

Student Speech Contest 2025

3D-printed Glass-Ceramic Composite Scaffolds Based on Borosilicate Glasses and Ag/Sr-Substituted Hydroxyapatite: Physicochemical and Antibacterial Properties



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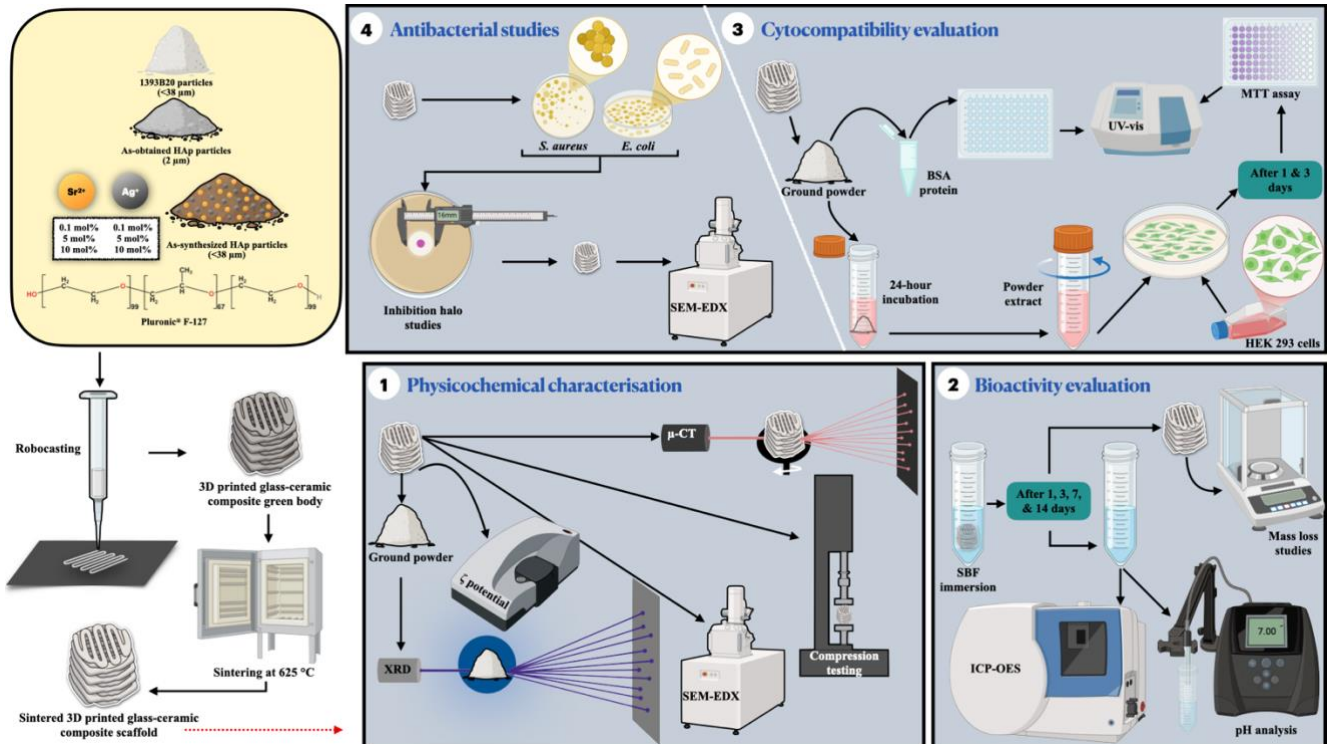
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Project: GlassBoneS ([link to the website](#))

Topic / keyword. 3D-printed bioactive glass-ceramic composites

Abstract



The incidence of critical-sized defects and subsequent surgical site infections has increased dramatically due to an aging population, rising trauma-related injuries, and the growing prevalence of bone diseases. Antimicrobial resistance poses a major threat to global public health and development, with bacterial resistance being directly responsible for 1.27 million global deaths in 2019 [1]. A wide range of bone tissue engineering approaches has been investigated to synergistically support the healing of bone defects and minimize surgical site infections. However, many current approaches fall short in effectively addressing both structural repair and infection control simultaneously.

To bridge this gap, novel robocasted glass-ceramic composite scaffolds based on 1393B20 borosilicate bioactive glass and hydroxyapatite (HAp) doped with silver (Ag^+) and strontium (Sr^{2+}) were explored, aiming to provide dual osteogenic and antibacterial functionality. Scaffolds were successfully fabricated with varying Ag^+ and Sr^{2+} molar substitution levels (0.2, 10.0, and 20.0%) and different weight ratios of 1393B20 to HAp (90/10, 80/20, 70/30, and 60/40 wt%). Physicochemical properties were characterized using compression testing, X-ray Diffraction, Fourier Transform Infrared Spectroscopy, Scanning Electron Microscopy with Energy-Dispersive X-ray Spectroscopy, and zeta potential analysis. The biological and antibacterial properties were investigated using protein adsorption tests, bioactivity testing with ion release examinations using Inductively Coupled Plasma Optical Emission Spectroscopy, cytotoxicity assays using human embryonic kidney cells (HEK 293), and inhibition zone tests against gram-positive and gram-negative bacteria. The XRD results of the fabricated scaffolds showed an interspersed pattern of both the broad halo region of 1393B20 and crystalline peaks consistent with HAp, confirming the successful fabrication of the scaffolds without decomposition or unintended phase formation. The scaffolds presented optimal mechanical properties comparable to those of trabecular bone, with a maximum compressive stress of 2.5 MPa. Additionally, scaffolds demonstrated controlled degradation kinetics suitable for supporting new bone tissue formation, with indication of HAp precipitation on the surface of all obtained scaffolds without cytotoxicity against HEK 293 cells. A sustained release of Ag^+ ions was observed, which contributed to the antibacterial effects of the scaffolds against *Escherichia coli* and *Staphylococcus aureus* strains. These results collectively demonstrate the potential of the obtained biphasic scaffolds to serve as multifunctional templates for bone regeneration while simultaneously preventing surgical infections.

References.

[1] <https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance>