PH.D. POSITION

Theoretical and experimental modeling of architected soft tissues

Modélisation théorique et expérimentale des tissus mous architecturés

Localization. TIMC-IMAG, University Grenoble-Alpes, Grenoble, France

Period. Starting date can be as soon as October 2016 till January 2017 for a 36-month duration

Funding. French Research Agency (ANR BioScaff)

Requirements. Competences in theoretical mechanics; Programming skills (e.g., C++, Matlab); Strong interest for interdisciplinary research and experimental studies.

BACKGROUND. Since the early 2000s, major efforts are being made to develop a new generation of implants for soft tissue combining both a biodegradable and biomimetic character, allowing its colonization by the host tissue while avoiding surgical removal action of the implant. The project focuses on the development of such scaffolds dedicated to the **regeneration of soft tissues**. The objective is to forecast the evolution of the mechanical properties of the biocomposite "scaffold/growing cells" during the antagonistic effects of the biodegradation of the scaffold and cell colonization. For this purpose, new biocompatible and biodegradable block copolymers having behavior close to that of soft tissues and favoring cellular growth will be synthesized. The aim of the project is to characterize the mechanical properties of the scaffolds at various stages of degradation in the presence of growing cells. Simulation methods will integrate the experimental results to characterize and finally forecast mechanical behavior of scaffolds according to these intrinsic properties.

KEYWORDS. Theoretical mechanics; Mathematical modeling; Experimental study; Architected biomaterial.

PROJECT. Task [1] At a mesoscopic scale, the combined effects of several cells on the structure can be analyzed with a model describing the cells as point able to induce local modifications in the mechanical properties of the structure (Stéphanou *et al.* , **2015**). The candidate will develop and implement the corresponding follow-up model accounting for mechanical and morphological properties of a degradable scaffold (for example, the elasticity modulus or the orientation tensor that can depend on the cell density and on the local architecture of the scaffold). **Task [2]** At the macroscopic scale, the candidate will use continuum mechanics theory to describe the mechanical behavior of Representative Element Volumes (REV) with characteristic length of the order of some millimeters (Rebouah *et al*. **2015**). Modeling of the REV mechanical behavior will take into account the coupling between constitutive equations describing the scaffold mechanical behavior and the equations describing the scaffold degradation together with the tissue development. Modeling will take into account hyperelasticity, viscoelasticity, anisotropy and scaffold mechanical behavior variation induced by its degradation and tissue formation. The candidate will implement constitutive equations in a finite element software in order to simulate evolution of the mechanical behavior of the biocomposite "scaffold/growing cells" over time. These equations will be validated on laboratory tests before the development of a simulation tool for the prediction of the biocomposite mechanical behavior as function of the microscopic properties of the scaffold. **Task [3]** Various usual mechanical tests on the biocomposite will be performed in physiological environment at different stage of degradation/colonization by the candidate to inform the model developed in task 3 with experimental data.

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Références:

Rebouah M., Chagnon G. and Favier D. *Development and modelling of filled silicone architectured membranes*. Meccanica **2015**.

Stéphanou A., Le Floc'h S. and Chauvière A. *A hybrid model to test the importance of mechanical cues driving cell migration in angiogenesis*. Mathematical Modelling of Natural Phenomena **2015**.