J Mater Sci: Mater Med (2012) 23:2483–2488
DOI 10.1007/s10856-012-4706-3

Fabrication of biocompatible titanium scaffolds using space holder technique

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Received: 18 February 2012 / Accepted: 13 June 2012 / Published online: 27 June 2012

Abstract Open-pore titanium scaffolds were fabricated by sintering of compressed mixtures of $TiH_{1.924}$ and urea. Spherical and irregular shaped space holders were used to investigate the effect of pore shape on cellular behavior. After removal of the space holder, the shape of the spacers was replicated to the pores. Average diameter of the pores was in the range of 300–600 μm. SEM images showed that titanium hydride resulted in higher surface roughness and larger micro porosities than pure titanium. In vitro evaluations were carried out by using MTT assay, measuring alkaline phosphatase activity and alizarin red staining in flow perfusion bioreactor for cell culture. Observations revealed excellent attachment and proliferation of G-292 cells to the highly porous scaffolds fabricated with titanium hydride and urea of this research.

1 Introduction

Porous ceramic and polymer biomaterials are not suitable for load bearing sites due to their poor mechanical properties. These materials are normally used for filling the cavities or regenerating the soft tissue [1–5]. Excellent biocompatibility and stiffness near to bone are significant properties required for wide application of titanium scaffolds [6–8].

Generally, there is no agreement between scientists about the perfect size of the pores in order to stimulate the cell proliferation. While some scientists believe that the size of the porosities does not affect on the cell proliferation [9], others have shown dependence of the cell proliferation to the pore size [10–12].

Many researchers have announced 100–500 μM as the perfect porosity size for proliferation of the cells [12–14]. Some evidences regarding the effectiveness of 50 μM porosities have at the same time been revealed, too [15, 16].

Previous studies have utilized pure titanium as precursor material for fabrication of bone scaffolds. Up to 30 wt.% space holder have been added to produce pore [17–20]. Since pure titanium is more expensive than titanium hydride, using the latter seems economically more feasible. If titanium hydride results in better properties, then these two-fold benefits are to be realized. Assessment of these proposed goals requires two sets of studies:

1. Elucidation of size and distribution effects of the pores: let's fabricate scaffolds having different levels of porosity and surface-roughness utilizing titanium hydride and pure titanium and then compare their biocompatibility behaviors.
2. Elucidation of pore shape effects: macro-porosities of different shapes can be obtained by initial addition and subsequent removal of spherical and irregular space holders.

Ultimate agenda of this research is to explore a newly developed method for fabrication of biocompatible titanium scaffolds needless of surface preparation. In vitro evaluations will be performed on the specimens to obtain the optimum selection of the porosity related parameters.

2 Materials and methods

2.1 Fabrication and material analysis

$TiH_{1.924}$ and pure titanium powders were utilized as rival precursor materials. Each powder was mixed separately

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