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In silico characterization of micro-CT based bioactive glass-ceramic scaffolds / D'Andrea, L.; A, ; Cet, De; Gastaldi, D.; Bains, F.; Verne', E.; Orlygsson, G.; Vena, P.. - STAMPA. - (2023), pp. 1-1. (Intervento presentato al convegno CMBBE 2023 Symposium – 18th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering tenutosi a Paris nel 3-5 May 2023).

Availability:

This version is available at: 11583/2984120 since: 2023-11-27T11:34:35Z

Publisher:

Congress press

Published

DOI:

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IN SILICO CHARACTERIZATION OF MICRO-CT BASED BIOACTIVE GLASS-CERAMIC SCAFFOLDS

Luca D'Andrea (1), Anna De Cet (1), Dario Gastaldi (1), Francesco Baino (2), Enrica Verné (2), Gissur Orlygsson (3), Pasquale Vena (1)

1. Politecnico di Milano, Department of Chemistry, Materials and Chemical Engineering, Italy; 2. Politecnico di Torino, Italy; 3. Innovation Center Iceland (ICI), Iceland

1. Introduction

As the application of bone tissue engineering scaffolds becomes widespread, experimental studies on the effects of different materials and production methods are becoming increasingly complex. Computational models [1] can substantially reduce both the costs and the duration of the development process of these devices.

The morphological and mechanical properties of glass-ceramic scaffolds manufactured through foam replication have been investigated through μ CT-based computational models.

2. Materials and Methods

The scaffolds characterized were obtained using an experimental composition of SiO_2 -based glass-ceramic called 47.5B-32 [2]. Six different temperatures, ranging from 600°C to 850°C, were used during the sintering process.

The 3D reconstruction of the scaffolds was carried out through μ CT images (pixel size 5 μm); two scaffolds for each sintering temperature were considered. The porosity, strut thickness and pore size were determined to characterize the morphology of each cylindrical scaffold, one of which is shown in figure 1.

The mechanical characterization was carried out through finite element based simulations with the ParOSol solver. Through an iterative algorithm allowing for damage-based material evolution [1], longitudinal compression was applied to obtain elastic and strength properties. To appropriately represent the tension-compression strength mismatch of the material, the Drucker-Prager criterion was used.

3. Results

The scaffold porosity varies between 50% and 80%. The average pore dimension for sintering temperatures lower than 700°C is 200-800 μm , while higher temperatures present both large

pores (200-800 μm) and smaller pores (<100 μm). Strut thickness decreases with sintering temperature from 400 μm to 60 μm .

The elastic and strength values of the scaffolds, normalized in respect to the composing material values, also vary between different sintering temperature, ranging from 0.5 to 0.15 and from 0.05 and 0.2 respectively.

4. Discussion and Conclusions

Two sets of scaffolds have been defined, based on sintering temperatures due to morphological and mechanical differences: scaffolds sintered below 690°C, the material's crystallization temperature [2], evidence large pores and thick struts; scaffold sintered at higher temperatures present both large and small pores, reducing the average strut thickness and pore size.

The algorithm used allows for the visualization of the fracture patterns inside the structure. Comparisons with experimental data [2,3] obtained from the same scaffolds that were computationally reconstructed were carried out to confirm the validity of the methodology.

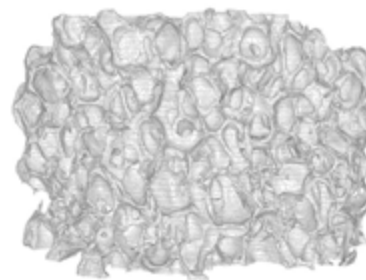


Figure 1: 3D computational reconstruction of a scaffold sintered at 600°C.

5. References

1. E. Farina et al., Acta Mech. Sinica 37(2) 292-306 (2012).
2. E. Fiume et al., Acta Biomater. 119 405-418 (2021).
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