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Parameter Optimization for Controlled Deposition of Bioglass Hydrogels by Direct Extrusion for Tissue Engineering

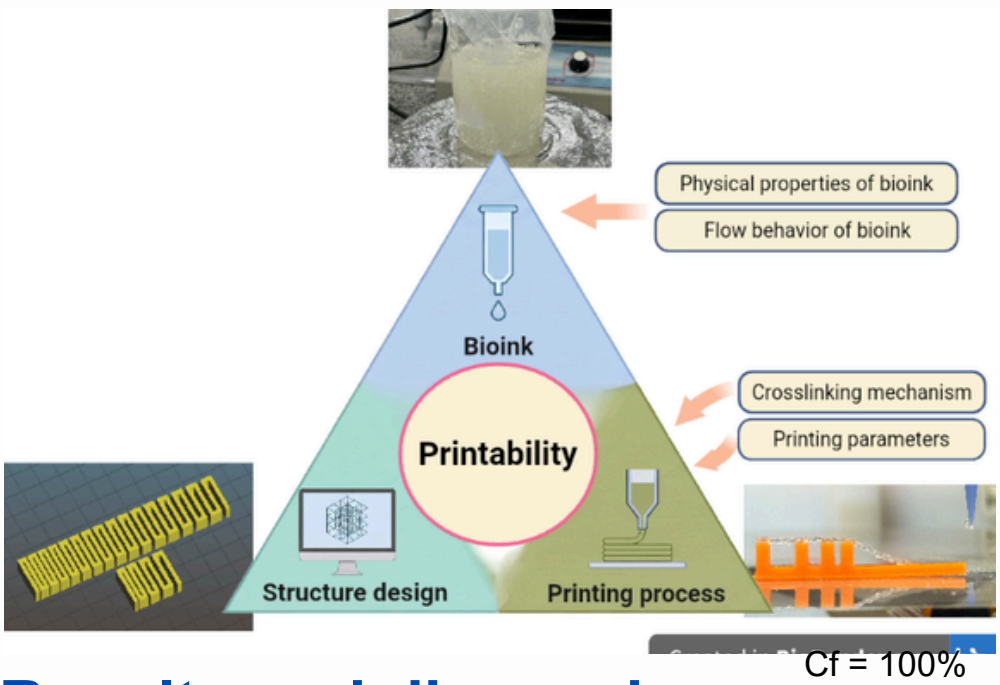
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Introduction

Bone defects represent a global health issue. In this context, bioactive glasses stand out as bioactive and osteoconductive materials, as they form a hydroxyapatite layer that interacts with the host tissue. The Stöber sol-gel route enables the production of SiO_2-CaO nanoparticles (BGNs), while collagen- and CMC-based inks show promise for the fabrication of scaffolds via robocasting.

This study involved the synthesis and characterization of these nanoparticles and evaluated the printability of hydrogel-based inks (Coll1 and Coll2) using a filament collapse test.

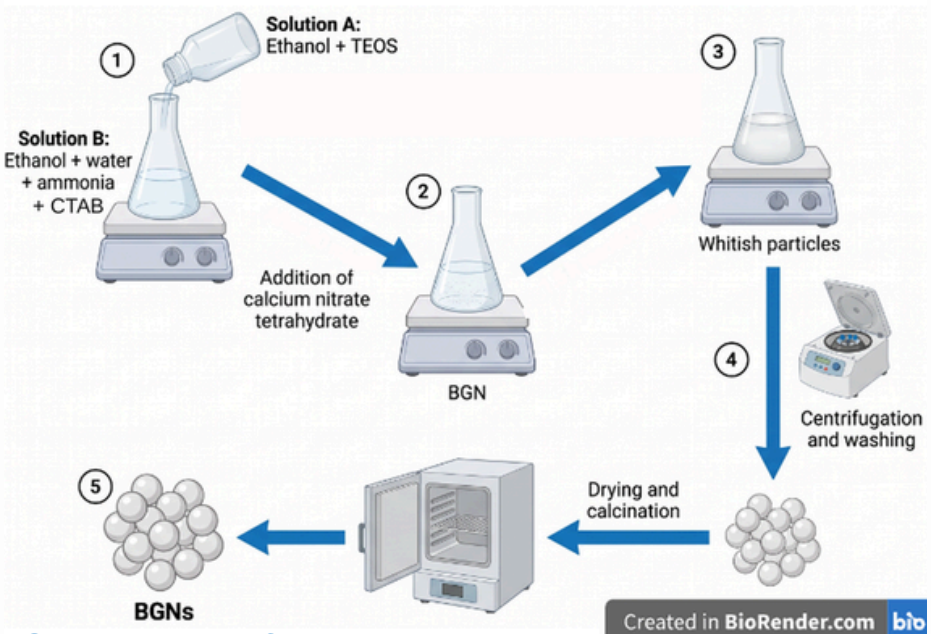


Objectives

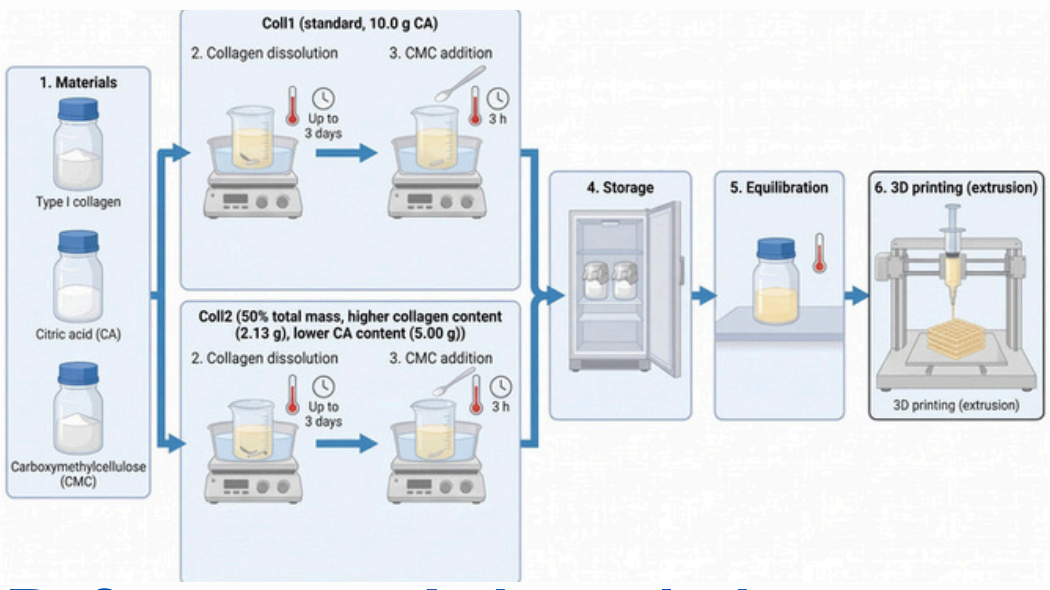
- Synthesize bioactive glasses in the SiO_2-CaO system via the sol-gel method.
- Characterize the physicochemical properties of the obtained glasses.
- Formulate inks consisting of type I collagen, citric acid, and CMC in varying proportions for 3D printing.
- Evaluate the printability via filament collapse test (FCT).

Methodology

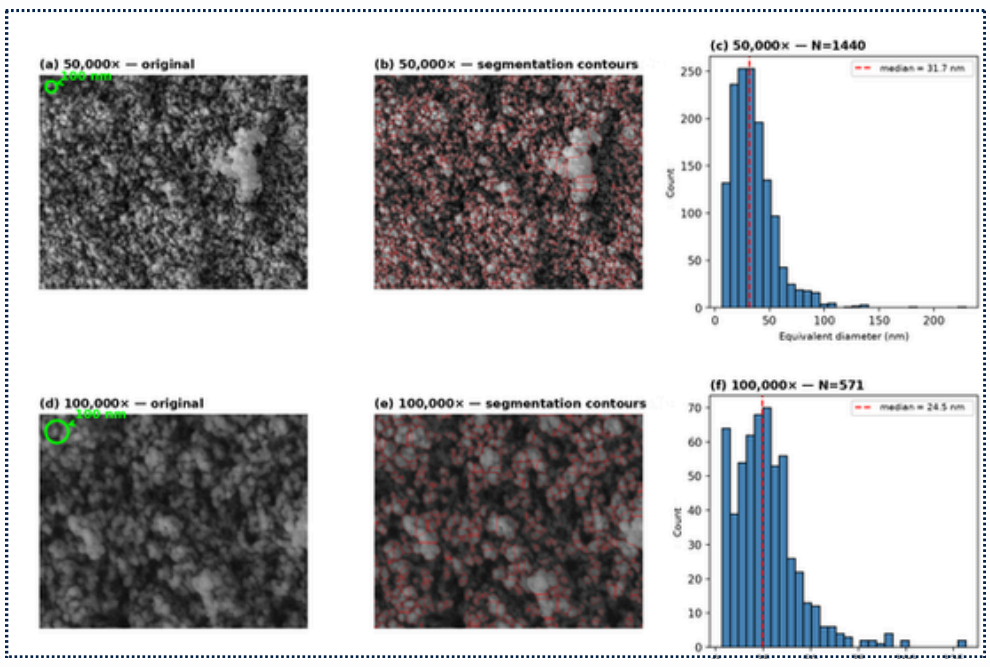
Synthesis of BGNs



Synthesis of hydrogel-based inks

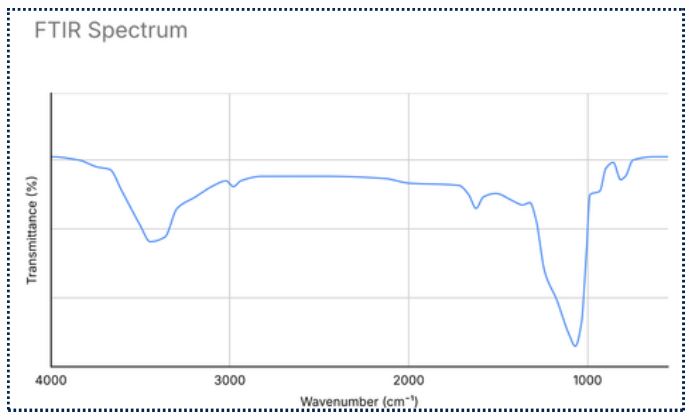


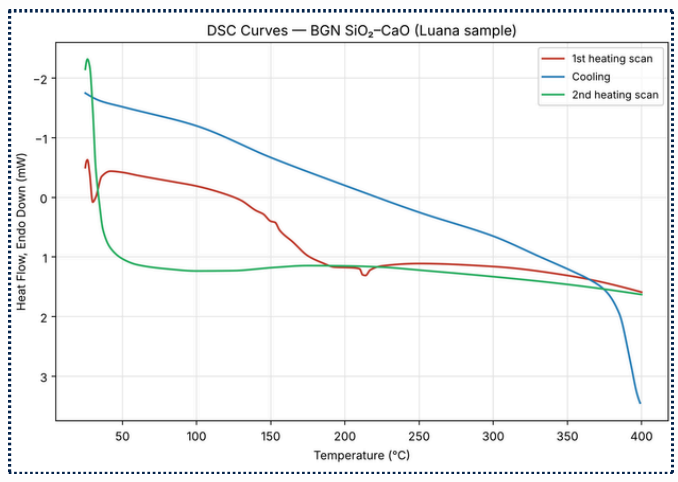
Results and discussion



The images observed via FEG-SEM revealed particles (~30 nm) with zeta potential (−11.7 mV) and DLS measurements (729.5 nm; PdI = 1.0).

XRD revealed an amorphous halo at 2θ ≈ 23°, which was corroborated by the presence of Si–O–Si bands in the FTIR spectra (~1086 cm^{-1}).





DSC indicated thermal stability up to 400 °C, with only dehydration occurring.

Conclusions

- SiO_2–CaO bioactive glass nanoparticles were successfully produced using a modified Stöber method.
- The particles are amorphous and thermally stable up to 400 °C.
- DLS and FEG-SEM showed significant agglomeration, so their dispersion needs to be optimized.
- The Coll1 and CMC ink showed good printability (Cf = 100%) and adequate stability after printing.
- Future works combine both systems into a single ink for 3D printing bone scaffolds.

References

Acknowledgments

ProCer processing ceramics
Central de Análises
LCME