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The beneficial impact of selected silane coupling agents on the physiochemical properties of novel α TCP-based robocasted scaffolds.

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Abstract

Background:

The growing interest in biomaterial development through additive manufacturing (AM) includes the robocasting of self-setting cementitious materials based on α-tricalcium phosphate (α-TCP). Robocasting enables a personalized approach for patient by allowing the customized design and fabrication of orthopaedic implants. Among bioceramic materials, α-TCP stands out due to its high bioactive potential and similarity of the chemical composition to the bones. Its self-setting properties facilitate shaping the implant without resorting to cytotoxic crosslinkers or additional sintering treatments.

Materials and methods:

The aim of the study was to investigate the impact of α-TCP powder modification with two distinct silane coupling agents (SCAs) - tetraethyl orthosilicate (TEOS) and (3-glycidyloxypropyl)trimethoxysilane (GPTMS) - on the properties of bioceramic 3D printed scaffolds. Two groups of scaffolds were prepared: one comprised materials solely based on the SCAs' modified

α-TCP, while the other incorporated SCAs' modified α-TCP alongside hybrid hydroxyapatite-chitosan powder. The liquid phase of the printable pastes was composed of a mixture containing 2.5 wt.% citrus pectin and 1.0 wt.% sodium hydrogen phosphate solution.

Results:

The highly porous scaffolds with pore sizes up to 350 μm were successfully obtained and developed. Leveraging natural polymers facilitated the formulation of pastes with optimal rheological properties for 3D printing of the scaffolds. XRD analysis revealed a dual crystalline phase composition, comprising α TCP and hydroxyapatite. Scaffolds produced using calcium phosphates and various biopolymers demonstrated enhanced mechanical properties attributed to synergistic interactions between the material components. Furthermore, reinforcement via modification of α TCP powder with silane coupling agents yielded a notable strength of 12.9 ± 0.8 MPa. Additionally, in vitro tests conducted in simulated body fluid (SBF) affirmed their remarkable bioactive potential, evidenced by the presence of apatitic layers on the scaffolds' surface.

Conclusions:

The developed α TCP-based cementitious materials have demonstrated suitability for robocasting, indicating their potential for application in bone tissue engineering. These 3D printed scaffolds hold promise as compelling candidates for facilitating bone regeneration. However, further biological studies are imperative to comprehensively evaluate their efficacy and biocompatibility in clinical settings.