Anisotropic Bone Scaffolds

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INTRODUCTION: Synthetic anisotropic tissue matrices are desirable for a wide variety of cases. Most non natural biomaterials are homogeneous in composition and structure while natural bone for example has cancellous and cortical parts which play different roles but are closely juxtaposed in the body. We report on the elaboration of a composite material based on hydroxylapatite and polylactic acid for the production of new materials with engineered properties.

METHODS: The polylactic acid (PLA) used was Galastic PABR-L-68 from Galactic (Brussels Biotech) which consists of 88% *l* lactic acid residues polymerized by a ring opening reaction of l-lactide. The hydroxylapatite (HA) was a fine powder form of less than 10 μm size provided by MediCal calcium phosphates (Toulouse) which contained HA and 30% tricalcium phosphate. The solvent used was industrial grade chloroform stabilized with methanol. The porogen used was natural sea salt of fine and coarse particle sizes.

The samples were made by dissolving the desired amount of polymer in solvent overnight and thereafter introducing the required amount of minerals and mixing until a homogeneous paste was obtained. The desired amount of porogen was incorporated then the paste was placed in a mould with one open face and air dried at room temperature until solid. The extracted sample was further oven dried at 40°C before immersion in distilled water. Following salt dissolution the samples were again oven dried and rectified with sand paper.

RESULTS: Despite much effort we could not make a composite containing 75% HA. Samples were made containing 0%, 30%, 50% and 66% HA by weight. The composites containing more minerals were harder and dried more quickly than those containing more polymer. Collapse of the porous structures was observed when the composites were immersed in water before complete removal of solvent. The anisotropic samples were made by superimposing different layers in the mould before drying.

DISCUSSION & CONCLUSIONS: Functional coatings such as HA on Titanium promote surface bioactivity by modifying an inert substrate. Similarly, organic molecules have been grafted on mineral surfaces[1] and organic structures have been mineralized in a biomimetic way[2]. Using HA and PLA as basic ingredients, we elaborated a series of composite and anisotropic materials based on these arranged as functional gradients. The objective was to ascertain the extent to which the gradients could be feasible. The 50% HA 50% PLA composite was made with intended porosities of 0% to 50%. Composites with lower porosities took longer to leach out the porogen but had better mechanical strength. An anisotropic sample was made by moulding three simultaneous layers of O%, 35% and 50% porogen contents. Transverse observation of the material confirmed the presence of a strong base material intimately bound to a porous material of increasing porosity. Conversely, a cylindrical specimen was made with high interior porosity and high external strength. Such materials are intended to offer choices for resorption rates, for the inclusion of pharmaceutical principles, or the recolonisation or differentiation of cells[3]. We also realized a biomaterial with anisotropic composition. This specimen had a 50% HA porous composition on one side, and a porous 100% PLA composition on the other. Such a material could be advantageous for simultaneous osteoblast binding on one side together with chondrocyte development on the other. We believe solvent casting is unique in providing a means for polymer diffusion leading to strong binding between layers of different composition or structure. This allows the modulation of biomaterial strength. Contrary to sintered ceramics, metal screws can be fixed into the composites without fractures.

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