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Mechanosynthesis of Calcium Phosphates for Additive Manufacturing of Nanostructured Scaffolds

Biomaterial scaffolds are commonly used to heal bone defects. For Bone Tissue Engineering (BTE), an ideal scaffold must be biocompatible, progressively biodegradable and mimic the structural and biochemical properties of bone [1]. Calcium phosphates (CaP) bioceramics, and in particular hydroxyapatite (HA), adequately meet such requirements and are thus selected for numerous biomedical applications [1].
This project aims to produce multiscale scaffolds for BTE from biogenic calcium-rich raw materials (chicken eggshell (Fig. 1), cuttlefish bone and other bivalve shells), processed via mechano-synthesis with H3PO4 and H2O. The obtained CaP mixtures are used to produce polymer-matrix-composite extruded filaments which feed the additive manufacturing process to yield 3D structures. The design of these structures is outlined and modeled by Finite Element Analysis. Subsequent selective dissolution of CaP forms a nano/submicropore network essential for scaffold's osteointegration and cell migration.
The 3D multiscale design and the biogenic origin of CaP are expected to elicit responses analogous to mechanical and biochemical stimuli as well as more closely emulate natural bone's hierarchical structure, leading to superior scaffold performance.
Studies were conducted to build milling maps for chicken eggshell (calcite) and cuttlefish bone (aragonite) as calcium carbonate sources [2]. Both systems yielded monophasic crystalline HA above milling energy values that depend on the calcium carbonate polymorph used and on H2O content, without any further treatment [2].
These initial results demonstrate the potential of aforementioned biogenic calcium-rich raw materials as natural precursors to produce HA and of high-energy milling as the corresponding processing route, representing an important step towards the production of the proposed enhanced scaffolds.

References

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