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Composite scaffolds based on mesoporous bioactive glasses and Sr,Mg-doped calcium-phosphates as cell carriers for bone tissue engineering

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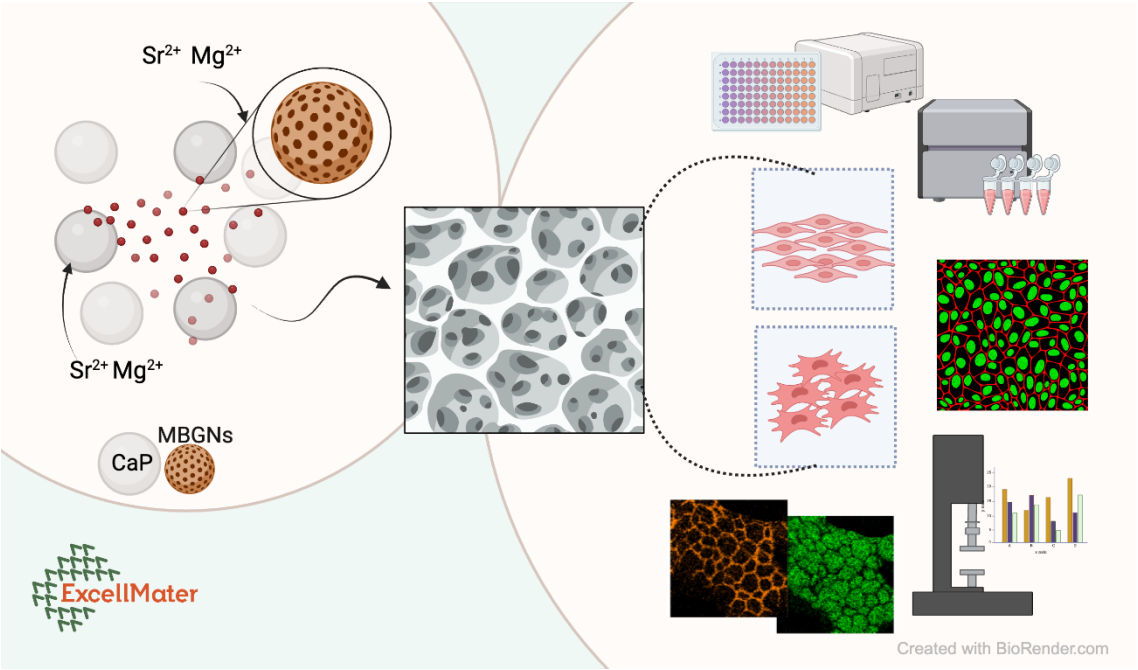
Project: Twinning to excel materials engineering for medical devices



Abstract.

Bioceramic scaffolds based on calcium phosphates (CaP) are widely investigated for bone tissue engineering (BTE) due to their bioactivity and biocompatibility, as well as ability to stimulate osteogenesis. Mesoporous bioactive glasses (MBGNs) present the latest generation of glasses for tissue regeneration owing to their specific properties: high specific surface area, large pore volume and fast dissolution rate.

The aim of this study was to obtain composite scaffolds based on MBGNs and Sr,Mg-doped CaP as cell carriers for BTE, and to evaluate the influence the MBGNs addition on properties of CaP scaffolds for BTE.

MBGNs were synthesized by a modified microemulsion sol-gel synthesis, while SrMgCaP was obtained by hydrothermal synthesis of hydroxyapatite and its further calcination. Scaffolds were fabricated by a sponge replica technique at composition 90% CaP and 10% MBGNs. Phase composition, microstructure, elemental mapping, and compressive strength of scaffolds were evaluated. Moreover, biocompatibility, osteogenic and angiogenic properties were analysed with human bone marrow derived mesenchymal stem cells BM-MSCs and endothelial EA.hy926 cell line by employing Resazurin assay, Live and dead assay, fluorescence staining and rtqPCR analysis. Bioactivity of the scaffolds was evaluated in static and dynamic conditions in perfusion bioreactor.

The results indicated that MBAG particles serve as sintering agent, allowing liquid phase sintering to take place, leading to reduced microporosity and superior compressive strength (CS) of SrMgBAG scaffolds. Addition of 10% SrMg-doped MBGN significantly improved CS compared to addition of pristine MBGN. Interestingly, incorporation of glass favored phase transformation to alpha tricalcium poshphate phase. All scaffolds were shown to be cytocompatible with BM-MSCs and EA.hy926 cells, which was also confirmed by the Live/Dead assay, highlighting not only cells' viability but also cells' distribution within the scaffolds. A better cell-cell and cell-material interaction in SrMgCaP and SrMgBAG scaffolds compared to CaP were shown, demonstrating that these scaffolds provide an optimal environment for Ea.hy926 proliferation. The rtqPCR results suggest that all scaffolds can sustain osteogenesis, however, SrMgCaP and SrMgBAG scaffolds show better performance. The collagen I/collagen II ratio demonstrated differentiation toward an osteogenic lineage. Although when tested in static, SrMgBAG scaffolds exhibited hindered bioactivity, in physiologically relevant condition in perfusion bioreactor they were confirmed to be bioactive.

Composite scaffolds based on Sr,Mg- doped CaP and MBGNs present favorable 3D environment for cell attachment and growth which is crucial for bone tissue engineering.