Manufacturing Porous BCP Body by Negative Polymer Replica as a Bone Tissue Engineering Scaffold

R. Tolouei[1], A. Behnamghader[2], S.K. Sadrnezhaad[2], M. Daliri[3]

[1] Biomedical Engineering Faculty, Science and Research campus, Islamic Azad University, Tehran, Iran
[2] Materials and Energy Research Center, Tehran, Iran
[3] National Institute of Genetic engineering and Biotechnology, Tehran, Iran

Abstract — **The porous calcium phosphate scaffolds with defined pore-channel interconnectivity were successfully prepared via negative replica method. The internal channel architecture was achieved using a water-insoluble polyurethane sponge. The PU sponge was first filled with aqueous slurry of biphasic calcium phosphate material containing pore forming agent. After drying at room temperature, a heat treatment was employed to remove all organic material. The bodies were finally sintered at the temperature of 1200°C. The phase composition and chemical structure of bodies were determined by X-ray diffraction (XRD) and FT-IR methods. Scanning electron microscopy (SEM) was used to study the pore size and distribution and pore-pore and pore-channel interconnectivity. The scaffold bodies were principally composed of HA and β-TCP with some traces of α-TCP. No residue of polymer replica or pore agent was remained. The scaffolds contained an interconnected pore-pore and pore-channel structure with a pore size less than 500 µm. The company of desired phase composition and pore-channel structure here increases the hope for the production of more effective biodegradable scaffolds for hard tissue engineering.**

I. Introduction

The importance of pore characteristics such as their size and interconnectivity along with the biodegradability of scaffold materials have been widely studied in tissue engineering domain [1,2]. The pore size and distribution, pore-channel interconnectivity and fenestration size are thought to play an important role in deep colonization and fast osseointegration of functional porous materials [3,4].

Calcium phosphate (CaP) bioceramics are known as the attractive biomaterials used in hard tissue surgeries [5, 6]. Among the different CaP compounds, mixtures of two or more calcium phosphates such as biphasic calcium phosphates (BCP) containing more stable hydroxyapatite (HA) and more bioactive tricalcium phosphate (TCP) have attracted a growing interest for use as scaffold materials [7]

The BCP compounds exhibit good *in vitro* and *in vivo* biocompatibility but the degree of bioactivity is found to be depended on the proportions of TCP to HA constituents in the mixture. The bodies composed of higher TCP/HA ratios are generally used to achieve high-level resorption and to promote osteoconduction. [8]. BCP powder can be synthesized in different methods such as simple mixing of HA and TCP, solid-state reactions, and co-precipitation [9]

The aim of this study was to prepare the scaffolds using polymeric foam and a pore forming agent. The objective of use of these agents was to produce microcapillaries allowing circulation of biological fluid and pores for seeding and stable cell proliferation during in vitro or in vivo experiments.

II. Materials procedures

The HA and tricalcium phosphate (TCP) powders used in this study were prepared from Merck (Darmstadt, Germany). Porlat (Zschimmer and Schwarz GmbH, Germany) was employed as pore forming agent, with a particle size range of 150-400 µm.

Based on own experiences and reported researches [10], the as received HA and TCP powders were firstly subjected to a calcination process conducted at temperatures of 1000 and 1200 °C respectively. Then, they were mixed with a weight ratio of 50:50. The dough was prepared with the following chemical composition: 16.7 wt% demineralized water and 80 wt% BCP powder, 1.5 wt% ammonia solution (33%, Merck Eurolab BV), 1.5 wt% defloculant (Dolapix, zschimmer and Schwarz GmbH, Germany) and 0.15 wt% binder.

After milling, the dough was injected into the cavities of PU foam through a syringe. This porous polymer structure is substantially insoluble in water, and is thermally decomposable into gaseous residues. After drying overnight, a heat treatment at a controlled heating performed to removal of pore agents and PU foam. After elimination of all organic components, up to 500°C, samples were finally sintered at 1200°C for 5 h in air.

To optimize the heating profile, simultaneous thermal analysis (STA) was performed on Porlat-contained dried dough. The phase composition and chemical structure of the scaffold products were determined by X-ray diffraction (XRD) and FT-IR analyses respectively. Scanning electron microscopy (SEM) was used to investigate the pore size and

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