Advanced flow synthesis of high purity calcium phosphate nano-bioceramics with different morphology and their response to human osteoblast cells in vitro

A.Anwar[a,b*], J.A. Darr[a]

[a]*Department of Chemistry, University College London, 20 Gordon Street, London WC1H 0AJ, UK.*

Introduction

Calcium phosphates (CaP) are the most ubiquitous family of bioceramics well known for their use as bone graft substitutes, coatings on metallic implants, reinforcements in biomedical composites and in bone and dental cements. Hydroxyapatite (HA), $[Ca_{10}(PO_4)_6(OH)_2]$ is similar to biological apatite, the main mineral constituent of teeth and bone because of its biocompatibility, bioactivity and low solubility in wet media.

Aim

The goal was to create nano-particulate materials that would be useful in the development of novel bioceramics for bone regeneration applications

Materials & Methods

Nanoparticles of phase-pure hydroxyapatite with very high surface areas were produced in a new low temperature continuous, plastic flow synthesis reactor, by mixing aqueous solutions of calcium nitrate tetrahydrate and diammonium hydrogen phosphate. Other calcium phosphate phases (Brushite, β-TCP, CDHA and biphasic HA / β-TCP) were also obtained by changing the Ca:P ratio and pH of the precursor solutions. A variety of ion substituted calcium phosphates (Mg, Sr, Ba, Zn, Fe, Mn, Si, CO_3^{2-}), nanocomposite materials (Fe_3O_4-HA, TiO_2-HA) and surface modified organopolymer nano-dental composites have also been developed successfully by using this novel continuous flow synthesis.

Results & Discussion

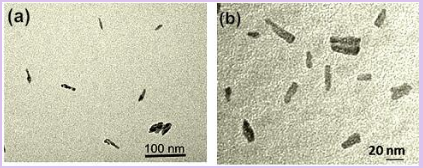
The powders were then characterized by transmission electron microscopy (TEM), BET surface area analysis, X-ray powder diffraction, FTIR spectroscopy, Raman spectroscopy and X-ray photoelectron spectroscopy (XPS). Particles synthesized at 60 °C in 5 minutes residence time possessed remarkably high surface area of 264 m^2g^{-1} and very small particle size of ~ 20 nm as shown in figure 1.The *in vitro* biocompatibility analysis indicate that these high surface area nano-sized bioceramics have better performance than commercial products and may have the potential to be used for biomedical applications where bone regeneration / replacement is required (figure 2).

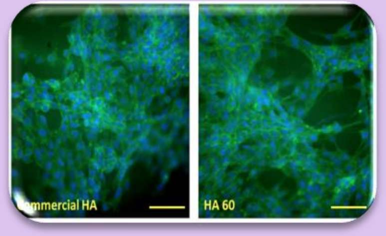
Conclusion

In summary, the continuous (plastic) flow synthesis (CPFS) technique employed here provides a rapid pathway to synthesize pure HA and a range of Ion-doped calcium phosphates nanoparticles near ambient conditions. The employed system could be a useful tool for the synthesis of a variety of pure and ion-doped calcium phosphates with tailorable properties, such as composition, particle size, and surface area.

Acknowledgements

Islamic Development Bank and University of Engineering and Technology are acknowledged for granting scholarship and study leave, respectively. Dr. Robin M.Delaine-Smith is thanked for their help with biological testing at University of Sheffield.





a.anwar.11@ucl.ac.uk