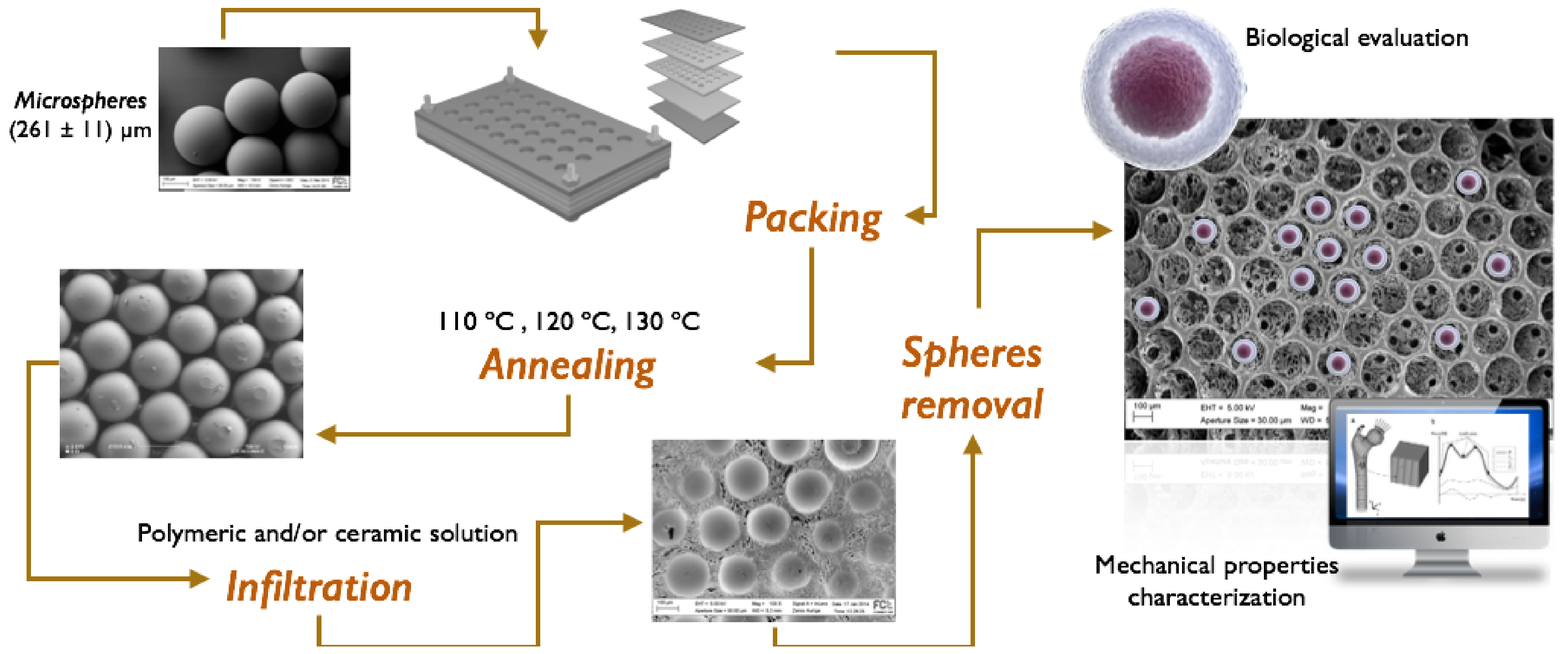
CENIMAT – Materials Research Centre, New University of Lisbon

Liquid Crystalline Inverse Opals
New Bone like Assemblies for Tissue Engineering



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Objectives

The field of Tissue Engineering (TE) relies extensively on the use of porous 3D scaffolds to provide the appropriate environment for the regeneration of tissues and organs. This work envisages the use of *Inverted Colloidal Crystal* (ICC), also known as *Inverse Opals*, to produce structures exhibiting a uniform pore size, interconnected network and a biodegradable matrix, essential for bone tissue engineering (Fig.1).

ICC scaffolds (Fig.2) - highly geometrically ordered structures that result from inverse replication of the structure of packed colloidal crystals (CC) – enhance oxygen and nutrient diffusion, providing optimum cellular development. For this purpose chitosan (CS) / chitin (CT) liquid crystalline solutions and gels (chiral nematic or cholesteric mesophases) will be used to produce the composite matrix of the scaffolds. These mesophases are present in collagen type I and are responsible for bone complex architecture and mechanical properties.

Fig.1 – New synthetic bone substitute.

Methods and techniques

Production of liquid crystalline Inverted Colloidal Crystals (LC-ICC)
- Production of uniform polymeric microspheres;
- Fabrication of HCP lattice (Colloidal Crystal mold – CC);
- Development of inverse opal structure (Fig.3);

Characterization and mechanical properties modeling
- Morphology (SEM, X-ray diffraction, FTIR);
- Mechanical evaluation (compression and flexural tests);
- Mechanical properties modeling through computational finite element method;

Biological evaluation.
- In vitro studies (cytotoxicity, cell morphology, functional assessment)

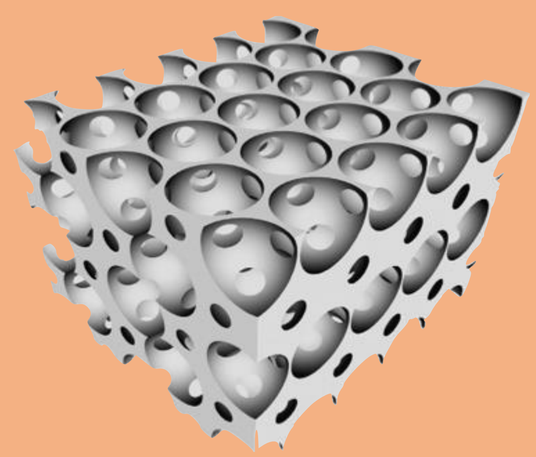

Fig.2 – ICC scaffold model. Adapted from *Takagi K. et al., J. Eur Cer Society. 2010.*

Results

Inverse opals exhibiting a uniform pore size, interconnected network and a biodegradable matrix have been produced as scaffolds for bone tissue engineering (Fig.4).

Composite matrixes of chitosan and hydroxyapatite (HA) were already developed and biologically tested with osteoblasts. Compression tests revealed that ICC scaffolds have enhanced mechanical properties with the presence of HA. The compressive modulus varies from 35 kPa to 146 kPa, in CS ICC to CS+6%HA (wt/wt) ICC, respectively. Cytotoxicity tests confirmed the viability of these scaffolds for biomedical uses. All samples had cellular viability superior than 80%.

Future work will be focused on the exploitation of chitin liquid crystalline suspensions to create an ICC matrix capable of mimicking collagen organization in the extracellular bone matrix. Also a combination of organic and calcium phosphate (HA, β-tricalcium phosphate or biphasic mixture) will be performed in order to replicate bone chemical and structural composition.

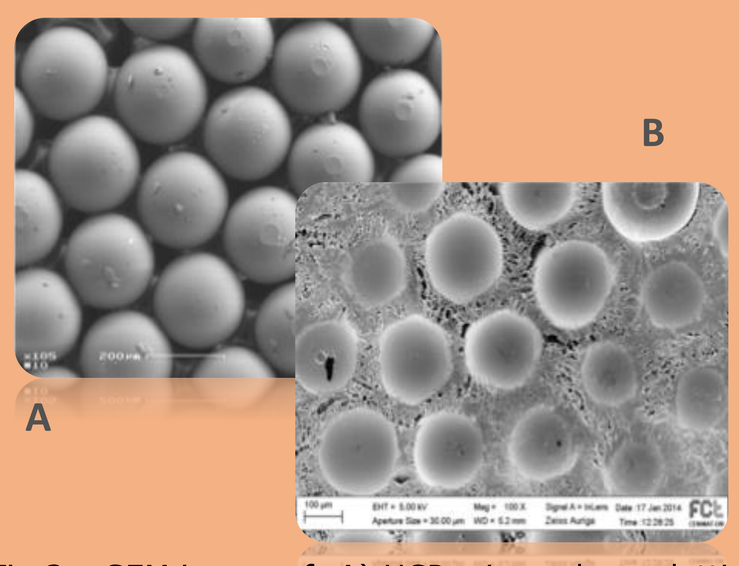

Fig.3 – SEM image of: A) HCP microspheres lattice; B) CC infiltration by a polymeric solution.

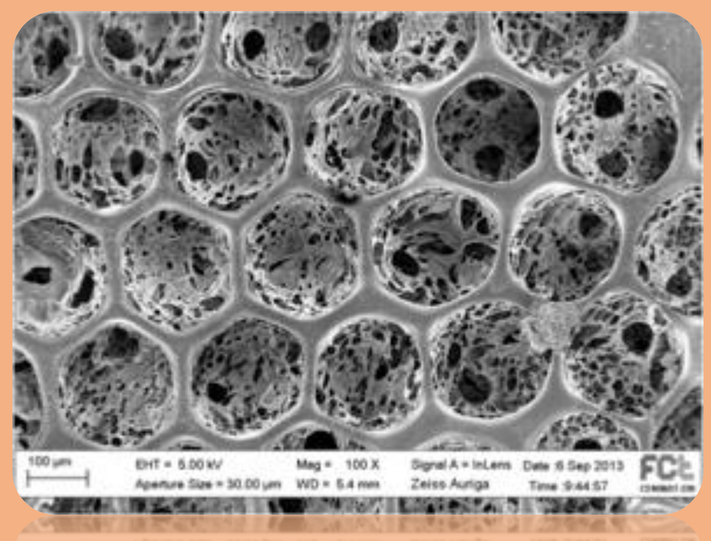

Fig.4 – SEM image of an ICC Chitosan scaffold.

Publications

João, C.; Silva, J.; Borges, J. *Chitin based Nanocomposites: Biomedical Applications.* Ecofriendly Polymer Nanocomposites: Chemistry and Applications. Springer, 2014. (acepted/under revision)

João, C.; Vasconcelos, J.; Silva, J.; Borges, J. *An Overview of Inverse Colloidal Crystal Systems for Tissue Engineering*.Tissue Engineering - Part B, 2013. doi:10.1089/ten.TEB.2013.0402 (ahead of print).

João, C.; Vasconcelos, J.; Silva, J.; Borges, J. Chitosan Based Inverse Colloidal Crystal Scaffolds. 25th European Conference on Biomaterials (ESB 2013). Madrid 8-12 September 2013 (Poster)

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