ADA
Science & Research Institute

Compositions and Methods for 3D Printing of Calcium Phosphate Cement Composite Scaffolds

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Background

The global market size for bone grafts and substitutes is estimated to be about $2.8B, with more than 2 million bone graft procedures performed worldwide each year. Although bone autografts and allografts are widely used, they suffer from a high risk of infections and rejection by the immune system. Additive manufacturing using hydroxyapatite-based scaffolds has been proposed as an alternative that can generate customized 3D-printed patient-specific implantable scaffold structures. However, present processes are incapable of printing with high resolution. Furthermore, the amount of ceramic material within many inks is limited to less than about 30% by weight of the printing ink, which reduces elasticity and structure strength. Furthermore, elevated temperatures are required for printing.

Invention Description

ADASRI researchers have developed new compositions of matter (inks) and associated 3D printing methods that allow room-temperature printing of high-resolution and mechanically stronger composite scaffold structures. The 3D printing inks include calcium phosphate cement (CPC) powders and a biocompatible polymer. Upon printing in an aqueous environment, the polymer material hardens first and provides initial strength for the composite structure as well as flexibility. A self-setting reaction of the co-deposited CPC materials in the aqueous solution then forms, in-situ, a cement, such as hydroxyapatite, which then hardens to produce the final composite structure.

Potential Applications

The present invention is ideally suited for use to 3D-print customizable scaffolds for

- Patient-specific implantable structures that promote bone regeneration
    - e.g. Craniofacial implants (as flat and irregular bone structures), including alveolar and calvaria bone types
    - e.g. Other trabecular and cortical bone implants
- Research applications: biological testing of materials, bone disease modeling

Benefits and Advantages

- High cement powder mass loading up to 75% produces structures with increased strength.
- High resolution printing: structures with feature sizes less than 100 μm can be formed, allowing for printing of a wider range of bone implant structures.
- Room-temperature process: printing eliminates cooling-induced stresses in structures.
- Biocompatible: printed structures are osteoconductive, and support cell attachment and growth.
- Reliable printing: use of an aqueous bath reduces nozzle clogging.
- Compatible with different deposition techniques, including syringe & pneumatic dispensers and filament extruders.