COMPACT PROTEIN-BASED MATERIALS AS TOUGH HYDROGELS FOR CARTILAGE AND TENDON REPAIR

DIRECTEUR DE THESE : ANDREAS REISCH
INSERM / CNRS / UNIVERSITE DE STRASBOURG, UMR_S 1121, BIOMATERIAUX ET BIOINGENIERIE, CRBS 1 RUE BOECKEL, 67000 STRASBOURG
TEL : 03 68 85 42 66 ; E-MAIL : reisch@unistra.fr

Hydrogels have proven to be valuable biomaterials for repair, regeneration and engineering of soft biological tissues. However, classical hydrogels are quite soft and fragile materials that fail in mimicking stiff yet elastic tissues like cartilage and tendon, stimulating an increasing interest in so-called tough hydrogels.[1] Ideally, such biomaterials should, at first, close the defect and assure the cohesion of adjacent tissues, while limiting adverse reactions, and then, in the longer run, help in the repair of the tissue and the (re)establishment of normal functionality.[2] Mechanical and adhesive properties therefore need to be combined with the presence of biological clues and controlled degradation.
Our lab has recently discovered a new approach to obtain mechanical resistant biomaterials composed only of albumin, through simple drying of protein solutions in the presence of certain salts, without any chemical crosslinking.[3] The objective of the present PhD thesis will therefore be to extend this approach to the development of protein based tough hydrogel materials with mechanical properties close to those of cartilage and tendon, suitable for tissue-engineering applications.
In a first step, the formation of albumin based materials will be monitored using fluorescence microscopy and Förster resonance energy transfer (FRET), IR spectroscopy, and mechanical tests. Modification of the surface chemistry of albumin will be used to link properties of constituents, assembly conditions and final properties. The results will be the basis to extend the approach to the incorporation of increasing concentrations of (i) other soluble proteins and peptides, notably fibrinogen, elastin like peptides, charged peptides and resilin. (ii) Different types of other biomacromolecules, notably charged polyscaccharides will be integrated. And (iii) fibrous proteins, notably collagens, will be included. In this way the spectrum of biochemical composition and mechanical properties will be largely extended, and elastic modulus and toughness will be increased. The obtained materials will then be evaluated with respect to their interaction and colonization with cells and their biodegradation profile.
The PhD project will result in a new family of all natural tough biomaterials produced in low-energy, waterborne processes with potential applications as structural biomaterials for cartilage and tendon repair and engineering.
This work will be performed at the Biomaterials and Bioengineering lab (https://www.biomaterials-bioengineering.com) in close collaboration with clinicians and the start-up Albupad .

1. Petelinšek, N.; Mommer, S. Tough Hydrogels for Load-Bearing Applications. *Adv. Sci.* **2024**, *11* (12), 2307404. https://doi.org/10.1002/advs.202307404.
2. Ullah, S.; Chen, X. Fabrication, Applications and Challenges of Natural Biomaterials in Tissue Engineering. *Appl. Mater. Today* **2020**, *20*, 100656. https://doi.org/10.1016/j.apmt.2020.100656.
3. Aloui, E.; De Giorgi, M.; Frisch, B.; Lavalle, P.; Schaaf, P. Protein Based Biomaterial with Viscoelastic Properties. EP 3811982 A1