Microstructural, mineralogical and chemical characterization of a new 3D stratified Si-Ca-P porous scaffolds obtained by sol-gel and polymer replica method

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Abstract

Statement of the Problem: Tissue engineering is a science which studies different ways to achieve the regeneration of diseased tissues. To get it, this field uses scaffolds or porous extracellular 3D matrices, which allow cell migration, vascularization and nutrient diffusion. These matrices need to have the appropriate physical and biological properties such as pore size and structure, surface topography, chemical composition, mechanical strength and degradation rate. These characteristics are capable to induce optimal osteogenesis throughout the scaffolds. For this reason, and because they exhibit an appropriate bioactivity, ceramics are excellent candidates for developing these 3D scaffolds, avoiding the process of stress shielding. The aim of this research was to develop and characterize a novel stratified porous scaffold for future uses in bone tissue engineering. Methodology & Theoretical Orientation: In this study, a calcium silicophosphate porous scaffold, with nominal composition 29.32 wt% SiO_2 – 67.8 wt% CaO – 2.88 wt% P_2O_5, was produced using the sol-gel and polymer replication methods. Polyurethane sponges were used as templates which were impregnated with a homogeneous sol solution and sintered at 950ºC and 1400ºC during 8 hours. The characteristics of the 3D stratified porous scaffolds were investigated by Scanning Electron Microscopy, X-Ray Diffraction, Fourier Transform Infrared Spectrometry, Diametric Compression of Discs Test and Hg porosimetry techniques. Findings: The result showed highly porous stratified calcium silicophosphate scaffolds with micro and macropores interconnected. Also, the material has a diametrical strength dependent on the number of layers of the stratified scaffolds and the sintering temperature. Conclusion & Significance: A new methodology has been developed to obtain a stratified porous 3D ceramic at different temperatures, whose microstructural study has shown a highly interconnected porosity, with an average pore size between 375-400 μm and a Ca/P ratio of 13.09. For this reason, this methodology will allow us to create new customized materials according to the needs of each situation. We will be able to create materials with a high resistant core and high bioactivity coverings or vice versa, depending on the place where you would place the bone implant.

Image

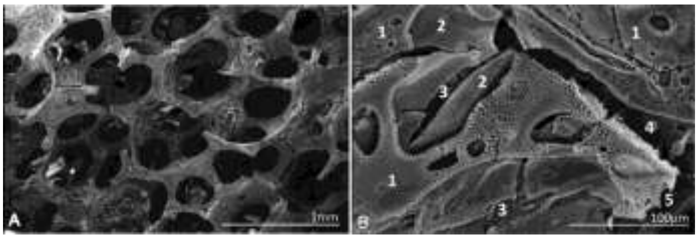

Fig. 1. SEM micrographs of the 3D-1400 ceramics with a) 10 and c) 12 immersions in sol-solution (numbers are the latest five layers)

Acknowledgements

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Recent Publications (minimum 5)

1. Ros-Tarraga P, Murciano, P, Mazón P, Gehrke, S.A, De Aza PN (2017). In vitro behavior of sol-gel interconnected porous scaffolds of doped wollastonite. Ceramic International DOI 10.1016/J.ceramint2017.05.146
2. Ros-Tarraga P, Murciano, P, Mazón P, Gehrke, S.A, De Aza PN (2017) New 3D stratified Si-Ca-P porous scaffolds obtained by sol-gel and polymer replica method: microstructural, mineralogical and chemical characterization. Ceramic International 43 (8),. 6548-6553.
3. Ros-Tarraga P, Mazón P, Rodriguez MA, Meseguer-Olmo L, De Aza PN (2016) Novel resorbable and osteoconductive calcium silicophosphate scaffold induced bone formation. Materials 9 (9):785
4. Ros-Tárraga P., Rabadan-Ros R., Murciano A., Meseguer-Olmo L., De Aza PN (2016) Assessment of effects of Nurse´s A-phase-silicocarnotite ceramic on the osteogenic differentiation of a population of multipotent adult human stem cells. Materials, 9(12), 969
5. Ros-Tarraga P, Mazón P, Meseguer-Olmo L, De Aza PN (2016) Revising the subsystem nurse's A–phase-silicocarnotite within the system $Ca_3(PO_4)_2$–Ca_2SiO_4. Materials 9 (5): 322

Biography (150 word limit)

Piedad N de Aza received her doctoral degree in Chemistry-Ceramic 1995. She did a postdoctoral stage at the IRC in Biomaterials at the Queen Mary College, University of London (U.K.) working on in vitro and in vivo behavior of bioceramics. At this moment, she is the Chair of the Materials Science, Optic and Electronic Technology Department, Professor of Materials Science and Metallurgical Engineering and Researcher at the Bioengineering Institute at the Miguel Hernandez de Elche University.

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