CaP coating of polyurethane foams for bone regeneration

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Statement of Purpose: Bioactive composites made of biodegradable polymeric matrices, and biomimetic Ca phosphates (CaP) as fillers, are receiving increasing attention for bone Tissue Engineering (TE).

We have recently set up a process to obtain biocompatible PU foams with a controlled range of pore size and open porosity [1,2]. Two types of PUFs were developed from two different polyether-polyol mixtures (EC and EF, EC being more hydrophobic). These foams are proving to be suitable for their use as TE matrices with good mechanical features and long-term biodegradability. With the aim to develop bioactive composites for bone TE, PU foams were loaded with hydroxyapatite (HA) or α-tricalcium phosphate (α-TCP) during the foaming process [3]. EF-based foams were more flexible than the EC-based ones, both foam types showing higher compressive properties in the dry state than in the wet state [3]. The corresponding composites co-foamed with CaPs showed a similar behavior, with higher mechanical properties only in the case of EF-based composites (EF-HA > EF-α-TCP), possibly due to a better affinity of the EF matrix with the inorganic phase. PUF-composites demonstrated their suitability to support cell growth [1,4], but there is some concern regarding the availability to cells of CaPs embedded into the matrix.

It can be hypothised that a biomimetic inorganic coating of the porous structure would improve the early osteointegration process. As a consequence, in this work we considered a coating process of the foamed matrices with the same inorganic powders (HA and α-TCP) used for the preparation of the composites. Once setup, this process could be applied as well to the PUF composites, to improve their performances in vivo.

Methods: EC- and EF-foams were synthesized by a one-step bulk polymerization of polymeric MDI (B141, BASF) with EC and EF polyol mixtures (ElastoFlex LF2946: EF; ElastoCoat 96827/4: EC; Elastogran, Italy) using Fe-Acetyl-Acetonate as catalyst and water (2%w/w_{polyol}) as expanding agent. Coating was obtained by immersion of the PUF samples, fixed in circular slots in a polymeric mesh, in a HA (A6021, Plasma Technik) or α-TCP (CNR-CSFM "G. Ciamician", BO) suspension. This experimental set-up avoids the sample flotation and forces the CaP particles to impact perpendicularly to the surface of the foam sample.

To mimic the *in vivo* behavior, the coated foams were immersed in SBF for 14 days at 37°C. Before and after the treatment, weight variations, XRD, SEM and EDS analyses were performed.

The *in vitro* cytocompatibility of coated PUFs was evaluated with the MG63 cell line. Samples were disinfected by immersion in ethanol for 48 h. After a careful drying, each sample/well was seeded with 10^4 cells and cell growth was allowed up to 14 days. Cell proliferation was evaluated by the Alamar Blue assay, and cell morphology was observed at SEM.

Results/Discussion: The coating process varied depending on the PU foam composition: EF-foam exhibited a higher weight variation both for α-TCP (98 vs 18%) and HA (221 vs 49%) powders. After the SBF treatment (fig. 1), the quantity of inorganic salts adherent to the foams changed, showing a weight increase for α-TCP-coated foams, possibly due to a phase change from α-TCP to HA (data confirmed by XRD analysis). EF-foam showed a better coating ability, possibly due to its more hydrophilic properties.

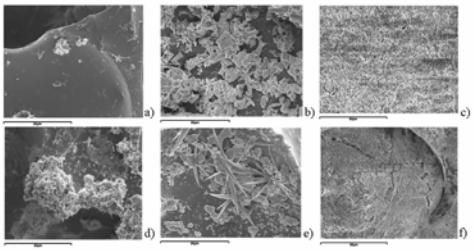

Fig.1: Morphology at SEM of EC- and EF- foam matrices (a, d); α-TCP coated foams (b, e); HA coated foams (c, f)

A good cytocompatibility was shown by both uncoated and HA or α-TCP coated foams (fig. 2). From Alamar Blue assay, the proliferative activity was higher on EC-foam than on EF-foam, at every time point. Both EC- and EF-α-TCP coated foams showed the higher cell proliferation (α-TCP-coated EC-foam > α-TCP-coated EF)

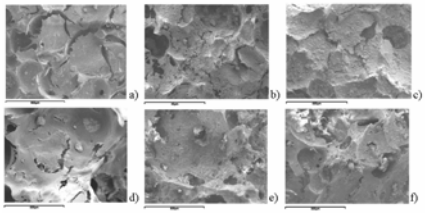

Fig.2: MG63 cell morphology at SEM after 14 days on EC- and EF-foams (a, d); α-TCP coated foams (b, e); HA coated foams (c, f)

Conclusions: The described coating process showed a good CaP salts deposition, depending on foam structure and morphology, and on CaPs particle size. As cell proliferation was higher for αTCP-coated foams, this coating appears promising for a better first osteointegration process. Next step of this research will be that to apply the α-TCP coating to PUF composites.

References:

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