1. Introduction

Repair and regeneration of critical size bone defects are challenging, and are hampered by frequent suboptimal outcomes, resulting in a significant increase in morbidity at a high economical cost to society [1]. The gold standard for bone defect repair – bone grafting with autologous bone – has significant drawbacks such as limited availability, second site surgery and donor site morbidity, leading to prolonged hospitalization [2]. Allografting also has several disadvantages which limit its use, including reduced bioactivity and increased risk of disease transmission. Scaffolds-based solutions offer an alternative way for promoting the bone growth in large bone defects by using a porous material [2–4]. Significant efforts have been made to develop an ideal synthetic scaffold that reproduces bone's structural properties combined with the necessary porosity, interconnectivity, bioactivity and mechanical strength [5,6]. While bioactive ceramics such as TCP (beta-tricalcium phosphate), HA (hydroxyapatite), TCP/HA (beta-tricalcium phosphate/hydroxyapatite) and bioactive glasses bond with hard (and in some cases soft) tissues, they are brittle and are difficult to form into complex shapes in highly porous form (porosity >80%, pore size >300 μm and interconnectivity between pores ~100) while providing an adequate mechanical stability for the defect site [7–13].

Calcium silicate ceramics have been proposed as potential biomaterials for bone tissue regeneration due to their good bioactivity and improved mechanical properties. However, a major drawback of the calcium silicate (CaSiO₃) biosemiconductors is their chemical instability. Our strategy for developing new biomaterials for use as bone substitutes is to select CaSiO₃ as the base material and to modify it through the incorporation of elements in order to enhance its physical and biological properties. Based on our previous investigations we identified zirconium as a candidate for inclusion with calcium silicate due to its ability to enhance bioactivity of calcium phosphate based materials [14]. We generated a calcium silicate ceramic containing zirconium and determined the optimal phase composition to be chemically identical to the previously identified mineral “baghdadite” [15] (Provisional Patent Application # 2007905843) and demonstrated its in vitro biocompatibility with