Preparation and characterization of cockle shell aragonite nanocomposite porous 3D scaffolds for bone repair

ABSTRACT

The demands for applicable tissue-engineered scaffolds that can be used to repair load-bearing segmental bone defects (SBDs) is vital and in increasing demand. In this study, seven different combinations of 3 dimensional (3D) novel nanocomposite porous structured scaffolds were fabricated to rebuild SBDs using an extraordinary blend of cockle shells (CaCo3) nanoparticles (CCN), gelatin, dextran and dextrin to structure an ideal bone scaffold with adequate degradation rate using the Freeze Drying Method (FDM) and labeled as 5211, 5400, 6211, 6300, 7101, 7200 and 8100. The micron sized cockle shells powder obtained (75 µm) was made into nanoparticles using mechano-chemical, top-down method of nanoparticles synthesis with the presence of the surfactant BS-12 (dodecyl dimethyl bataine). The phase purity and crystallographic structures, the chemical functionality and the thermal characterization of the scaffolds' powder were recognized using X-Ray Diffractometer (XRD), Fourier transform infrared (FTIR) spectrophotometer and Differential Scanning Calorimetry (DSC) respectively. Characterizations of the scaffolds were assessed by Scanning Electron Microscopy (SEM), Degradation Manner, Water Absorption Test, Swelling Test, Mechanical Test and Porosity Test. Top-down method produced cockle shell nanoparticles having averagely range 37.8±3–55.2±9 nm in size, which were determined using Transmission Electron Microscope (TEM). A mainly aragonite form of calcium carbonate was identified in both XRD and FTIR for all scaffolds, while the melting (Tm) and transition (Tg) temperatures were identified using DSC with the range of Tm 62.4–75.5 °C and of Tg 230.6–232.5 °C. The newly prepared scaffolds were with the following characteristics: (i) good biocompatibility and biodegradability, (ii) appropriate surface chemistry and (iii) highly porous, with interconnected pore network. Engineering analyses showed that scaffold 5211 possessed 3D interconnected homogenous porous structure with a porosity of about 49%, pore sizes ranging from 8.97 to 337 µm, mechanical strength 20.3 MPa, Young's Modulus 271±63 MPa and enzymatic degradation rate 22.7 within 14 days.

Keyword: Characterization; Cockle shells; Aragonite; 3D porous nanocomposite scaffold; Bone