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# Solvent-free manufacturing and sintering of PLLA/nano-Hap and PLLA/Fiber-Hap scaffolds

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**Abstract** – PLLA / Hap (90% / 10%) composite scaffolds has been manufactured by different methods. However, nowadays the most cases tested use other elements besides biomaterials, such as solvents, which may leave residues inside the scaffold, or cause chemical changes in the materials, compromising the viability of them in biological environment. In this work the scaffolds were manufactured by powder sintering process, without binding addition, using two types of hydroxyapatite (fibers and nanoparticles). The scaffolds were characterized by SEM, compressive and controlled porosity tests. The scaffolds produced with the nanoparticles presented the highest porosity. The mechanical strength presented no significant variations.

Ceramics of calcium phosphate type, such as hydroxyapatite (Hap) and tri-calcium phosphate (TCP) are widely used in medical applications due to its biocompatibility and osteocondutivity. However, these materials present the relative brittleness as its principal disadvantage [1].

Various polymers and different polymers/ceramics associations have been studied, in the research, for the appropriate composite to different needs of replacement (temporary or permanent) of bone tissue. The poly(α-hydroxy esters) constitute the major class of bioreabsorbable and biodegradable synthetic polymers used in tissue engineering. The poly (L-lactic acid) has been used with good results, because it presents goods bioreabsorbility and biodegradability characteristics [2].

The studies and the current challenges are directed to understand the relationships between chemical composition and morphology of the scaffolds, their mechanical properties and processing of these materials. These factors will interfere directly or indirectly in the microstructure characteristics of the matrix, and consequently in it behavior in biological environment.

Conventional methods for several porous scaffolds manufacturing techniques have been proposed, such as combination on porogen leaching and freeze-drying techniques [3], gas foaming [4], thermally induced phase separation [5], foaming and hydrolysis [6], among others. In most of these methods organic agents as pore formers are used, which may lead to residues of solvents or from thermal decomposition of the polymeric templates.

The propose of this work was produce composites by the process of sintering based on reinforced PLLA with different types of hydroxyapatite (fibers and nanoparticles) The composites were prepare with mass fraction of PLLA/Hap 90/10 and polymer particle size 106-212 µm. The mixture was sintered at 185ºC, since low densification degree was observed at this temperature. The influence of sintering time, and Hap morphology of the scaffolds was evaluated. The scaffolds were characterized by scanning electron microscopy (SEM) and compressive tests. The results revealed that the scaffolds with both ceramics exhibited interconnectivity between pores, pore sizes between 100 to 300 µm and suitable compressive strength to be used in bone tissue engineering. However the porosity of Hap nanoparticles scaffolds reaches the highest value.

**Table 1 – Sintering time, porosity and compressive strength for each type of PLLA/HA scaffolds.**

| Material | Sintering Time [min] | Mean Porosity [%] | Compressive Strength [MPa] |
|---|---|---|---|
| Hap Nanoparticles | 4.00 | 55.5 | 9.50 ± 5.06 |
| Hap Fibers | 1.00 | 48.0 | 9.61 ± 4.25 |

**References**

[1] W.J.E.M. Habraken, J.G.C. Wolke, J.A. Jansen Advanced Drug Delivery Reviews. 59 (2007) 234–248
[2] S.H. Lee, H. Shin, Advanced Drug Delivery Reviews. 59 (2007) 339–359
[3] G. Chen, T. Ushida, T. Tateishi, Materials Science and Engineering. C, 17, 63–69 (2001).
[4] D. J. Mooney, F. Daniel, D. F. Baldwin, N. P. Suht, J. P. Vacanti, R. Langer, Biomoterials. 17, 1417-1422 (1996).
[5] Y. S. Nam, T. G. Park, Biomaterials. 20, 1783-1790 (1999).
[6] A. Almiralla, G. Larrecqa, J. A. Delgadoa, S. Martinezb, J. A. Planella, M. P. Ginebraa, Biomaterials. 25, 3671–3680 (2004).