Poly(ε-caprolactone)/Halloysite Nanotube Nanocomposites Scaffolds for Tissue Engineering

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Abstract : Tissue engineering offers a new approach to regenerate diseased or damaged tissues such as bone. Great effort is devoted to eliminating the need of removing non-degradable implants at the end of their life span, with biodegradable polymers playing a major part. Poly(ε-caprolactone) (PCL) is one of the best candidates for this purpose due to its high permeability, good biodegradability and exceptional biocompatibility, which has stimulated extensive research into its potential application in the biomedical fields. However, PCL degrades much slower than other known biodegradable polymers and has a total degradation of 2-4 years depending on the initial molecular weight of the device. This is due to its relatively hydrophobic character and high crystallinity. Consequently, much attention has been given to the tunable degradation of PCL to meet the diverse requirements of biomedicine. Poly(ε-caprolactone) (PCL) is a biodegradable polyester that lacks bioactivity, so when used in bone tissue engineering, new bone tissue cannot bond tightly on the polymeric surface. Therefore, it is important to incorporate reinforcing fillers into PCL matrix in order to result in a promising combination of bioactivity, biodegradability, and strength. Natural clay halloysite nanotubes (HNTs) were incorporated into PCL polymeric matrix, via in situ ring-opening polymerization of caprolactone, in concentrations 0.5, 1 and 2.5 wt%. Both unmodified and modified with aminopropyltrimethoxysilane (APTES) HNTs were used in this study. The effect of nanofiller concentration and functionalization with end-amino groups on the physicochemical properties of the prepared nanocomposites was studied. Mechanical properties were found enhanced after the incorporation of nanofillers, while the modification increased further the values of tensile and impact strength. Thermal stability of PCL was not affected by the presence of nanofillers, while the crystallization rate that was studied by Differential Scanning Calorimetry (DSC) and Polarized Light Optical Microscopy (POM) increased. All materials were subjected to enzymatic hydrolysis in phosphate buffer in the presence of lipases. Due to the hydrophilic nature of HNTs, the biodegradation rate of nanocomposites was higher compared to neat PCL. In order to confirm the effect of hydrophilicity, contact angle measurements were also performed. In vitro biomineralization test confirmed that all samples were bioactive as mineral deposits were detected by X-ray diffractometry after incubation in SBF. All scaffolds were tested in relevant cell culture using osteoblast-like cells (MG-63) to demonstrate their biocompatibility

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