different scaffolds to demonstrate the effect of hydroxyapatite in the fabrication of 3D printing filaments

- **This study contains a brief review of hydroxyapatite and then design and simulation of different bone scaffolds to define the composite material consisting of PLA, PHB, and Ha on the scaffold. in order to compare material a load of 200 N was applied to structures.**

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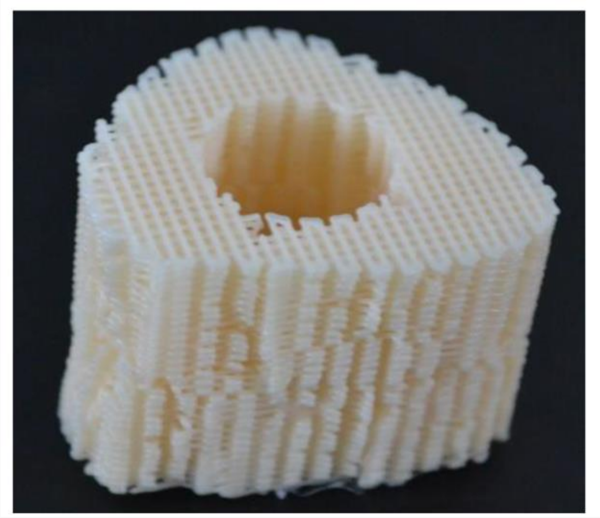
Motahareh Sadat Raziyan

Supervisor: Giedrius Janusas

Introduction

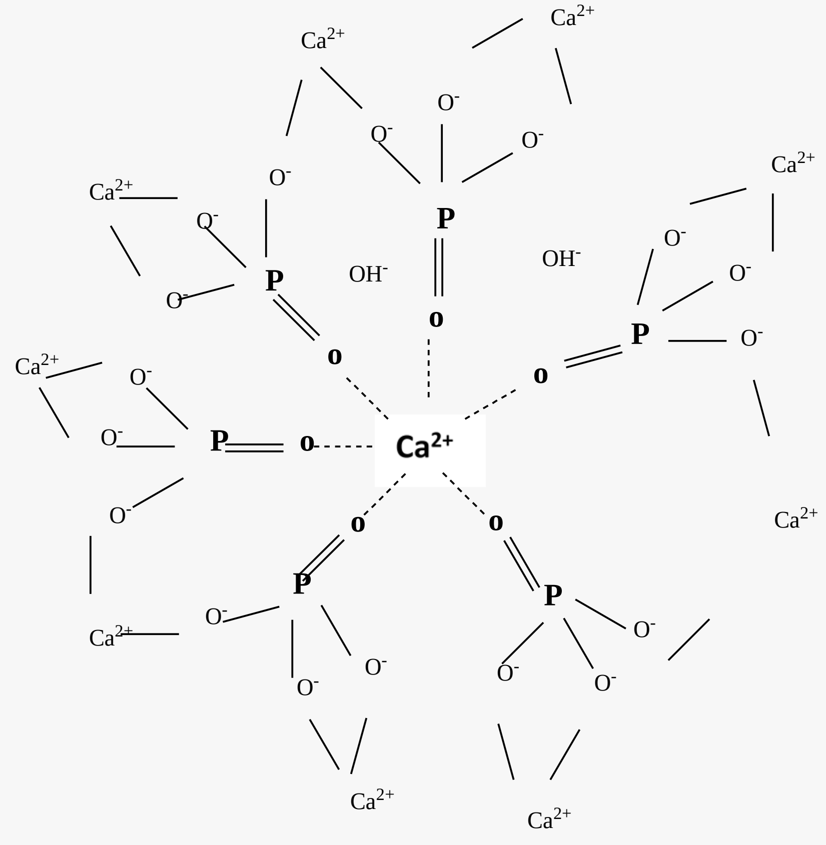
Tissue engineering scaffolds have become a research focus as it gives an anchored spatial structure and mechanical support for the cells while inducing the cells to create new bone



Design of the internal porous structure and the material utilized may have a significant impact on the mechanical properties of the scaffold. The pore size should be sufficient to facilitate the movement of nutrients, and porosity is critical to improve bone formation, nutrient transport, and the degradation rate of the scaffold in the human body.

Hydroxyapatite

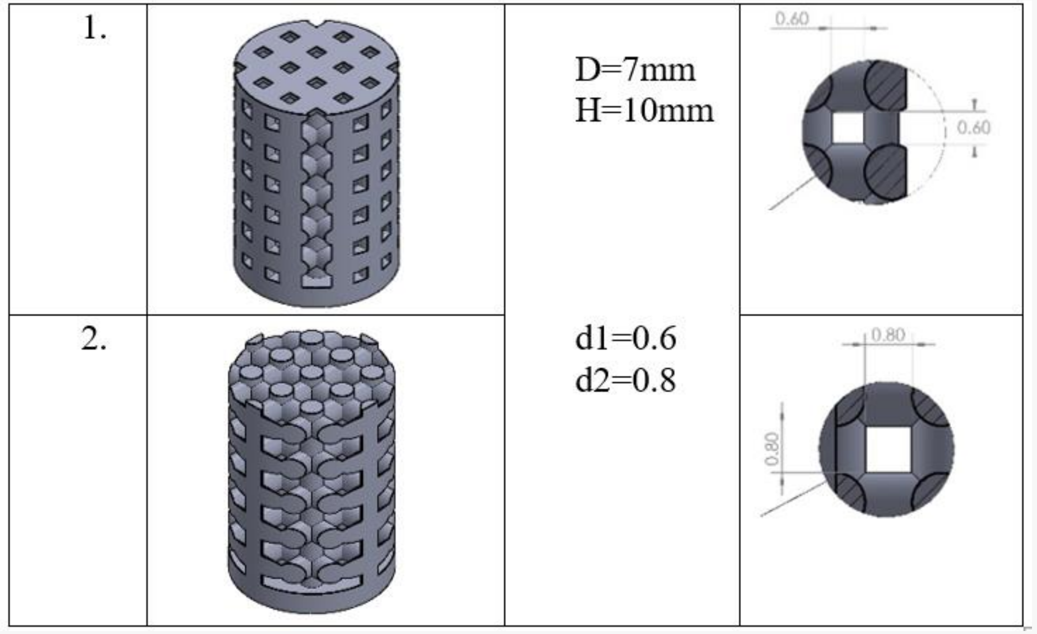
Is a naturally occurring mineral form of calcium apatite with the formula → **Ca10(PO4)6(OH)2**



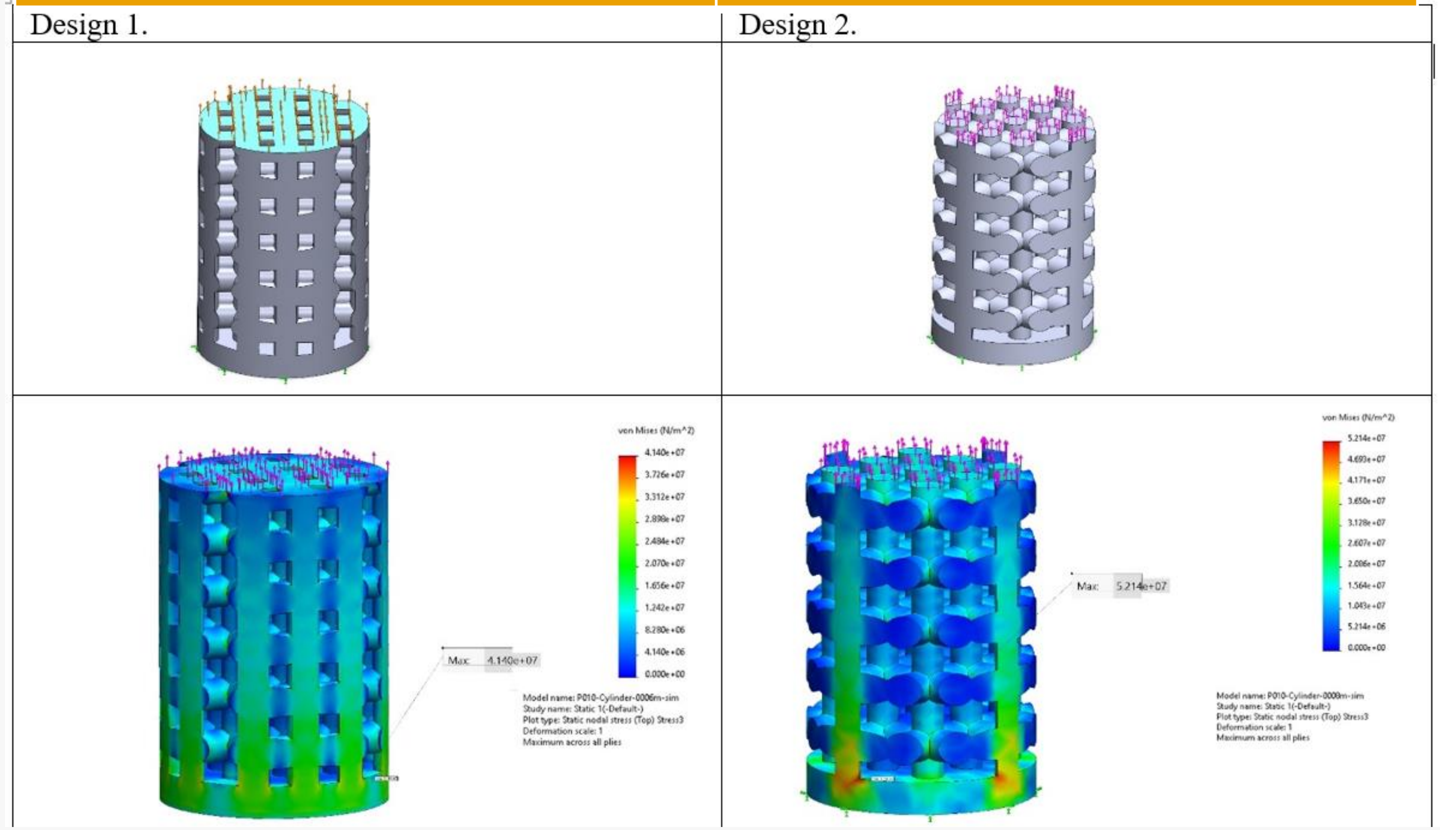
- Hap is a calcium ceramic compound and also exhibits brittleness, it also has very high compressive strength while having very poor tensile properties.
- HAP can be used directly in bone tissue engineering, or it can be doped with a variety of metallic or nonmetallic contaminants to modify its properties for further applications.

Design of the scaffold

Design, geometry information, and porosity view of two distinct shapes of a porous cylinder that depicts the scaffold.



$\sigma_{max} = 41.4\ MPa$	$\sigma_{max} = 52.14\ MPa$

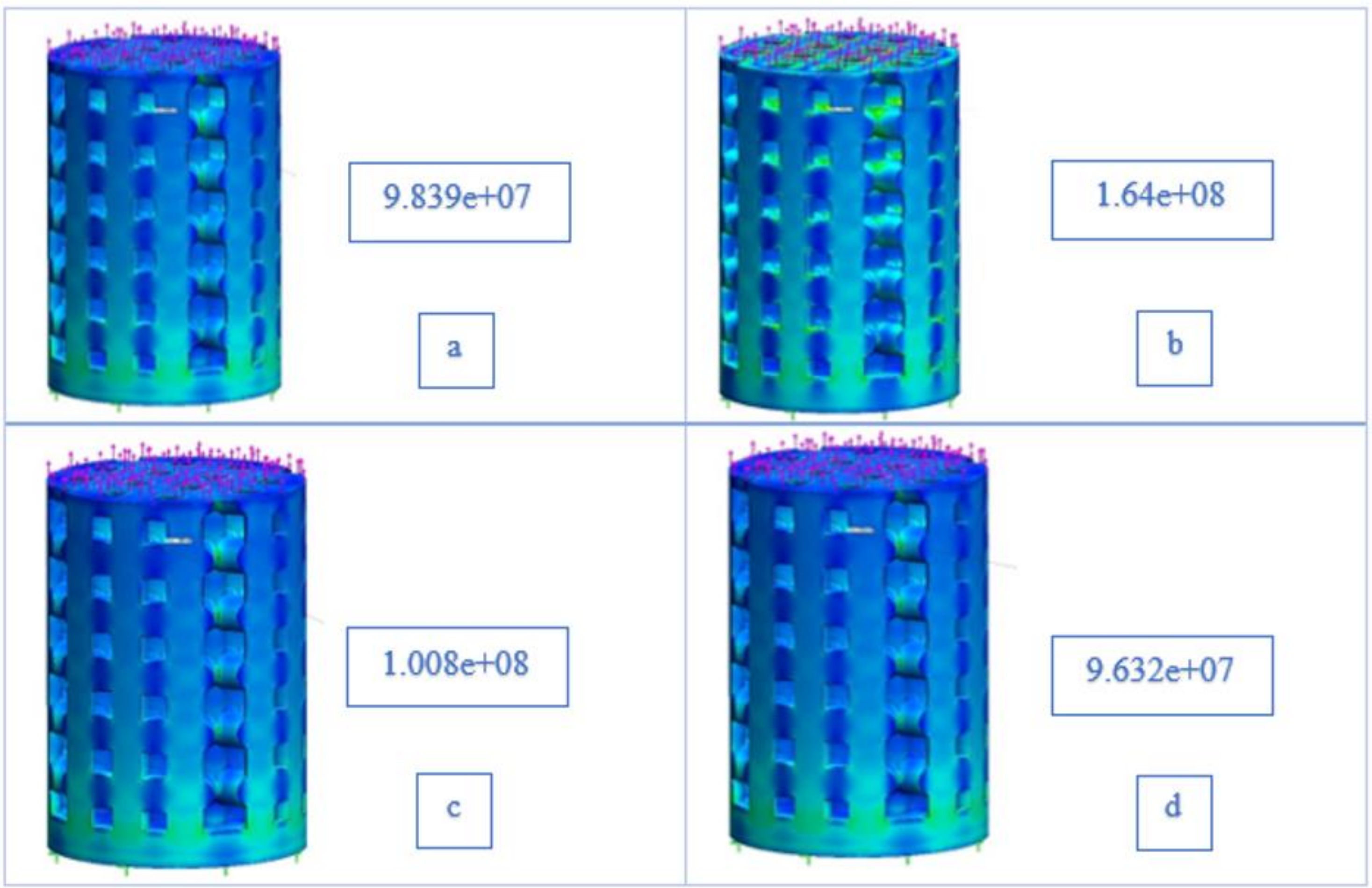


Since under the same loading conditions in both models, the maximum stress is lower in model 1, so it has more strength than model 2. Therefore, model 1 is used as the target model for other analyses.

Material combination and Simulation

Four different type of material combination were applied on the chosen scaffold (design 1), in Solid work.

Material were combined with given % wt in the table below:



Nr.	PLA	PHB	HA
a.	20	20	60
b.	30	30	40
c.	0	40	60
d.	40	0	60

Results and discussion

- ✓ Introduction of HA reduces the mechanical strength while increasing biocompatibility.
- ✓ When the position contains HA, the combination (d) has the lowest maximum stress, making it the strongest model.
- ✓ Considering that PLA improves mechanical resistance and barrier performance, it is a desirable combination, PHB is used to increase the crystallinity of PLA and hence its mechanical strength, which leads to design (a) consisting of 40% wt. of polymers combined and 60%wt. HA, the promising combination and the chosen design for future work in 3d printing matters.

Summary of all the applied combination and the stress obtained after applying the force 200N, has been

Model: 0.06cm			**F= 200N**			
Composite			σ_{max} (MPa)			
PLA (%)	PHB (%)	Hydroxyapatite (%)	PLA	PHB	Hydroxyapatite	Total
50	50	0	40.71	37.36	00	41.40
20	20	60	27.70	1.076	98.39	98.39
30	30	40	5.987	2.551	164.0	164.0
0	40	60	0.00	1.046	100.8	100.8
40	0	60	2.216	0.00	96.32	96.32

Conclusion

- Hydroxyapatite (HA) is widely used in biosensors due to its similarities to natural bone and teeth, remarkable biocompatibility, and interaction with human fluids.
- HA and its blends serve as matrix components for bioreceptor immobilization, offering a large surface area, stability, multiple absorbent sites, and biomolecule affinity.
- In bone scaffold production, two designs with different pore structures were modeled using Solid Works, with design one having a lower maximum stress (_max=41.4 MPa) than design two (_max=52.14 MPa).
- Design one, with a combination of polymers and HA, was selected for further investigation, resulting in the preferred combination (a) with _max=98.39 MPa, including HA, PLA, and PHB.
- Porosity analysis revealed that design number two had the best porosity, although all parameters played a role in deciding the chosen combination for fabricating the scaffold.

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