Radial control of cell colonization inside 3D scaffolds by means of plasma processes

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The production of 3D porous biodegradable scaffolds with proper porosity, pore size, shape chemical composition and mechanical integrity, able to act as temporary backbone for the regeneration or repair of a living tissue, represents a paramount challenge for scientists working on tissue engineering applications [1].
The optimization of surface properties of scaffolds is a critical aspect, as they influence the interactions between the cells and the material. Very often, scaffold's chemical composition is not fully cell compatible, e.g., polymer hydrophobicity. On top of that, cell adhesion in the core regions is often hampered by the tortuosity of the 3D porous polymer structure, leading to limited and heterogeneous scaffold's cell colonization.
By modifying both chemical surface properties and morphological parameters of the scaffolds, a better control over cell adhesion mechanism can be achieved.
Plasma processes can be used to create chemical gradients inside the scaffolds, enabling homogeneous cell colonization [2]. Nonetheless, the 3D architecture of the structures can represent by itself a great barrier to the penetration of the plasma species throughout the scaffold pores, promoting uniform treatment of the 3D structures. Thus, a fully interconnected porous scaffold is required in order to guarantee improved plasma penetration and consequent cell ingress inside the scaffold core regions.
In this study, poly(ε-caprolactone) (PCL) scaffolds, produced by means of conventional and additive manufacturing techniques were treated using low pressure plasma depositions and treatments with the aim of creating chemical gradients throughout the 3D scaffold thickness.
Scaffolds were treated in a stainless steel parallel-plate plasma reactor, with low pressure plasma depositions, fed with C_2H_4/N_2 mixtures, followed by H_2 post treatment, or plasma treatments with O_2/H_2 mixtures. In the first case, nitrogen-rich hydrocarbon films were deposited creating chemical gradients inside the porous structures; while with the second process, hydroxyl groups were grafted on the PCL scaffolds. Chemical (XPS), Wettability (WCA absorption kinetics), morphological (SEM) and mechanical (compression tests) characterizations were performed on scaffolds, before and after plasma modifications. *In vitro* biological analyses were performed on both plasma treated and untreated scaffolds using Saos2 osteoblast cells. Quantitative (MTT assay) and qualitative (actin staining) results clearly highlighted the influence of plasma processes on the behavior of osteoblast cells. In particular, chemically modified scaffolds with amines or hydroxyl groups, revealed better cell proliferation respect to the pristine material.
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