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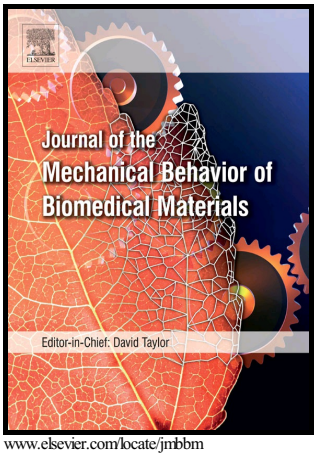

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Effect of freezing conditions on β-Tricalcium Phosphate /Camphene scaffold with micro sized particles fabricated by freeze casting

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Abstract

The long standing need of the implant manufacturing industries is to fabricate multi-matrix, customized porous scaffold as cost-effectively. In recent years, freeze casting has shown greater opportunity in the fabrication of porous scaffolds (tricalcium phosphate, hydroxyapatite, bioglass, alumina, etc.) such as at ease and good control over pore size, porosity, a range of materials and economic feasibility. In particular, tricalcium phosphate (TCP) has proved as it possesses good biocompatible (osteoinduction, osteoconduction, etc.) and biodegradability hence beta-tricalcium phosphate (β-TCP, particle size of 10μm) was used as base material and camphene was used as a freezing vehicle in this study. Both freezing conditions such as constant freezing temperature (CFT) and constant freezing rate (CFR) were used for six different conditional samples (CFT: 30, 35 and 40 vol.% solid loading; similarly CFR: 30, 35 and 40 vol.% solid loading) to study and understand the effect of various properties (pore size, porosity and compressive strength) of the freeze-cast porous scaffold. It was observed that the average size of the pore was varying linearly as from lower to higher when the solid loading was varying higher to lower. With the help of scanning electron micrographs (SEM), it was observed that the average size of pore during CFR (9.7/ 6.5/ 4.9μm) was comparatively higher than the process of CFT (6.0/ 4.8/ 2.6μm) with respect to the same solid loading (30/ 35/ 40 vol.%) conditions. From the Gas pycnometer analysis, it was found that the porosity in both freezing conditions (CFT, CFR) were almost near values such as 32.8 % and 28.5%. Further to be observed that with the increase in solid loading, the total porosity value has decreased due to the reduction in the concentration of the freezing vehicle. Hence, the freezing vehicle was found as responsible for the formation of appropriate size and orientation of pores during freeze casting. The compressive strength (CS) testing was clearly indicated that the CS was majorly depending on the size of pore which was depending on solid loading. The CS of CFT-based samples (smaller pore sizes and higher resistance to the propagation of crack) were higher due to the higher solid content (pore size) in compared with CFR-based samples on the similar solid loading conditions. As evidently, it was noted that the CFT-based sample with 40% solid loading has given the compressive strength which has come in the range of cancellous bone. The positive note was that the ratio of Ca/P has come as 1.68 (natural bone) after sintering and that was the required value recommended by the food and drug administration (FDI) for manufacturing of bone implants.

Keywords: Freeze casting, Constant freezing temperature, Constant freezing rate, Tricalcium phosphate, Camphene, Mercury intrusion porosimetry.