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Sterilization Effects of Low Concentration of Hydrogen Peroxide Solution on 3D Printed Biodegradable Polyurethane Nanocomposite Scaffold for Heart Valve Regeneration

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Abstract : Biodegradable polyurethane (PU) has emerged as a potential material to promote repair and regeneration of damaged/diseased tissues in heart valve regeneration due to its excellent biomechanical profile. Understanding the effects of sterilization on their properties is vital since they are more sensitive and more critical of porous structures compared to bulk ones. In this study, the effects of low concentration of hydrogen peroxide (H_2O_2) solution sterilization has been investigated to determine whether the procedure would be efficient and non-destructive to porous three-dimensional (3D) elastomeric nanocomposite, polyhedral oligomeric silsesquioxane-terminated poly (ethylene-diethylene glycol succinate-sebacate) urea-urethane (POSS-EDSS-PU) scaffold. All the samples were tested for sterility following sterilization using phosphate buffer saline (PBS) as control and 5 % v/v H_2O_2 solution. The samples were incubated in tryptic soy broth for the cultivation of microorganisms under agitation at 37˚C for 72 hours. The effects of the 5 % v/v H_2O_2 solution sterilization were evaluated in terms of morphology, chemical and mechanical properties using scanning electron microscopy (SEM), Fourier transform infrared (FTIR) and tensile tester apparatus. Toxicity effects of the 5 % v/v H_2O_2 solution decontamination were studied by in vitro cytotoxicity test, where the cellular responses of human dermal fibroblast (HDF) were examined. A clear, uncontaminated broth using 5 % v/v H_2O_2 solution method indicated efficient sterilization after 3 days, while the non-sterilized control shows clouding broth indicated contamination. The morphology of 3D POSS-EDSS-PU scaffold appeared to have similar morphology after sterilization with 5 % v/v H_2O_2 solution regarding of pore size and surface. FTIR results show that the sterilized samples and non-sterilized control share the same spectra pattern, confirming no significant alterations over the surface chemistry. For the mechanical properties of the H_2O_2 solution-treated scaffolds, the tensile strain was not significantly decreased, however, become significantly stiffer after the sterilization. No cytotoxic effects were observed after the 5 % v/v H_2O_2 solution sterilization as confirmed by cell viability assessed by Alamar Blue assay. The results suggest that low concentration of 5 % v/v hydrogen peroxide solution can be used as an alternative method for sterilizing biodegradable 3D porous scaffold with micro/nano-architecture without structural deformation. This study provides the understanding of the sterilization effects on biomechanical profile and cell proliferation of 3D POSS-EDSS-PU scaffolds.

Keywords : biodegradable, hydrogen peroxide solution, POSS-EDSS-PU, sterilization
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