The effect of strontium and silicon substituted hydroxyapatite electrochemical coatings on bone ingrowth and osseointegration of selective laser sintered porous metal implants

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Supporting information

S1 Supplementary Data

Electrochemical HA

Analytical grade $Ca(H_2PO_4)_2$ (Sigma-Aldrich, UK) was dissolved in deionised water to form 0.13M calcium phosphate solution. Deposition was conducted by passing a 130mA current at room temperature for 15 minutes. Subsequently, the implants were immersed in 0.1M NaOH solution for 72 hours to convert the initial calcium phosphate precipitate (Ca_2HPO_4-$2H_2O$; Brushite) into hydroxyapatite, $Ca_5(PO_4)_3OH$.

Electrochemical SiHA

The electrolyte contained 1g/l of nano-SiO_2 (Sigma-Aldrich), 0.042M $Ca(NO_3)_2.4H_2O$ (Sigma-Aldrich, UK), and 0.025M $NH_4H_2PO_4$ (Sigma-Aldrich, UK) in $^dH_20$. The supersaturated electrolyte was adjusted to pH 4.2 using 10% HCl and 10% NaOH (Fisher Scientific, UK) at room temperature. Before electrochemical deposition, the implants were anodized by submerging them in 5M NaOH solution at 65°C whilst being actively stirred. Due to the relative non-reactivity of Ti6Al4V to alkali treatment, this process was done for 24 hours instead of 12 hours for commercially pure Ti.

A deposition time of 45 minutes, using a current density of 0.8 mA /cm^2 was found to give the thickest coating of 19.2 ± 5.7 μm (mean ± SD) for the optimisation process. Hence the porous implants were coated using a current of 11.2mA for 45 minutes at 65°C. Once coated, the implants were placed in a RHF 1600 furnace (Carbolite Gero, UK) at 300°C for 2 hours.

Electrochemical SrHA

The electrolyte contained 0.06M $CaCl_2$, 0.036M $NH_4H_2PO_4$, 0.00667M of $SrCl_2$ (Sigma-Aldrich, UK) and 0.2M NaCl (S7653; Sigma-Aldrich, UK) in ^dH_2O. The $SrCl_2$ acted as the Sr source with the NaCl as the conducting agent. The solution was adjusted to a pH of 4.5 by the addition of 10% HCl (Fisher Scientific, UK) at room temperature.

An optimisation process was conducted using Ti6Al4V discs by varying the duration and current of the coating process. A current density of 15 mA /cm^2 and a deposition time of 2.5 minutes gave the most even coating. The thickness of 14.2 ± 5.2 μm (mean ± SD) was also closest to the thickness obtained for SiHA (S1 Table). Therefore, the porous implants were coated using a current of 210mA over 2.5 minutes at 60°C. After coating, the implants were placed in 0.1M NaOH for 72 hours at room temperature before being rinsed with deionised water and left to air dry.