Biomimetic Approaches To Engineer Bioactive Glass-Based Nanosystems

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Introduction

In native mineralized tissues, the blend of organic with inorganic phases is frequently the key for remarkable mechanical properties.[1] In this work we aim to use multilevel fabrication techniques to recapitulate the complex environment of natural mineralized tissues. Bioactive glass and chitosan were chosen as materials to be combined respectively as mineral and organic phase in order to mimic bone structure.

Materials and Methods

Bioactive glass nanoparticles (BG-NPs) were previously produced by sol-gel route[2]. Chitosan, a natural origin polymer, was combined with the bioactive glass nanoparticles to obtain nanocomposites. Two strategies were followed. BG-NPs were dispersed in a chitosan solution and then transformed in membranes through a traditional solvent casting procedure. Regarding the 3D level, a simple procedure of adding a drop of aqueous suspension of BG-NPs and then leave it to dry on a superhydrophobic surface was used to induce the self-assembly of the BG-NPs.

Results

SaOs-2 osteoblastic-like cells were seeded on the nanocomposites films based on a chitosan blend with BG-NPs with different formulations, namely SiO_2:CaO:P_2O_5(mol.%)=55:40:5 and SiO_2:CaO:P_2O_5:MgO(mol.%)=64:26:5:5. Cells adhered, while maintaining their viability. The nanocomposite containing particles doped with Mg presented moderate bioactive character and higher hydrophilicity and was found to stimulate a better osteoblastic response. By allowing the evaporation induced self-assembly of the BG-NPs on a superhydrophobic surface, BG-NPs based aggregates comprising the nano, micro and macro levels were created. Besides having a hierarchical organization, known to give mineralized materials their great mechanical properties, we also proved that these systems allow for the inclusion of drugs by dispersing dyeing additives in the macrospheres. See Figure 1. Their bioactive character was controlled by changing the evaporation ratio.

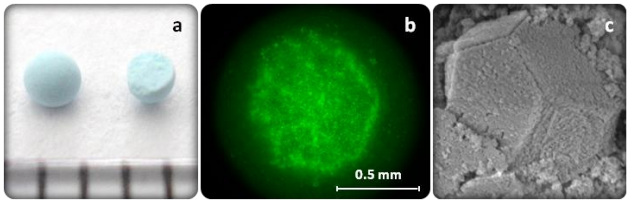

Fig. 1. a) Methylene blue dyed sphere (whole and cross-section); **b)** Fluorescence image of a calcein AM stained sphere (cross-section); **c)** SEM image showing self-assembly of the BG-NPs.

Discussion and Conclusions

Regarding 2D applications of the BG-NPs, bioactive nanocomposites, results showed a positive effect on the osteoblastic response. At the 3D, the results showed that BG-NPs are capable of self-assemble into organized multilevel structures. Therefore, self-assembly proved to be a powerful tool in mimicking mineralized structures.
The described research work is based on simple techniques highly competitive against other existing technologies for bone´s structure mimicking.

References

1. Luz GM. Comp Sci Tech.70, 1777, 2010.
2. Luz GM. Nanotechnology. 22, 494014, 2011.

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Disclosures

The authors have nothing to disclose.