Poster 4

Process intensification and optimization for hydroxyapatite nanoparticles production

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Nanoparticles are of particular interest in biomedical applications since their critical size dimensions are close to cells and biological molecules. As they exhibit a variety of size- and shape dependent physical and chemical properties, a very good control of the reaction conditions is the key to obtain particles with desired characteristics.

Conventional approaches for nanoparticles synthesis are based on wet chemical synthesis in stirred tank. But this kind of system generally yields particles with rather broad size distributions because of the low mixing efficiency and wide residence time distributions.

Miniaturization of synthesis systems offers many advantages, including cost saving from reduced consumption of reagents and safer operation since the process consumes much reduced hazardous chemical. Further, transfer processes, mixing of reactants as well as residence time are fast in miniaturized systems, which is favorable for the generation of nanosized particles with a narrow size distribution.

The present work aims at the production of hydroxyapatite (HAp) $Ca_{10}(PO_4)_6(OH)_2$ nanocrystals at physiological conditions of temperature and pH, with controlled size distribution and high biocompatibility, making them suitable for application in bone replacement. For this, precipitation of HAp was investigated in meso- and micro-scale systems. Part of the work consists in a comparative study between HAp precipitation in batch in a 1 L stirred tank and in a novel oscillatory flow meso reactor (meso-OFR) of about 4.5 mL, developed at CEB. The experiments were performed under the same conditions of temperature (T=37 ^{o}C), initial Ca/P molar ratio and power density (31.5 W/m3). Both systems yielded HAp nanoparticles at a pH close to 7 for an initial Ca/P = 1.33, HAp particles being produced faster in the meso-OFR, namely due to a higher mixing efficiency. Precipitation of HAp was also studied in continuous in two ultrasonic microreactors, a tubular microreactor of 600 µL and a Teflon stack microreactor with an integrated piezoelectric element of 1000 µL. HAp nanoparticles under near-physiological conditions of temperature and pH were produced. Moreover, HAp particles were produced in a very short time and with higher crystallinity compared to the particles produced in stirred tank batch reactor.

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