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BIORESORBABLE SCAFFOLDS PREPARED BY SUPERCRITICAL FLUID FOAMING

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INTRODUCTION: With orthopaedic implants, bone grafts represent a large part of bone surgery. Tissue engineered scaffolds can serve as 3D-templates to guide and enhance bone regeneration, by facilitating cell migration, proliferation and differentiation [1]. Supercritical CO_2 foaming of polymers has been reported to create highly porous structures [2], and start to be used for bioresorbable polymer scaffolds [3]. It avoids the use of organic solvents. This simple and flexible technique allows also to add fillers to reinforce the structure, or solvent-sensitive biological factors. After saturation of the polymer, the reduction of pressure induces a thermodynamic instability, which causes nucleation and growth of gas pores in polymer matrix. Varying foaming conditions allows to control foam morphology [4].

METHODS: Two commercial bioresorbable polymers were used, without further purification: a poly L-lactic acid PLA (Boehringer Ingelheim, Germany) and a copolymer of D,L-lactic and glycolic acids PLGA 85/15 (Purac, Netherlands) characterized respectively by intrinsic viscosity of 1.8 and 2.5 dL/g. PLGA 85/15 discs were obtained by compression moulding. PLGA preforms or PLA pellets were placed in the high pressure chamber (Autoclave France). Amorphous PLGA 85/15 was heated to 40°C, and semi-crystalline PLA to 190°C. Both were saturated by supercritical CO_2 (pure >99.995%; SL gas, CH) under different pressures, before depressurizing, and additional water cooling in case of PLA. Foam morphology was characterized by SEM (Philips XL30) observations of fracture surfaces. Apparent density and compression modulus (Universal Tensile Testing machine; 0.5 mm/min) were also evaluated.

RESULTS: Several parameters (saturation pressure and time, depressurization and cooling rates) were varied to study their effects on foam morphology, porosity and mechanical properties and to determine which conditions lead to a suitable scaffold for bone tissue engineering (Fig1). Partially interconnected pores with a diameter ranging from 200-1000 μm can be manufactured (Fig2).

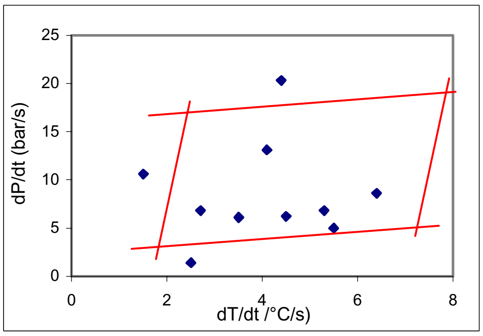

Fig 1. Processing window for PLA

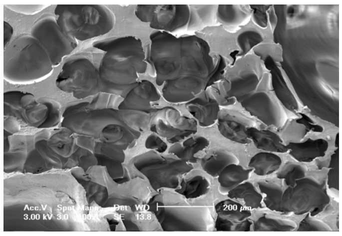

Fig. 2. PLA morphology (2.5 bar/s; 2.7 °C/s)

DISCUSSION & CONCLUSIONS: Foaming conditions, polymer composition and viscosity have a significant effect on the 3D-matrices' porosity and properties. Increasing saturation pressure will increase the potential number of pores, whereas a slow cooling (in case of melt foaming) will promote coalescence and thus larger pores but also interconnections. Porosity and pore size of bioresorbable structures obtained by supercritical fluid process will likely be adequate for bone tissue engineering. Flexibility of the technique can also allow to integrate reinforcing fillers into the polymer matrix to improve its mechanical behavior.

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