Development of conductive 3D scaffolds for tissue engineering

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With the aging of the population, the replacement of tissues by prosthesis or artificial devices has become of primary importance. Biomaterials have evolved progressively from being bio-inert, to biodegradable and now bio-active. The development of innovative biomaterials was based on two essential features: (i) the incorporation of bioactive compounds able to favor cell proliferation/differentiation and (ii) the control of the mechanical properties of the material, as Young moduli play a major role in cell differentiation. Recently, another interesting feature arose in the design of biomaterials, *i.e.* the electrical property [1]. The conductivity of tissues (ventricular muscle, nerve, lung, cardiac, and skeletal muscle) lies in an ordered manner in between 0.03 and 0.6 S/m^2 and conductive polymers cover this range of conductivity. Conductive biomaterials can be considered as new generation of “smart” biomaterials, allowing direct transference of electrical and electromechanical stimuli to cells. Few conductive 3D scaffolds were developed mainly based on a biocompatible conjugate polymer, Poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS), to sustain the growth and differentiation of mesenchymal stem cells into bone cells [2]. However, all the methods used to design them are either tedious, requires specific devices or the use of cross-linker. The PhD subject aims at the development of new conductive 3D materials using a easy handling method: compaction of polyelectrolytes complexes [3] (Figure 1).

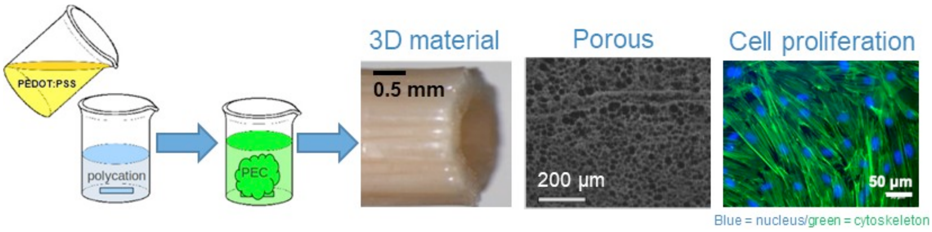

Figure 1: Summary of the project

First, a synthetic scaffolds based on commercial PEDOT-PSS will be investigated to optimize its mechanical and conductive properties by varying parameters such as the polymer ratio and the type and concentration of salt. Secondly, a biobased PEDOT-based scaffold will be designed by synthesis of a conductive polysaccharide and its formulation with biopolymers. The chemical composition of the developed scaffolds will be determined using spectroscopic techniques (UV/Visible, infrafred), XPS and elemental analysis. Their internal structure and organization will be analyzed by confocal fluorescence and scanning electron microscopies. To characterize their mechanical properties, the complex shear modulus behavior will be studied using a conventional rheometer. The ultimate tensile stress and strain and Young modulus of the material will also be determined under controlled humidity and temperature. The conductivity of the scaffolds will be determined in dry and wet state using the 4 points method. Finally, biocompatibility tests will be done using osteoblasts and the differentiation of stem cells will be studied under electrical stimulus to demonstrate the ability of PEDOT-based scaffolds to be used in regenerative medicine.
Motivated candidates interested in chemistry and/or physical-chemistry of polymers and their biological applications are invited to apply. No knowledge in biology or electrochemistry are required.

[1] Saberi, A.; Jabbari, F.; Zarrintaj, P.; Saeb, M. R.; Mozafari, M. Biomolecules 2019, 9.
[2] Guex, A. G.; Puetzer, J. L.; Armgarth, A.; Littmann, E.; Stavrinidou, E.; Giannelis, E. P.; Malliaras, G. G.; Stevens, M. M. Acta Biomater 2017, 62, 91-101.
[3] Reisch, A.; Roger, E.; Phoeung, T.; Antheaume, C.; Orthlieb, C.; Boulmedais, F.; Lavalle, P.; Schlenoff, J. B.; Frisch, B.; Schaaf, P. Adv Mater 2014, 26, 2547-2551