Biogenic Hydroxyapatite From Batissa violacea Shells For Hap/Carboxymethyl Cellulose/Polyvinyl Alcohol Hydrogel as Potential Bone Extracellular Matrix-Mimicking Infill in Biodegradable 3D-Printed Polylactic Acid/Hap Scaffolds

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Bone is a hierarchically structured tissue composed of a collagen-based organic matrix reinforced with hydroxyapatite (HAp). Replicating this complexity using sustainable materials remains a challenge in scaffold design. This study investigated biogenic HAp synthesized from Batissa violacea shells at varying loadings (5, 10, 15 wt%) incorporated in a HAp/Carboxymethyl Cellulose/Polyvinyl Alcohol (HAp/CMC/PVA) lyophilized hydrogel as a bone extracellular matrix-mimicking infill within 3D-printed HAp/Polylactic acid (PLA) scaffolds. HAp was characterized using XRD, FTIR, SEM, and EDS. XRD confirmed hexagonal HAp with peaks at 2? ˜25.9° and 31–34° and a crystallite size of ~57.53 nm. FTIR revealed hydroxyl, phosphate, and minor carbonate groups. SEM showed porous agglomerates, while EDS indicated Ca/P ratios of 1.64–3.79. Thermogravimetric analysis of HAp/PLA filaments showed thermal stability suitable for additive manufacturing, with 94.82% weight loss at 489°C. Scaffolds infilled with 10 wt% HAp hydrogel exhibited optimal swelling (62.2%), water uptake (79.2%), porosity (70.8%), moderate hydrolytic degradation (10.2% at 21 days), and superior mechanical properties (compressive: 42.2 MPa; tensile: 34.2 MPa). These results demonstrate the feasibility of biogenic HAp-based hydrogels as infill components in 3D-printed PLA scaffolds, highlighting mineral loading's role in tuning physicochemical and mechanical properties for bone tissue engineering applications.

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