Development and characterization of porous organic/inorganic composite scaffolds by freeze casting for mandibular osteoradionecrosis treatment

P. LAGARRIGUE[1,2], J. SOULIE[1], D. GROSSIN[1], A. DUPRET-BORIES[3], C. COMBES[1], V. DARCOS[2]

1. CIRIMAT, Université de Toulouse, CNRS, Toulouse INP - ENSIACET, Toulouse, France
2. IBMM, Université de Montpellier, CNRS, ENSCM, Montpellier, France
3. Institut Universitaire du Cancer de Toulouse – Oncopole, Toulouse, France

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ABSTRACT

Mandibular osteoradionecrosis appears in 10% of patients after radiation therapy for ear, nose and throat cancers treatment. In the case of bone defects larger than 2 cm^3, the only existing treatment is a major surgery with uncertain efficacy and handicap for the patient. Another strategy is based on the use of synthetic bone substitute materials promoting bone repair and regeneration. The recent bone tissue engineering researches lead to the development of 3D porous scaffolds allowing cells colonization and growth [1]. The ideal scaffold should be a 3D scaffold with high porosity and be biocompatible and bioresorbable with a controllable degradation rate. It should also present a surface chemistry suitable for cell attachment and proliferation and mechanical properties matching with those of the implantation site [2]. This work investigates the preparation of macroporous organic/inorganic composite scaffolds combining freeze-casting with a “bricks and mortar” strategy. The developed scaffold is a composite of biodegradable polymer (poly(D,L-lactide), the “mortar”) grafted on silicate-based bioactive glass nanoparticles (“bricks”), in the aim to improve global mechanical properties and tissue regeneration.

Silicate-based bioactive glass nanoparticles are synthetized following a modified Stöber process. Well-defined poly(D,L-lactide) (PDLLA) is obtained by ring-opening polymerization of D,L-lactide. Then polymer chain-end groups are functionalized to allow a chemical association of PDLLA with filler nanoparticles, according to “bricks and mortar” concept, to improve nanoparticles dispersion and homogeneity in the final scaffold. Complementary techniques are used to characterize both initial nanoparticles and PDLLA-functionalized nanoparticles (TEM, DLS, solid-state NMR, Zeta potential, FTIR, TGA).

The suspension of PDLLA-functionalized glass nanoparticles is then freeze-casted to obtain a porous composite scaffold. This process, based on solvent freezing and sublimation, yields to a controlled continuous porosity of the scaffold in the solidification direction [3]. Scaffolds obtained are characterized by SEM to investigate anisotropic porosity and by mechanical compression test.

This work demonstrates the feasibility of this concept to prepare macroporous composite scaffolds with promising mechanical properties and bioactivity for bone tissue regeneration.

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