Physico-chemical Characterisation of Functional Electrospun Scaffolds for Bone and Cartilage Tissue Engineering

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Introduction
Electrospun fibres have received much attention for their potential application in Tissue Engineering [1]. These fibrous scaffolds are similar to native collagen fibrils in the extracellular matrix both in scale and 3D arrangement.
This study investigates the potential of the electrospinning technique to build a three-dimensional construct recapitulating the zonal matrix of the bone-cartilage interface. Mimicking the zonal organisation of this interface will help the production of functional osteochondral grafts for regeneration of skeletal joint defects [2,3].

Experimental Methods
Polymer solutions were prepared by dissolving poly(lactic-co-glycolic acid) (PLGA) without or with collagen type I (at ratio 7:3, 8:2 and 9:1) at 15% (w/v) in hexafluoroisopropanol. Hydroxyapatite nanoparticles (nHAp) were also added at concentrations up to 50% (w/v). Homogenised polymer solutions were then electrospun on a thin layer of phosphate buffer saline solution spread on the collector in order to facilitate the membrane detachment and recovery.

Results and Discussions
Results have shown that electrospun membranes containing different amounts of nHAp could easily be obtained after a proper homogenisation of the initial solutions. Incorporation of increasing amounts of nHAp in PLGA solutions were not affecting significantly the average diameter of the fibres, generally of about 700nm. However, in presence of collagen, fibres with diameters below 100nm were generally observed and the number of these fibres was inversely proportional to the ratio PLGA:collagen and proportional to the content of nHAp.
In absence of collagen, the membranes were rather hydrophobic, although the contact angles were progressively dropping from 125° to 110° when the content of nHAp was increased from 0% to 50%. Membranes containing collagen were much more hydrophilic: the contact angles were between 60° and 110°, the values being proportional to the ratio PLGA:collagen and the content of nHAp.

With regards to the mechanical properties, the addition of nHAp from 0% to 50% in absence of collagen resulted in decreasing dramatically both the Young modulus (Ym), from 34.3±1.8MPa to 0.10±0.06MPa, and the ultimate tensile strain ( ɛ max), from a value higher than 40% to 5%. However, the presence of collagen together with nHAp allowed the creation of membranes much stiffer, although more brittle, as shown for membranes made with a ratio 8:2 and 10% of nHAp, for which Ym=70.0±6.6MPa and ɛ max=7%.

Conclusion
This work shows the potential of electrospinning as a technique to produce a wide range of membranes from which some can be selected in order to create, thanks to a multilayered arrangement, a 3D scaffold with a gradient of properties mimicking the zonal matrix of the bone-cartilage interface.

References