Student Speech Contest 2024

Octacalcium Phosphate Biomaterials: Formation Process, Modification and Application

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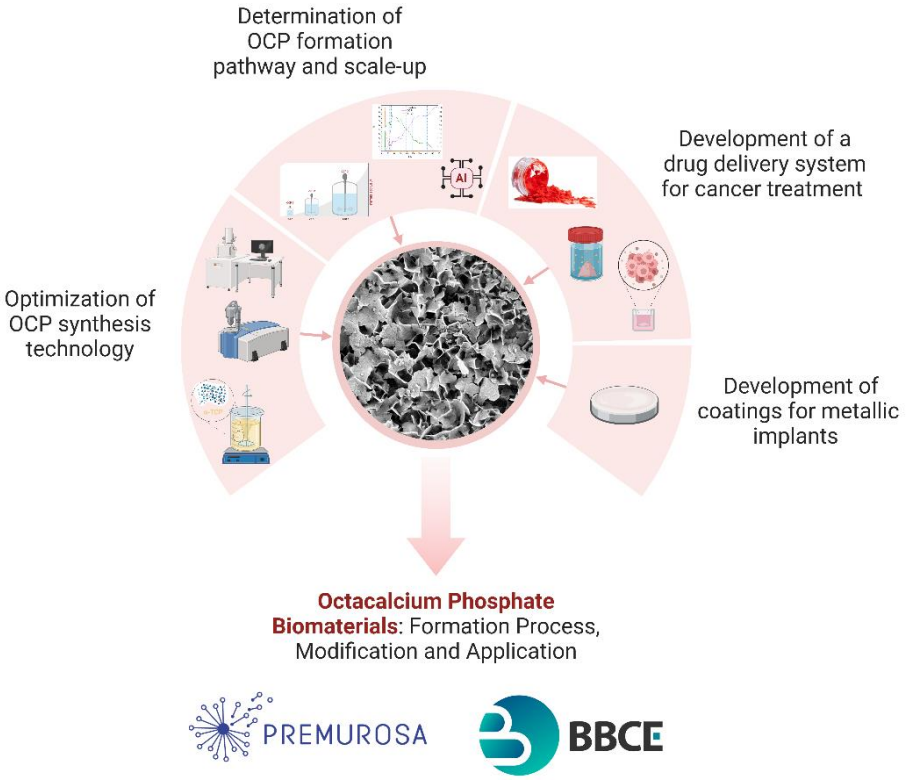
Project: PREMUROSA project and Baltic Biomaterials Centre of Excellence project



Abstract

Musculoskeletal diseases (MD) affect approximately half of the global population aged over 60 years. Presently, MD treatment predominantly relies on regenerative procedures that in turn are heavily dependant on the suitability of biomaterial implantation. Octacalcium phosphate (OCP) stands out as a material that facilitates advanced healing processes at bone implantation sites. The present study aimed to develop OCP biomaterials in a patient-centered manner by optimizing OCP production technology and subsequently functionalizing it as a drug delivery system for bone cancer treatment and a protective coating for musculoskeletal applications.

To obtain OCP, low temperature α-tricalcium phosphate (LT- α –TCP) was immersed into acidic solution at room temperature, during the 180h period. In-situ incorporation of 1, 5, 10 and 20 wt% (theoretical loading) of doxorubicin into OCP was performed via the hydrolysis of LT- α –TCP, and the sodium alginate was used to make OCP protective coatings. Physico-chemical characterization encompassed XRD, FTIR, Raman, SEM and BET, whereas the release kinetics of doxorubicin were determined by UV-VIS at λ=480nm. Biocompatibility of the obtained OCP was evaluated using hBMSC, EA.hy926, and U2OS cell lines and the influence of doxorubicin-OCP on MG63 and MC3T3-E1 cell lines was examined. Alginate-OCP protective coatings were analysed with electrochemical impedance spectroscopy to test their ability to enhance corrosion resistance.

Results indicated that the as-synthesized OCP exhibited high phase purity and biocompatibility with all proposed cell types. The phase composition of all doxorubicin-OCP samples was verified using XRD, showing characteristic peaks consistent with the theoretical structure of OCP. However, OCP formation was hindered when the doxorubicin content exceeded 10wt%. Doxorubicin had a continuous release from OCP drug deelivery systems over six week period, whereas the in vitro cell studies exhibited a time and concentration-dependent decrease in the proliferation rate of MG63 and MC3T3-E1 cells, when exposed to the doxorubicin-OCP powders. Furthermore, electrochemical analysis revealed that OCP particles in the alginate matrix notably increased electrical charge transfer resistance at the substrate and coating interface.

The research findings offer a novel perspective on the synthesis and functionalization of OCP, shedding light on its phase composition and benefits of it as a drug delivery vehicle. This perspective emphasises the potential of OCP for biomedical applications, while also highlights the challenges associated with achieving optimal phase purity and drug loading.