Abstract

The present investigation is aimed at the selection of processing technique and optimization of compatibilizer for TPU-PDMS blends, detailed analysis of nanocomposites with various types of nanohydroxyapatite (Hap) and their use in skin and bone related applications. The effect of processing route on physico-mechanical and thermal characteristics of compatibilized TPU-PDMS blends prepared by melt mixing and the solution mixing technique were compared and solution mixed blends showed improved phase morphology, mechanical, thermal and dynamical mechanical properties than the melt blends.

Modified Hap with different shapes have been prepared by co-precipitation methods and characterized using FTIR, XRD, FESEM and HRTEM techniques. The decorated Hap has been introduced in TPU-PDMS blend matrix by solution mixing technique. The incorporation of polypropylene glycol modified spherical Hap (PPG-Hap) in TPU-PDMS blend at 70:30 blend ratio (T70P30) promoted the nucleation effect and has shown a considerable improvement in the tensile strength, crystallinity and thermal stability over the neat blend. Chitosan modified Hap nano rods (CS-Hap) were introduced in compatibilized blend matrix (T70-P30) which enhanced the physico-mechanical and thermal properties of the blend. Tensile strength has been improved upto 140% at an optimum dosage of 5 parts of CS-Hap. Further, hybrid filler of nanohydroxyapatite and halloysite nanotubes (HNT-Hap) was synthesized by co-precipitation method. The incorporation of an optimum dosage of 3 phr of HNT-Hap shows significant improvement in physico-mechanical and thermal characteristics of the compatibilized TPU-PDMS (T70-P30) blend. From DSC, it was observed that the crystallization enthalpy (ΔH) of TPU soft segments (TPUss) increased with nanospheres (PPG-Hap and HNT-Hap) and cold crystallization enthalpy of PDMS increased with nanorods (CS-Hap and HNT-Hap) in nanocomposites. It confirms the physical compatibility of nanospheres with TPUss and nanorods with PDMS chains.

The scaffolds of TPU-PDMS blends and the blend nanocomposites based on PPG-Hap were fabricated using electrospinning technique. The morphology, porosity, surface wettability, and mechanical properties of electrospun scaffolds were distinctly influenced by the presence of PDMS. The scaffold architecture varied from electrospun fibres to porous fibres and finally occurrence of unique porous beads were noticed at 30% PDMS (ET70-P30) in the microstructure using FESEM. Micro-CT analysis revealed that the porosity of electrospun scaffolds was enhanced from 61% to 79% with 30 parts of PDMS addition. Moreover, MTT assay and cell proliferation were studied using human skin fibroblast cells and found to be significantly enhanced with the PDMS. Electrospun scaffolds based on 5 parts of PPG-Hap (ET70-P30H5) exhibited good dispersion, which was confirmed using FESEM, Cryo-TEM and Micro-CT. Furthermore, MTT assay and cell proliferation were examined using human skin fibroblast cells and osteoblast-like cells (MG-63) and found to be extensively improved with PPG-Hap addition. These observations reveal the potential application of ET70-P30H5 for bone-cartilage interface and ET70-P30 and its nanocomposites for skin tissue engineering.

Keywords:

thermoplastic polyurethane, polydimethylsiloxane rubber, nanohydroxyapatite, electrospinning technique, tissue engineering.