

A Biomimetic Hydroxyapatite Coating on Polyetheretherketone

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Background: Polyetheretherketone (PEEK) is a biocompatible thermoplastic that is being used as an alternative to metal alloys in orthopaedic surgery however its use is limited due to poor osteointegration. A biomimetic calcium phosphate (CaP) coating deposited onto the implant surface may increase its bioactivity and augment bone-implant integration.

Aim: The aim of this study was to investigate the proliferation and osteogenic differentiation of mesenchymal stem cells (MSCs) on a biomimetically deposited calcium phosphate coated PEEK, carbon reinforced PEEK (CFR-PEEK) and titanium (Ti) surface.

Methods: Samples were coated using a two-step biomimetic procedure using x 5 concentrated simulated body fluid (SBF) under a constant supply of CO₂¹. CaP coatings were characterised by measuring surface roughness (Ra), coating thickness (µm) using an optical 3D surface profilometer, scanning electron microscopy (SEM), energy dispersive x-ray spectroscopy (EDAX) and X-Ray Diffraction (XRD). Cells were seeded on SBF coated PEEK, CFR-PEEK, Ti alloy 6% aluminium, 4 % vanadium, plasma sprayed HA Ti alloy surface and a thermonox control. Cell metabolic activity, proliferation, and alkaline phosphatase (ALP) activity was quantified on days 7, 14 and 21. A Mann Whitney-U test was used to compare groups where p values < 0.05 were considered significant.

Results: An increase in surface roughness of coated PEEK ($6.378 \pm 0.318 \mu\text{m}$) and CFR-PEEK ($5.528 \pm 0.371 \mu\text{m}$) was measured when compared to the uncoated surfaces ($4.271 \pm 0.371 \mu\text{m}$, PEEK and $4.592 \pm 0.740 \mu\text{m}$; CFR-PEEK ($p < 0.05$). Coating thickness on SBF Ti discs ($20.2 \pm 11.35 \mu\text{m}$) was significantly increased when compared to PEEK ($13.52 \pm 6.82 \mu\text{m}$) and CFR-PEEK ($13.0 \pm 9.58 \mu\text{m}$) ($p < 0.05$). There was no significant difference in coating thickness when PEEK and CFR-PEEK surfaces were compared. EDAX results showed calcium and phosphate peaks with a Ca/P ratio of 1.55 ± 0.30 , 1.62 ± 0.06 , and 1.73 ± 0.12 in the PEEK, CFR-PEEK and SBF Ti respectively. XRD results showed that the deposited HA layer had an amorphous structure.

Metabolic activity and proliferation on SBF coated samples was comparable to plasma sprayed HA coated samples. ALP activity per µg of DNA was significantly increased on coated samples when compared to Thermonox (Figure 1). Osteogenic differentiation was enhanced on all coated samples at day 7 when compared to thermonox.

Conclusion: The formation of a calcium-phosphate coating on PEEK is possible using a biomimetic method at 5 times simulated body fluid. This may enhance bone apposition in vivo.

References

- 1) Habibovic *et al.* J Am Ceram Soc 2002; 85(3):517-522

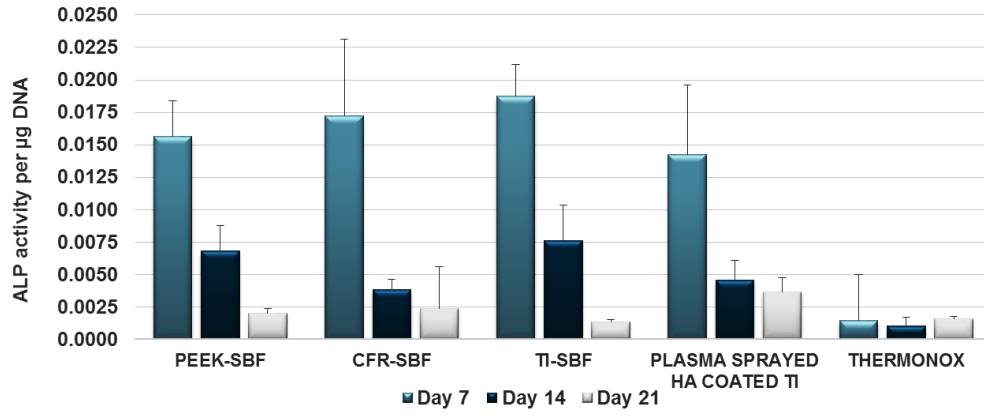


Figure 1. Enhanced osteogenic activity of cells on coated substrates