Mechanical property evaluation of porous 13-93 Bioactive Glass and GL1550 Borate Glass 3D scaffolds

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Reconstructing large craniofacial defects is clinically challenging and current engineered scaffolds are inadequate in either mechanical or biologic properties. Borate bioactive-glass (BBG) is a promising material for scaffolds due to its higher solubility compared to traditional 13-93 bioactive glass. The main objective of the research is to compare the mechanical properties ($\sigma_{failure}$, P_b) of scaffolds made from 13-93 bioactive-glass (A) and GL1550 borate bioactive-glass (B) powders, at different sintering temperatures, and with/without polymer coatings. In this paper, dense scaffolds are made via dry-pressing while porous scaffolds are made via a sol casting method using polymers to promote porosity (d=6mm, t=3-4mm). All the scaffolds were sintered in a tube furnace. The temperature increased 10˚C/min until reaching the sintering temperature which varied from 500^{o}C and 700^{o}C. All the samples were cooled in the furnace. The mechanical properties were measured using a diametral test on a Universal Testing Machine (MTS Sintech Renew, Model 1123, Minnesota, USA). For each group and temperature, at least 3 samples were tested. The mechanical properties ($\sigma_{failure}$, P_b) of scaffolds made from 13-93 bioactive-glass and GL1550 bioactive-glass powders are compared. Samples are then coated with 1% or 5% PLLA. Effects of porosity, sintering temperature, and polymer coating are related to mechanical properties to find the optimal heat treatment procedures and polymer concentration. Balanced with the porosity, the optimal sintering temperature was set to be 540˚C for GL1550 bioactive-glass powder and 690˚C for 13-93 bioactive glass. At the optimal sintering temperature, P_b=14.516±2.075N, σ_f=0.487±0.036MPa for borate glass scaffold with ~67% porosity, and P_b=36.725±5.786N, σ_f=1.280±0.276MPa for 13-93 bioactive glass scaffold with ~50% porosity. The 5% coating of PLLA offers a good balance between maintaining a high level of porosity and mechanical property improvement. The processing conditions will be used for their future in vivo evaluations.

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