CHARACTERIZATION OF HYDROXYAPATITE WHISKER REINFORCED COMPOSITES AND SCAFFOLDS FOR MECHANICAL AND BIOLOGICAL FUNCTION IN ORTHOPAEDIC AND SPINAL IMPLANTS

Abstract

By

Timothy L. Conrad

The overall objective of this study was to investigate mechanical and biological properties of HA whisker reinforced polyaryletherketone (PAEK) composites and scaffolds, which are key to clinical translation for orthopedic and spinal implants. The fatigue behavior of polyetherketoneketone (PEKK) reinforced 0, 20, and 40 vol% hydroxyapatite (HA) was investigated in four-point bending fatigue. The fatigue life decreased with increasing HA reinforcement load. However, PEKK reinforced with 40 vol% HA whiskers exhibited a fatigue life greater than $2 \cdot 10^6$ cycles at 40 MPa. Moreover, HA whisker reinforcement resulted in decreased creep deformation and minimal modulus degradation.

The effects of the mold temperature and polyetheretherketone (PEEK) powder were investigated on the mechanical properties and crystallinity of HA whisker reinforced PEEK scaffolds prepared using compression molding and porogen leeching. The mechanical properties of the scaffolds increased while the PEEK crystallinity decreased, with increasing mold temperature and suggested an optimal mold temperature of 370 -375°C for PEEK scaffolds comprising of 75%

porosity, 20 vol% HA whisker reinforcement and regardless of the PEEK powder size.

The effects of the porogen morphology on the architecture, mechanical properties, and permeability of HA whisker reinforced PEEK scaffolds were investigate in 75 – 90% porous scaffolds. HA whisker reinforced PEEK scaffolds prepared with an ellipsoidal porogen exhibited a greater permeability than scaffolds prepared with a cubic porogen for scaffolds with 75 – 85% porosity. The compressive modulus, yield strength, and yield strain were not affected by the porogen morphology.

The effects of HA reinforcement morphology and content on the behavior of primary osteoblasts on HA reinforced PEEK *in vitro*. The number of osteoblasts attached to PEEK substrate surfaces was increased with increasing HA content and for HA whiskers compared to equiaxed HA powder reinforcement. This suggests that the HA reinforcement content morphology can promote cellular attachment and proliferation at early time points.