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Sintered β-TCP/Bioactive Glass composites for bone replacement

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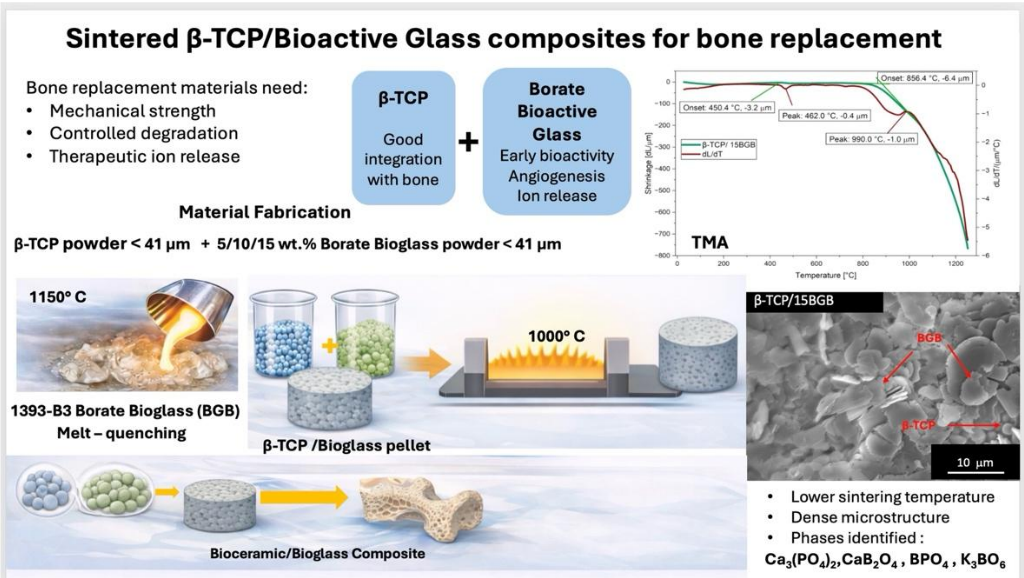
Abstract.



The fabrication of a bioceramic bone replacement material of high densification, adequate mechanical performance, controlled resorption rate and ion release concurrently remains challenging. A bone regeneration biomaterial characterized by such properties is possible to be obtained with the combination of calcium phosphate-based bioceramics and bioactive glass.

In this work, novel β-Tricalcium Phosphate/Borate Bioactive densified glass composite biomaterials were manufactured and characterized. β-TCP is a bioactive, extensively used form of calcium phosphate known for good integration with human bone tissue and for promoting bone regeneration. Although β-Tricalcium Phosphate exhibits bioactivity in vivo following implantation to the bone defect, it does not form an apatite-like layer on its surface in vitro in Kokubo test, due to its strong chemical stability in Simulated Body Fluid (SBF). In contrast, bioactive glasses- particularly the borate ones are distinguished by early stage bioactivity, prominent angiogenesis and can easily incorporate therapeutic ions.

In this study, β-TCP powder was synthesized by the wet chemical method. 13-93B3 borate bioglass, with a composition (B2O3- CaO -Na2O- K2O- MgO- P2O5) was obtained via melt-quenching technique and milled into a powder. Both powders were sieved below 40 μm to ensure good homogenization. The borate bioglass was added to the β-TCP powder in the amount of 5, 10 and 15 wt%. Samples of the composites were prepared in the form of pellets with a diameter of 8 mm and a weight of 0.3 g. Studies of thermomechanical analysis (TMA), X-Ray diffraction (XRD) for phase composition, and SEM microstructure observations of the pellets were performed. TMA was conducted to evaluate the shrinkage and thermal behaviour of pellets during heating and to determine the sintering curve. Based on the results of the TMA studies, the pellets were sintered in the temperature of 1000°C. The TMA curve for all pellets showed thermal effects corresponding to partial melting of the bioactive glass, liquid phase formation, and a shift in sintering dynamics, which intensified with increasing bioactive glass content. The sintering temperature of β-TCP was successfully lowered from over 900°C to 856°C. XRD analysis revealed crystalline phases beneficial for bioactivity of the material like calcium phosphate borate - Ca9.93(P5.84B0.16O24)(B0.67O1.79). SEM studies revealed residual bioactive glass phase and, beneath it, sintered β-TCP, confirming effective sintering.

This successful material system shows strong potential for further studies; preliminary bioactivity tests are ongoing, and future work will focus on doping the glasses with bismuth for implementing radiopaque properties.

References.

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