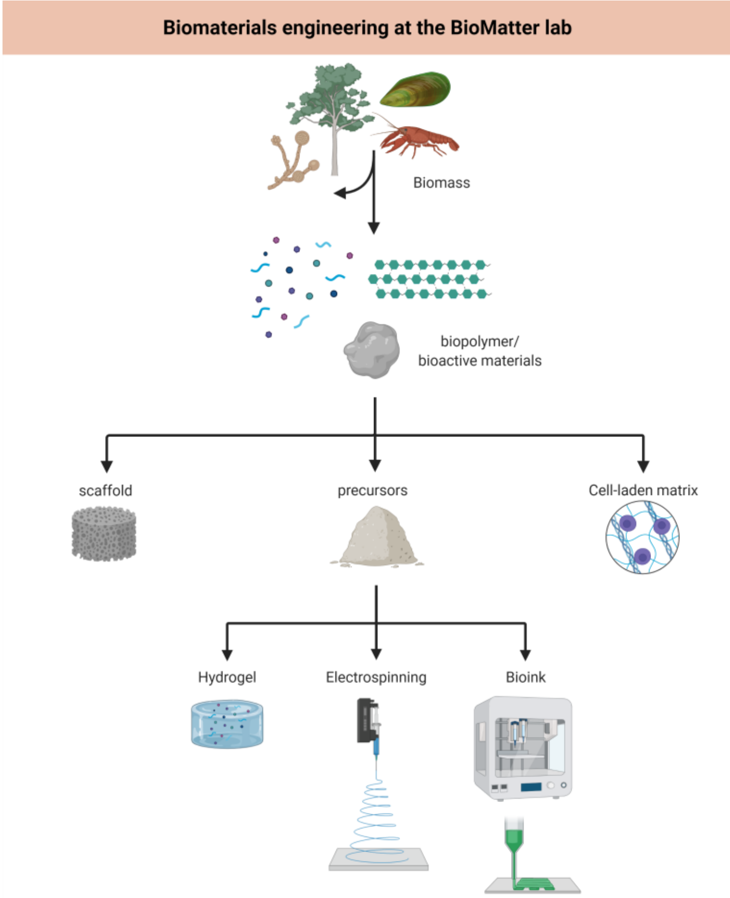
BioMatter *lab works at the interface of polymer science, physical chemistry, and biology. The overall focus of the lab is the fundamental understanding and development of biohybrid/bioinspired materials for biomedical applications with a specific emphasis on biomaterials engineering and tissue regeneration. Although significant advances in tissue engineering have been made in recent years, the continued lack of organs and tissue for transplantation calls for the development of innovative treatment alternatives. To achieve this, we are working on new approaches to modify natural polymers and new methods of manufacture, combining engineering, chemistry and biology to design biomaterials that control and direct the interaction with cells. While most of our target applications lie within biomedical engineering e.g., cell encapsulation, biomedical devices, and tissue engineering, we also apply our engineered hydrogels in food, nutraceutical delivery, agricultural, and environmental applications.*

http://biomatter.ulb.be/

Amin Shavandi (Head of the lab)



Master Thesis subjects 2021-2022 proposed by BioMatter *lab-BTL-3BIO*

Subject 1:

Antibacterial hydrogel with potential wound healing applications: The effect of Tannic acid on hydrogel gelation and adhesive properties.

Tissue adhesives are required to close wounds and stop bleeding efficiently; however, existing biomaterials are cytotoxic, expensive, and bond to tissues weakly. Synthesize of a compatible, and self-healable hydrogel through dynamic non-covalent bond with high mechanical strength and deformability is highly challenging. In this work, a polyethylene glycol (PEG) based hydrogel containing tannic acid-Fe (III) (TA-Fe) nanoparticles will be fabricated by an eco-friendly and straightforward strategy. The hydrogel will be formed through multiple dynamic non-covalent bonds between TA and PEG and between TA and Fe (III). These multiple dynamic bonding endow the hydrogel with high mechanical properties. The synthesized hydrogel will be able to exhibit high adhesive properties due to the presence of abundant dihydroxyphenyl and trihydroxyphenyl groups in the TA structure. The hydrogel will be tested for its mechanical properties, antibacterial activity, and cell biocompatibility. The hydrogel can become a promising antibacterial wound dressing for biomedical applications.

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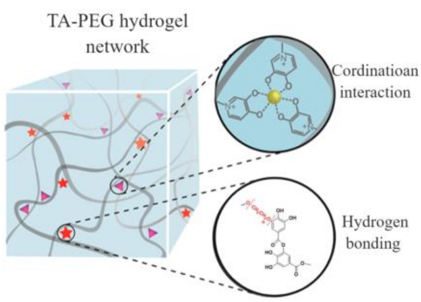
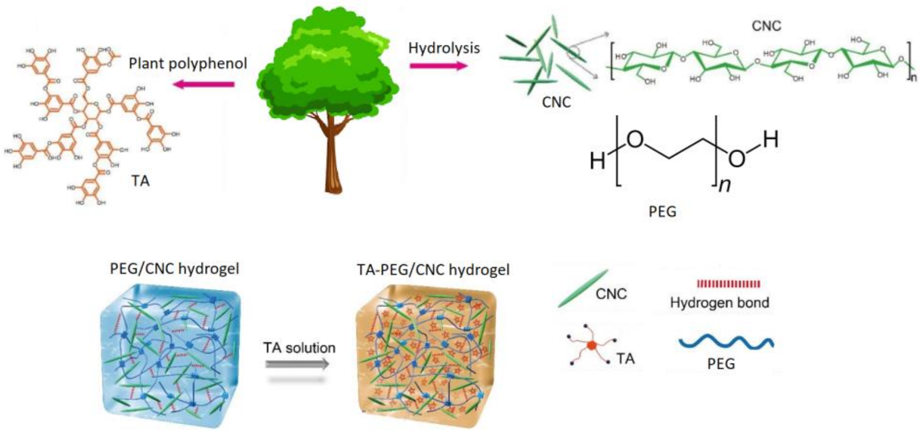


Adopted from Andersen et al 2018.
DOI: 10.1021/acs.biomac.7b01249 Biomacromolecules 2018, 19, 1402−1409

Subject 2:

Investigation of the effect of tannic acid concentration and treatment time on the physicochemical and biological properties of hydrogels reinforced by cellulose nanocrystal

Developing hydrogels with advanced mechanical performance and multi-functionalities as alternative materials for load-bearing soft tissues remains a significant challenge. In this work, tannic acid (TA) will be exploited as a molecular coupling bridge between cellulose nanocrystals (CNC) and polyethylene glycol (PEG) chains for the fabrication of a bio-based advanced physical hydrogel via strong multiple H-bonds and hydrophobic interaction. By exposing to mechanical stress, the sacrificial H-bonds effectively dissipate energy on a molecular scale through dynamic breakage and reformation. This phenomenon will result in biomimetic hydrogels with high toughness and strength, significant elongation, and good self-recoverability superior to most of the hydrogen bond-based hydrogels. This project will investigate the effect of TA concentration and treatment time to develop a robust biocompatible hydrogel with suitable mechanical strength and functionalities for potential applications in tissue engineering.



Adopted from Lin et al 2020.
https://doi.org/10.1039/D0TB00424C, J. Mater. Chem. B, 2020

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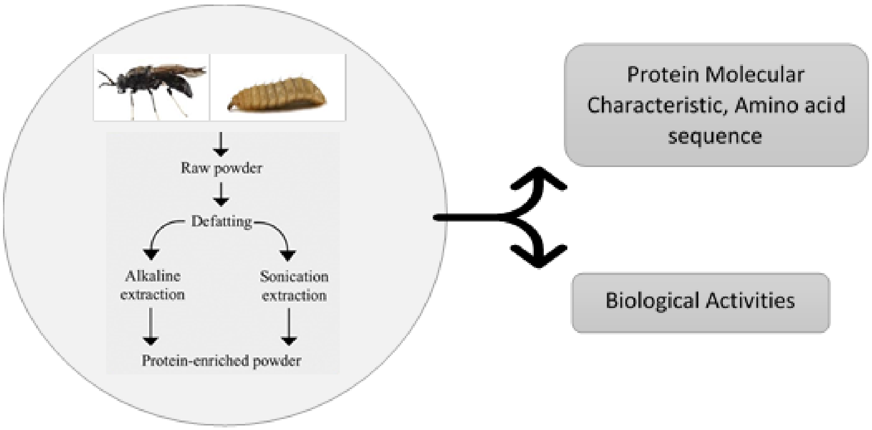
Subject 3:

Isolation and physicochemical properties of protein from insect farm side stream as a new source of bioactive molecules

Many insects naturally feed in organic wastes, converting biomass nutrients into their biomass and reducing the amount of waste material. Hermetia illucens Linnaeus 1758 (Diptera: Stratiomyidae), better known as black soldier fly (BSF), is one of the most critical species proposed as a converter of organic waste. BSF larvae can develop on a wide range of substrates, including agricultural by-products and organic waste. BSF is a good source of proteins, lipids, minerals, and chitin and has been proposed as a valuable source of animal feeds for different species such as fish, pigs, and chicken. This project is aimed to isolate protein from the side stream of an insect farm. The protein content of three different life stages of Black soldier fly BSF (Hermetia illucens), Adult Black Soldier Fly insect, Puparia, and Flake will be investigated. Chemical structure, the thermal stability of the extracted protein will be analyzed by FTIR spectroscopy and TGA, respectively. Besides, molecular weight and amino acid sequence will be investigated, as well as the antioxidant activity.



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Subject 4:

Collagen extraction and characterization from mussel byssus and possible application as a wound healing patch.

Mussel byssus is a by-product of mussel production and is a potential source of collagen. Mussel byssus mostly found in rocky intertidal, salt marsh, subtidal, and hydrothermal vents, which consist of a collagen fiber-reinforced composite that can withstand the wave forces. This project is aimed to extract collagen from mussel byssus by using the Deep eutectic solvents extraction method. The first objective of the project is to optimize the extraction parameters (the type of solvents and ratio, time, temperature, solid/liquid ratio) in order to obtain the highest collagen extraction yield. Besides, the wound healing application of the isolated collagen will be investigated through crosslinking the extracted collagen by the polyphenol chemistry as a green and sustainable protein binder. The chemical structure (FTIR analysis), thermal properties (DSC, TGA), molecular weight distribution (SDS-Page) of the extracted collagen will be investigated. Besides, the biological activities of the wound dressing patch will be evaluated through cell viability assay and antioxidant activity assay.

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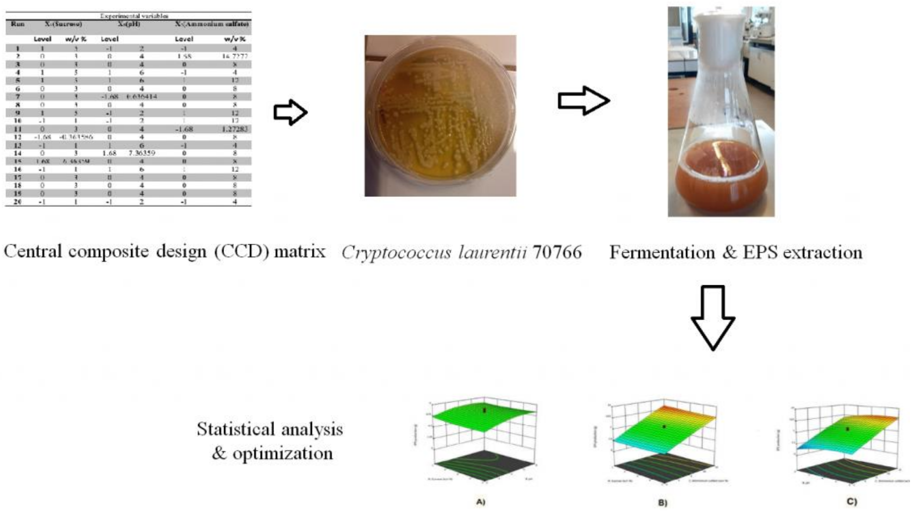
Subject 5:

Optimization of exopolysaccharide production by *Cryptococcus laurentii* 70766 and *Sclerotium glucanicum* using response surface methodology

Microbial exopolysaccharides (EPSs) have many features that can be used in different ways. For example, Scleroglucan is a water-soluble extracellular polysaccharide produced by the fungus *Sclerotium*. It has potential in several application areas. It showed safe immune stimulator, antitumor, antiviral and antimicrobial activities. In addition, Scleroglucan and some of its derivatives at different oxidation degrees, have been widely employed as starting material for the synthesis of hydrogels, as suitable matrices for the preparation of controlled release formulations. The systems obtained either by physical interactions or chemical bonds, are particularly attractive because of their high biocompatibility. EPS production by fungi (including yeasts) mainly depends on the type of fungal strain, physical and cultural conditions of the fermentation process. Because of their low production cost, eco-sustainability, low environmental impacts and well-known biodegradability, these biopolymers have been standing out as new and industrially worthy of attention polymeric materials. Optimization of biosynthesis conditions is necessary for industrial EPSs application. Response surface methodology (RSM) is the most preferred method for fermentation media optimization. In this work, culture condition optimization for two interesting EPS production, one from *Cryptococcus laurentii* 70766 (significantly improved excisional wound healing in healthy rats) and another one (Scleroglucan) will be done by RSM. In this regard, at least 3 parameters (carbon and nitrogen sources and pH) will be optimized for maximum EPS production. So using the Design-Expert® Software, central composite design (CCD) methodology will be used to design the experiments. For each strain, after subculturing the isolate in its culture medium, EPS extraction and purification will be done, and the yield will be recorded as the response. Finally, statistical analysis of the data will be performed for determination of optimum points.



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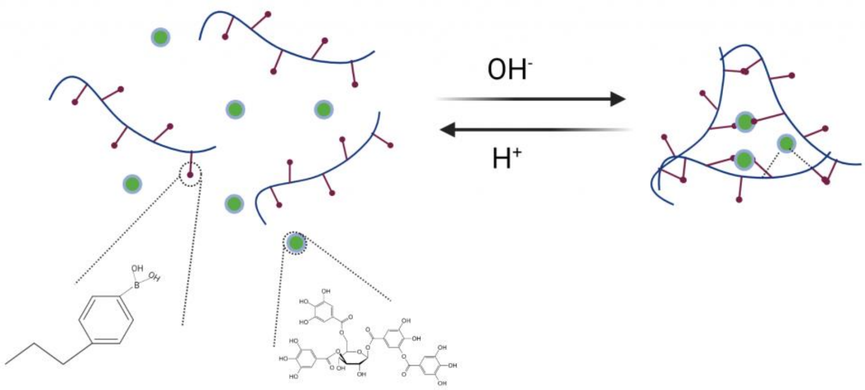
Subject 6:

Bronic acid alginate hydrogel reinforced by tannic acid for tissue adhesive applications

The development of bioadhesives has emerged as one of the critical research fields in tissue sealants, wound dressings, and hemostatic agents. Alginate-based bioadhesives are being increasingly used due to alginate's unique properties, including biocompatibility and availability to chemical modification for optimizing adhesive properties. Mussels-imitated cis-diol-based alginate-boronic acid hydrogels have demonstrated good adhesiveness and pH-responsive self-healing properties. However, high pH (>7) requirements in gel formation and its low hemostatic activity might limit its biomedical applications. Thus, we are looking for innovative approaches to strengthen the physiochemical and biological activity of alginate boronic acid-based hydrogels. Tannic acid is a natural polyphenol with high hemostatic activity containing a high density of pyrogallic acid or catechol groups which make it an excellent candidate for the formation of boronate ester bonds with boronic acid. Furthermore, TA is able to form multiple hydrogen bonds with carboxyl and hydroxyl groups of the alginate which contributes to an advancement in the toughness and self-healing properties of the hydrogel. Hence, this project aims to design an adhesive hydrogel with high hemostatic activity through reinforcing interaction between cis-diols that are embedded in alginate and boronic acid and also dynamic covalent boronate ester bonds between tannic acid and boronic acid.



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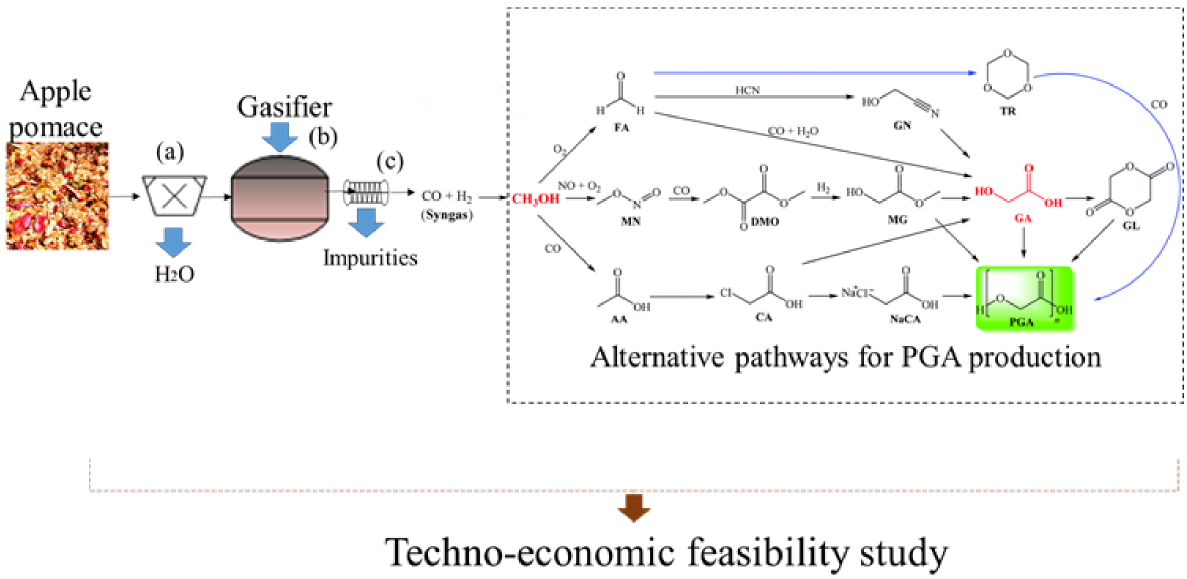
Subject 7:

Waste pomace to Polyglycolic acid (PGA) for biomedical applications

There is now a consensus in the scientific community that anthropogenic activities are responsible for existing challenges of natural resource depletion, global warming, and climate change. In an attempt to circumvent these aforementioned challenges, the Belgian Government sought to explore practical solutions to facilitate a net-zero greenhouse (GHG) gas emission scenario by the year 2050, via the reduction in Belgium's reliance on fossil resources. In line with this important national target, the proposed project seeks to explore the production of renewable and biodegradable alternatives to fossil-sourced plastics. This is because fossil-sourced plastics exacerbate the depletion of limited global fossil resources and lead to significant pollution issues when poorly managed. The poor degradability potential of fossil-sourced plastics also poses many challenges since its retention in the environment may lead to the uncontrolled release of toxins, such as dioxins, to land and groundwater, overtime. In other to replace these fossil-sourced plastics, the proposed study, therefore, seeks to explore the valorization of locally sourced waste apple pomace for the production of the biodegradable polyester (plastic) of polyglycolic acid (PGA). PGA is a novel biodegradable polymer that has been extensively researched in the biomedical field due to its favorable characteristics such as biocompatibility, excellent thermal and mechanical properties, and gas barrier property (Budak, Sogut, & Aydemir Sezer, 2020; Manoukian et al., 2019). Indeed, PGA is commonly incorporated into scaffold fabrication in multiple tissue engineering applications such as bone, cartilage, and spinal regeneration (Manoukian et al., 2019). In this project, conceptual process models that integrate unit operations for the different PGA production pathways highlighted in Figure 1, will be developed based on existing experimental data that must be 'mined' from literature. Process simulation of the conceptual models will be achieved using ASPEN Plus as the preferred process simulation tool. Comparative assessments of the technical, energetic, and economic viability of the waste apple pomace to PGA conversion processes via the alternative pathways highlighted in Figure 1, will be undertaken using classic engineering and techno economic assessment methods. In this project, the minimum selling price of the resulting PGA product will be specified as the preferred comparative economic performance metric. It is anticipated that the project will provide useful information that will instructive in ascertaining the feasibility of future explorations of large-scale PGA production plants in Belgium, for the benefit of all Belgians.



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