Selective Laser Sintering and Freeze Extrusion Fabrication of Bioglass Bone Scaffolds

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Bioactive glasses are promising materials for bone scaffolds due to their ability to assist in tissue regeneration. When implanted *in vivo*, bioactive glasses can convert to hydroxyapatite, the main mineral constituent of human bone and form a strong bond with the surrounding tissues, providing an advantage over polymer scaffold materials. Bone scaffold fabrication using additive manufacturing (solid freeform fabrication) methods provides control over design and fabrication of pores in the scaffold. 13-93 bioglass (manufactured by Mo-Sci Corporation), a third-generation bioactive and resorbable material designed to accelerate the body's natural ability to heal itself, was used in the research described herein to fabricate bone scaffolds using two different additive manufacturing methods – Selective Laser Sintering and Freeze Extrusion Fabrication.

Selective Laser Sintering (SLS) is a process where a laser light is controlled to selectively sinter the particles in a powder bed layer-by-layer to fabricate a 3D part based on a CAD model. The SLS machine used in this research was a DTM Sinterstation 2000. 13-93 bioglass mixed with stearic acid (as the polymer binder) by ball milling was used as the powder feedstock for the SLS machine. The fabricated green scaffolds underwent binder burnout to remove the stearic acid binder and then sintered at temperatures between 650^0C and 700^0C. After sintering, the scaffolds were mechanically tested, achieving a maximum compressive strength of 16 MPa for scaffolds with 60% apparent porosity. Bioactivity results showed the ability of the SLS scaffolds to support the growth of

osteoblastic cells. Scanning electron microsocopy analysis and MTT formazan formation measurements provided evidence that the bioglass scaffolds fabricated by the SLS process offer a surface capable of supporting robust cell growth.

Freeze Extrusion Fabrication (FEF) is a process where an aqueous-based glass paste is extruded and deposited layer-by-layer to fabricate a 3D part in a sub-freezing temperature environment. The FEF system, developed at Missouri S&T, consists of a 3-axis positioning system, a ram extruder for paste extrusion, and position and force sensors for measurement and control. Bioglass slurry was prepared by ball milling 13-93 bioglass particles along with a dispersant (surfynol) and a binder (aquazol). Further, a lubricant (PEG-400) was added to the paste to aid in extrusion. The bioglass slurry was then heated to obtain bioglass paste. Scaffolds with varying pore sizes from 300μm to 800μm were successfully fabricated using the FEF process. Post processing of green scaffolds, including binder burnout and sintering, is currently being performed. Scaffolds produced by the FEF process will be evaluated and compared with the scaffolds obtained using the SLS process.