Production and Evaluation of PCL/HA Biological Scaffold with Unidirectionally Aligned Pore Channels

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Introduction: Porous biomaterials have received a great deal of attention in the field of tissue engineering as scaffold. Their three-dimensional porous structures and biocompatible surfaces provide a favorable condition for cells to attach, proliferate, and differentiate [1,2]. Among these biomaterials, poly(ε-caprolactone) (PCL) is regarded as one of the most potential biodegradable polymers because it undergoes auto-catalyzed bulk hydrolysis without causing any toxic by-products and possesses rubbery characteristics [3]. Hydroxyapatite (HA, $Ca_{10}(PO_4)_6OH_2$) is a particularly promising bioceramic, owing to its osteoconductive property. Recently, the hybrid composites of PCL/HA have been proposed as a leading candidate for the tissue engineering scaffolds, in that the ductile PCL matrix protects them against brittle failure and the bioactive HA enhances the osteoblast-like cell responses [4-6]. The purpose of this study is to fabricate biological PCL/HA scaffolds with unidirectionally aligned pore channels by gradual freezing and freeze-drying, to offer excellent biological properties and enhanced mechanical properties.

Methods: PCL pellets were dissolved in dichloroethane at a concentration of 10% w/v and stirred for 6 hours at room temperature. Subsequently, HA particles were added to the prepared PCL solution with various HA contents (0, 5, 10, and 20 wt%) and sonificated for 1 hour. After stirring for additional 2 hours, the solution was poured into polyethylene cylinders with a diameter of 12.5 mm attached to a copper plate. The cylinders were placed in a dip-coater and gradually submerged into liquid nitrogen with constant dipping rate to induce the unidirectional freezing. Frozen samples were freeze-dried for 24 hours. The microstructures of the samples were observed using scanning electron microscopy and the pore sizes were measured.

Results: Figure 1 shows the scanning electron microscopy images with various initial HA contents (0, 5, 10, and 20wt). HA particles were well-dispersed without any defect or agglomeration and pore channels showed typical fish-bone structures. Figure 2 shows the measured pore sizes of the samples. The widths of pore channel were narrowed as the HA contents increased, due to the stronger capillary force affecting among the HA particles. In other words, HA particles acted as obstacles for unidirectional freezing of solvent which is the pore channel formation step. In addition, mechanical behavior and *in vitro* tests are being performed to assure the effect of HA incorporation.

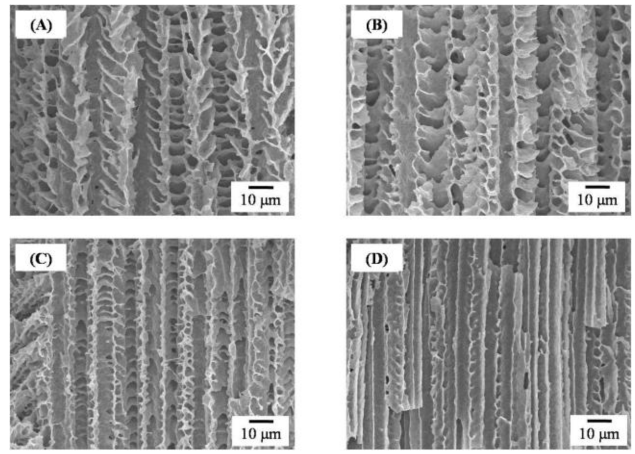

Figure 1. Scanning microscopy images of the samples produced using various initial HA contents of (A) 0wt%, (B) 5wt%, (C) 10wt%, and (D) 20wt%, showing unidirectionally aligned pore channels.

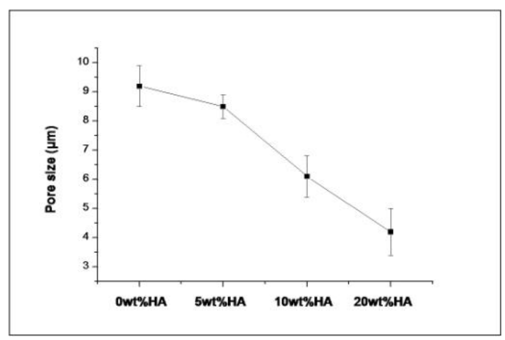

Figure 2. Measured pore sizes of the samples.

Conclusions: Biological PCL/HA scaffold with unidirectionally aligned pore channels were successfully fabricated by gradual freezing and freeze-drying with various initial HA contents. Scaffolds showed aligned pore channels without any agglomeration of HA particles. So far, these results suggest that PCL/HA scaffold with aligned pore channels is a promising hybrid scaffold for the application in tissue engineering field. More evaluations are essential to ascertain the effect of HA incorporation and pore size, thus mechanical and *in vitro* tests are in progress.

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