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Tampere University of Applied Sciences

Cleaning strategies for 3D-printed porous scaffolds used for bone regeneration fabricated via ceramic vat photopolymerization

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AffordBoneS
Personalized and affordable multi-substituted calcium phosphate scaffolds
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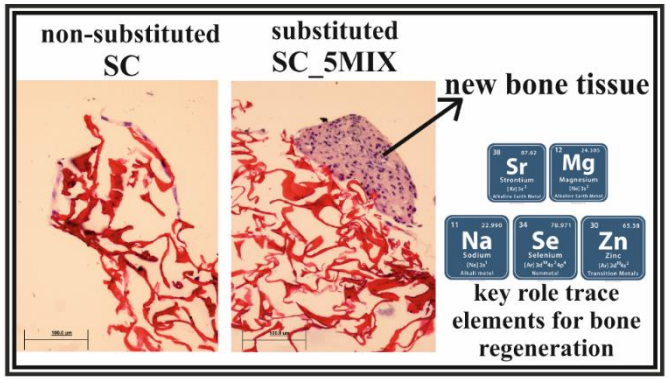
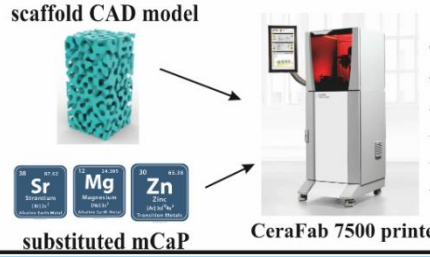


Objective 1/WP1

mCaP precipitation, design of mCaP scaffolds using CAD and scaffold fabrication

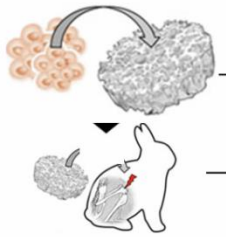


The mCaP scaffold properties accroding to the bone tissue engineering requirements:
-porosity: 50-90 %
-pore size distribution: 100-500 µm
-phase content: hydroxyapatite/tricalcium phosphate
-mechanical properties reqired for bone augmentation

Collaboration with : LITHOZ

Objective 2/WP2

***In vitro* and *in vivo* osteogenic properties of mCaP scaffolds**



***In vitro* cell culture in static and dynamic conditions**
-live/ded assay, Cell Counting
-quantitative reverse transcription polymerase chain reaction
-imunocytochemical and immunohistochemical staining
-histological staining

***In vivo* characterization during three months in rats**
-micro-computed tomography
-inflammation detection

Objective 3/WP3

Obtaining a demonstration of personalized mCaP scaffolds in collaboration with Planmeca

-obtaining CAD design according to the real patient cases provided by Planmeca

-printing costumized scaffolds on CaraFab 7500 using previously optimized printing parameters

Collaboration with : PLANMECA

Prof. Erkki Levänen

Dr. Erkka Frankberg

Prof. Susanna Miettinen

LITHOZ

Dr. Martin Schweintenwein

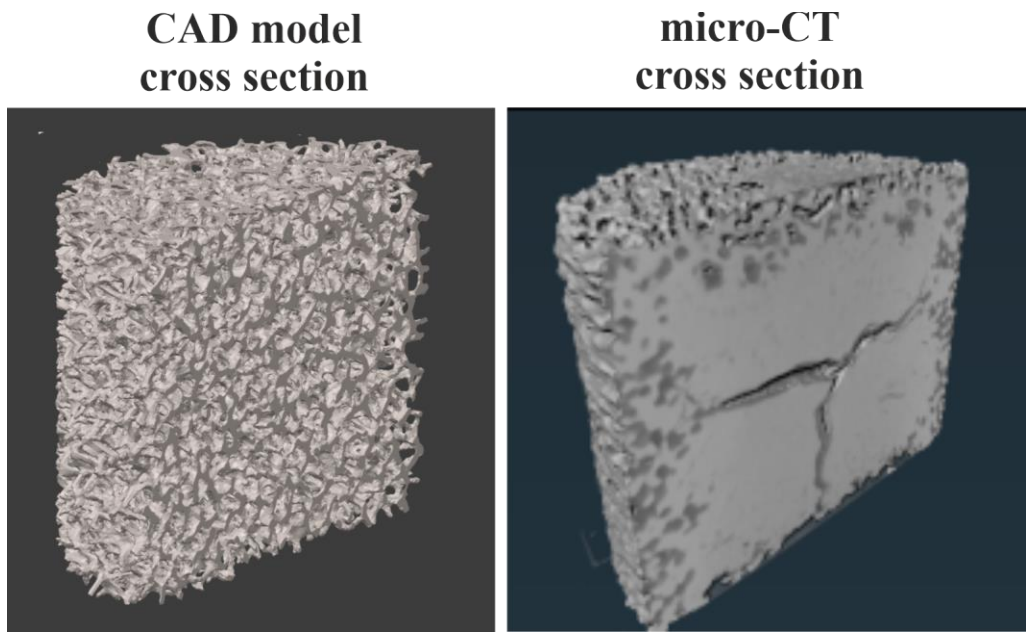
Pontus Degerlund

PLANMECA

Dr. Antonia Ressler

Cleaning challenge of porous scaffolds

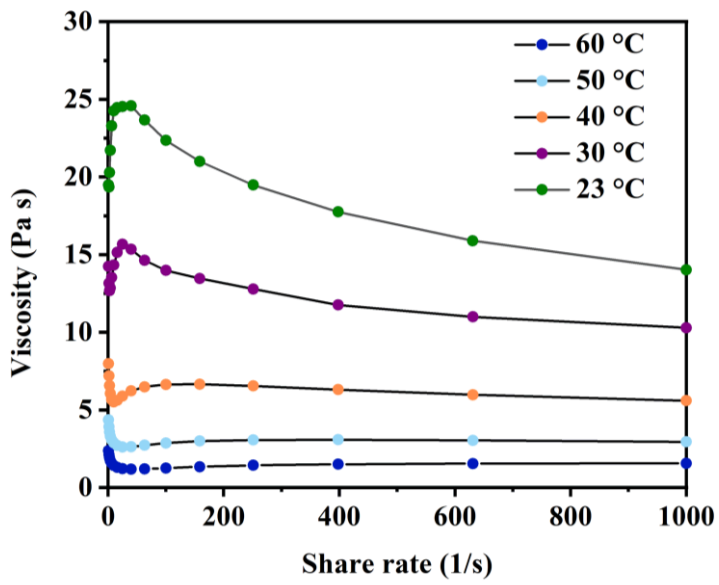
- porous structures where the interconnected pores are intentionally designed to remain uncured
- the uncured slurry in these porous regions can become intricately trapped between the cured layers, complicating the cleaning process
- effectively removing the uncured slurry from within the intricate and porous geometries of the printed structures becomes a critical task as the presence of residue within the structure can obstruct pores during sintering
- biomedical implants → pore characteristics are crucial for tissue integration and substance exchange.

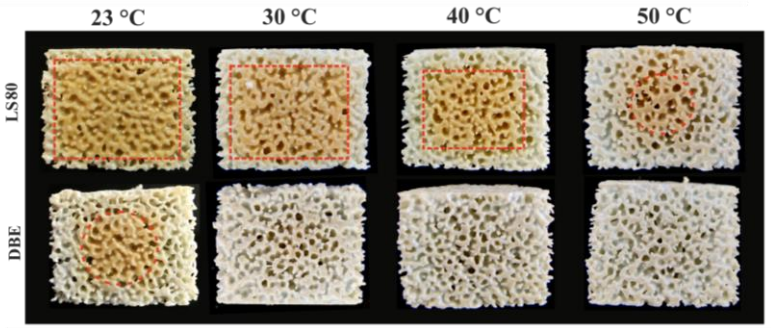


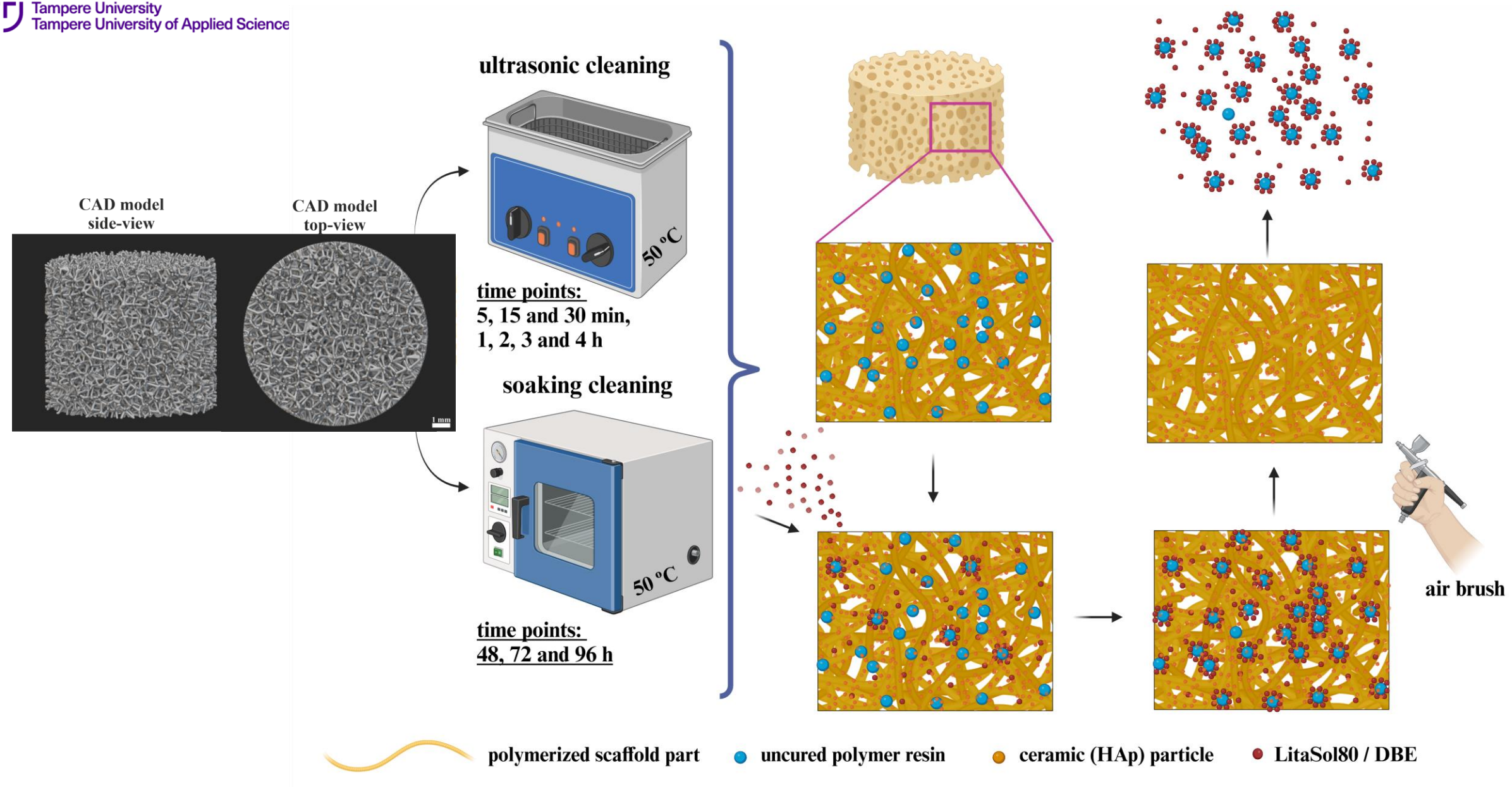
Preliminary experiments

- Increasing the temperature is effective in lowering viscosity and improving slurry flowability, leading to enhanced cleaning of the as-printed structures

- the difference in viscosity of slurry at 50 and 60 °C was small, leading to the exclusion of 60 °C from further studies to mitigate any risk of thermal polymerization of the ceramic slurry during the cleaning process

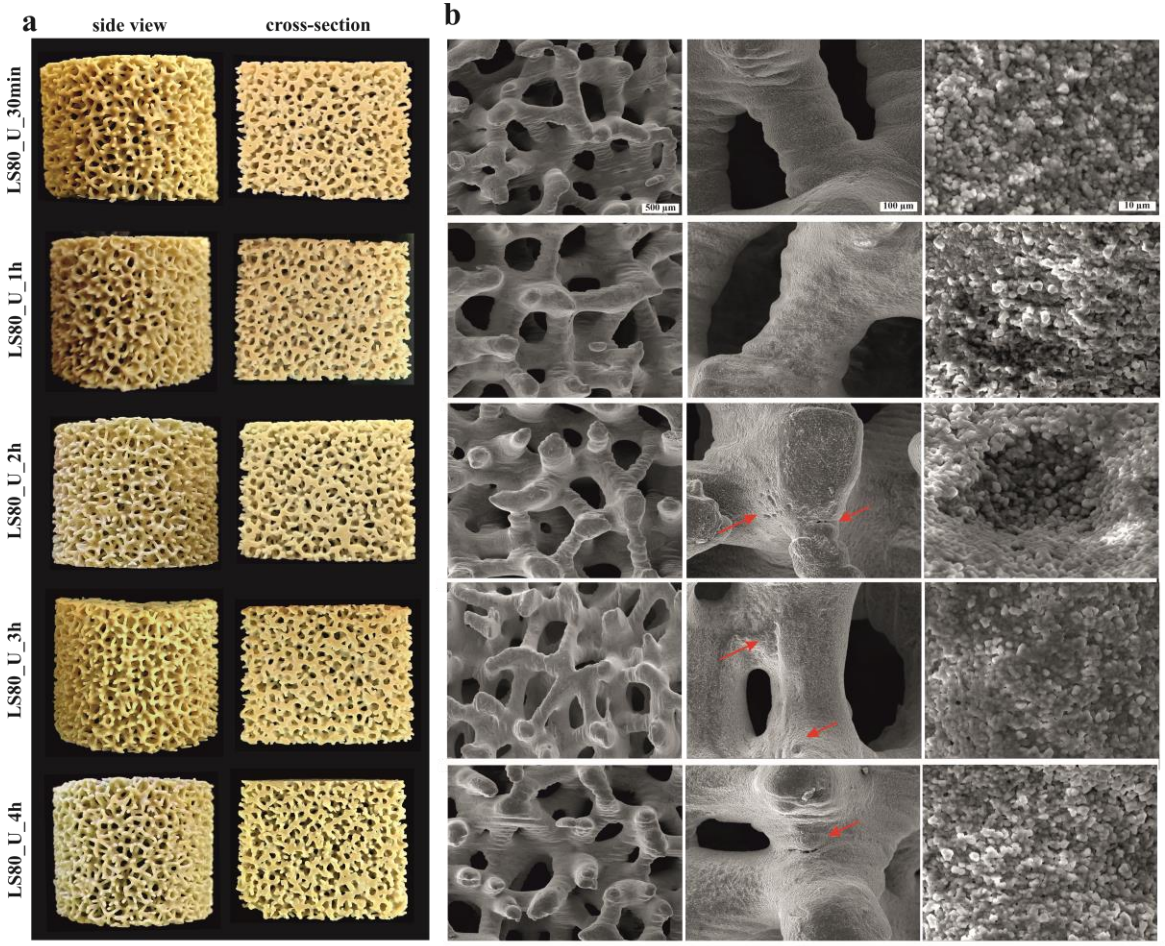




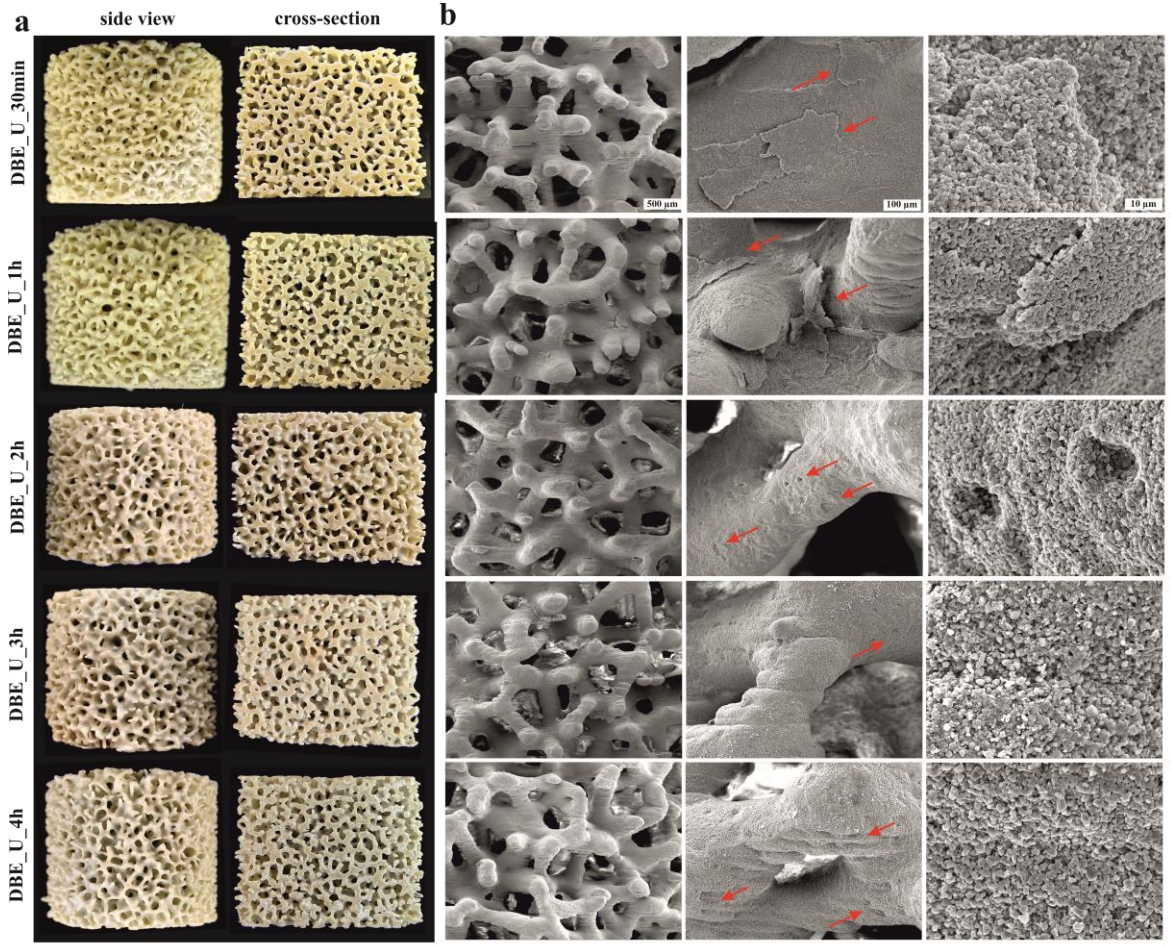

CAD model
side-view
CAD model
top-view
1 mm
ultrasonic cleaning
50 °C
time points:
5, 15 and 30 min,
1, 2, 3 and 4 h
soaking cleaning
50 °C
time points:
48, 72 and 96 h
air brush
polymerized scaffold part
uncured polymer resin
ceramic (HAp) particle
LitaSol80 / DBE

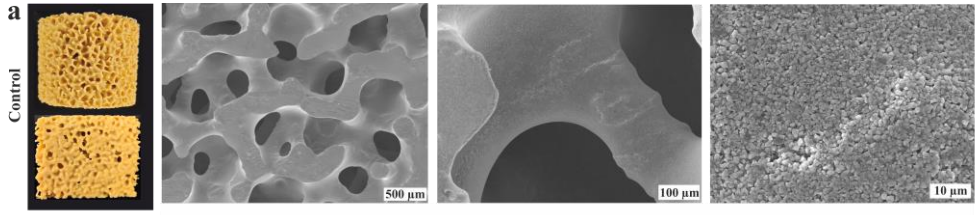
Morphological characterization - ultrasonication

LithaSol 80

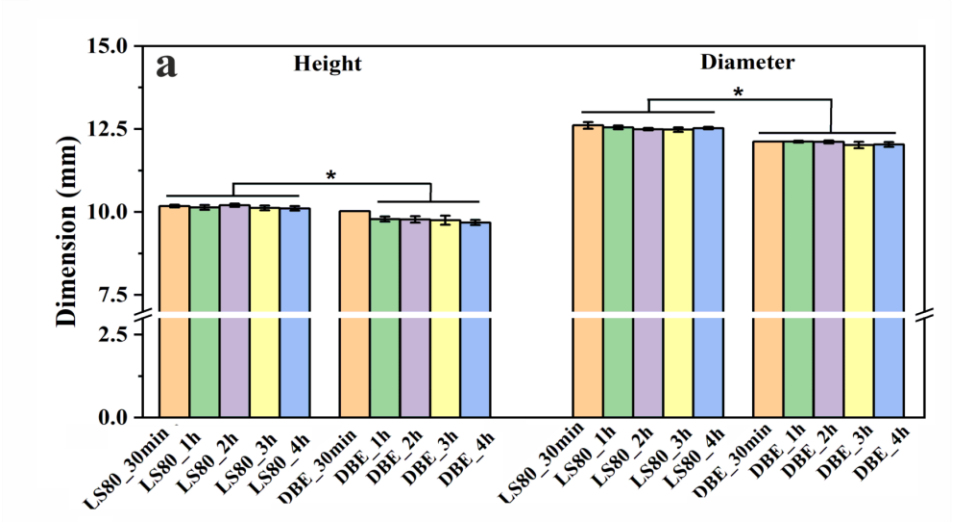


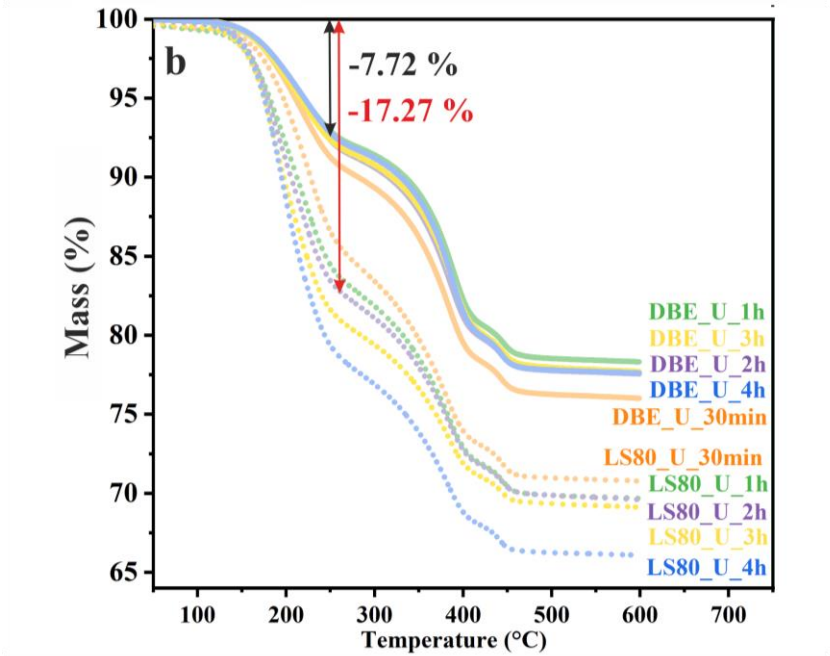
DBE





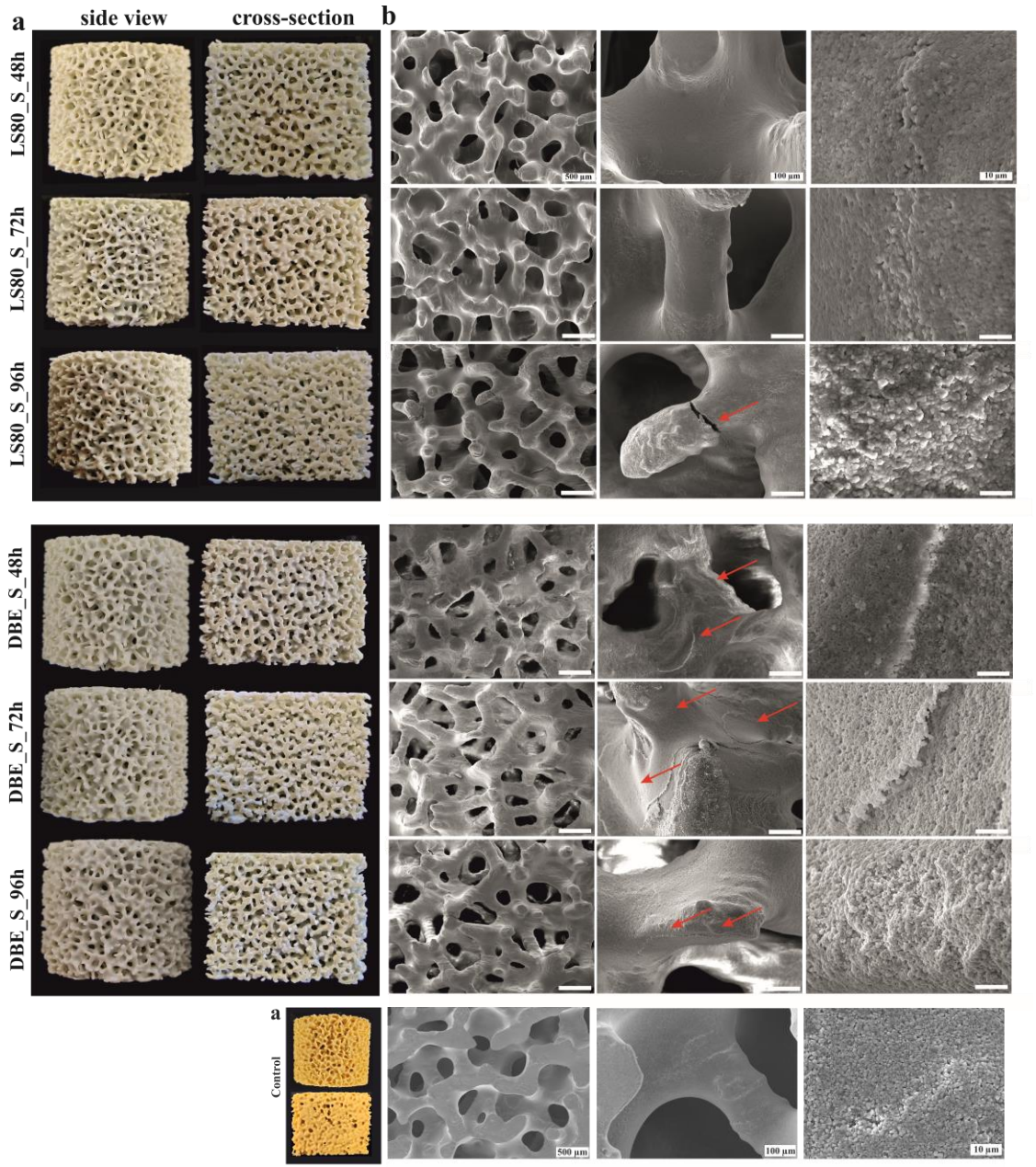
Scaffolds dimensions and thermal stability

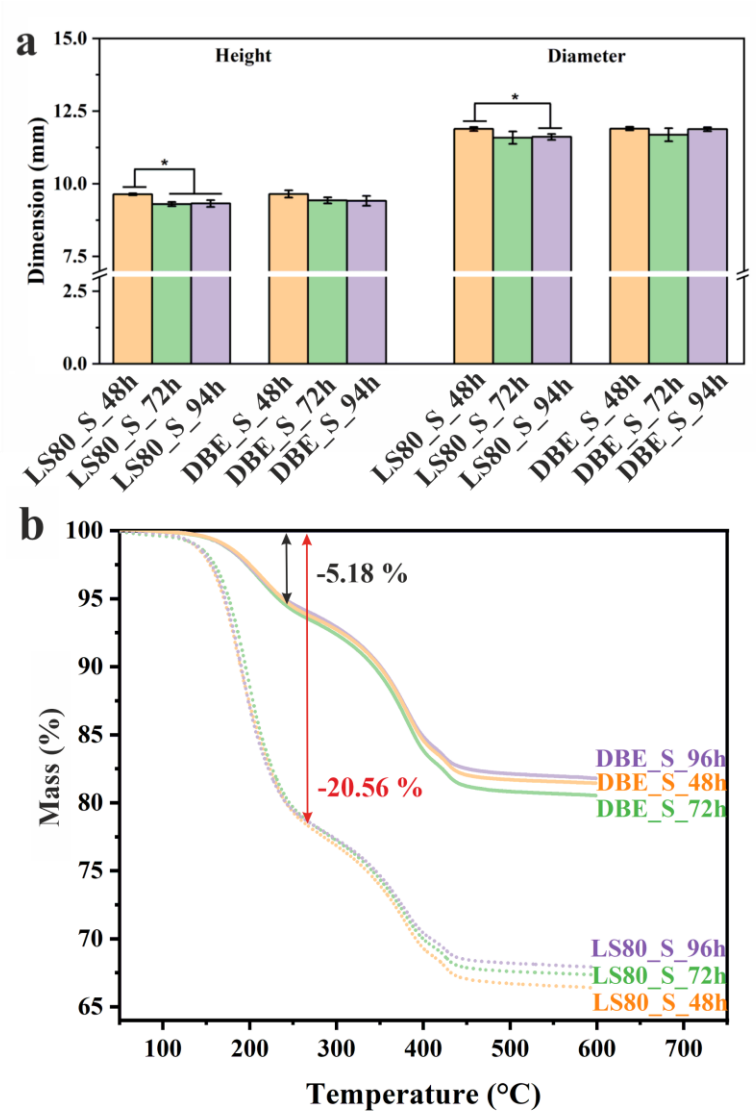




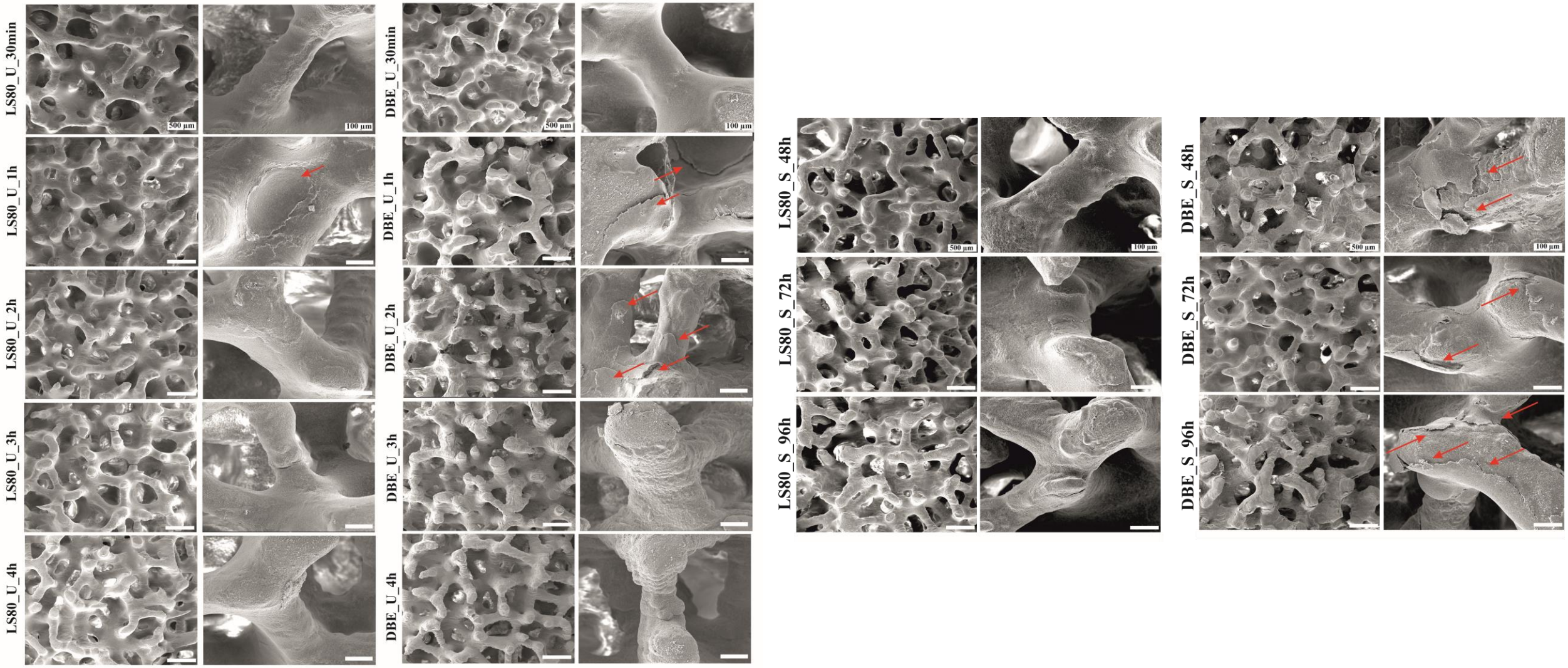
- mass loss started at approximately 150 °C, primarily attributed to the diffusion and evaporation of additives, unreactive diluents and uncured slurry
- the degradation of the major cured organic components initiated around 250 °C
- the significant contrast in the TG curves between scaffolds treated with LithaSol 80 and DBE primarily lies in the initial stage of weight loss
- the observed difference in total mass loss (14.15%) between samples treated with Lithasol 80 and DBE implies the potential occurrence of chemical debinding during cleaning with DBE. However, further detailed examination is required to provide conclusive evidence

Morphological characterization - soaking

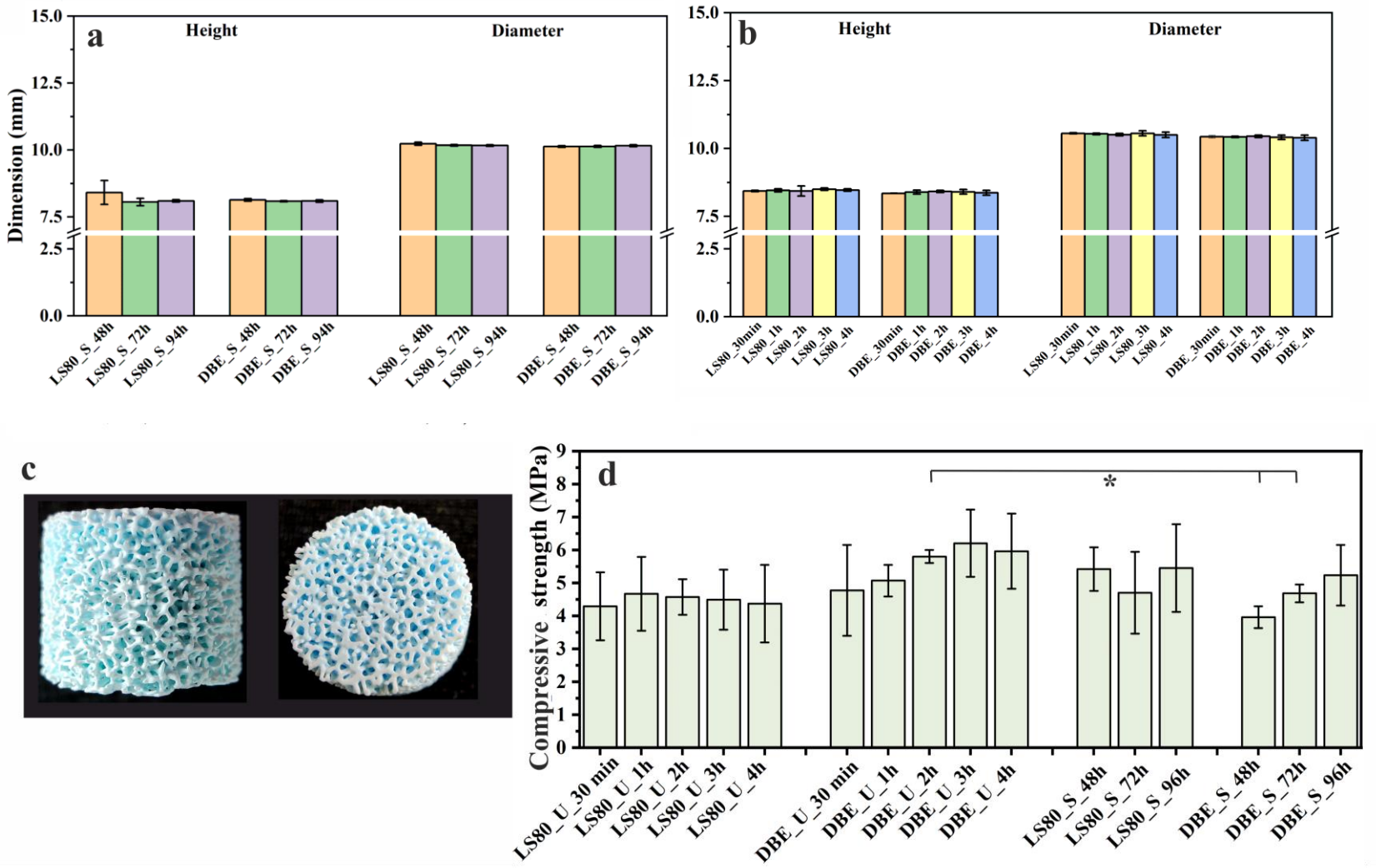




Morphological characterization – sintered samples



Scaffold dimensions and mechanical properties – sintered samples



Conclusion…

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Thank you for your attention!

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