Toulouse Biotechnology Institute
Bio & Chemical Engineering

THESIS PROPOSAL AT INSA TOULOUSE

Doctoral contract from the research Ministry

SUBJECT : RESSOURCE RECOVERY FROM WASTEWATER: OPTIMISATION OF THE PRODUCTION OF GEL-FORMING BIOPOLYMER

Key words : Biopolymer production, bioprocesses, granular sludge technology, resource recovery from wastewaters, circular economy.

CONTEXT

Framework of the research program

The biological granulation process is a highly promising alternative to the activated sludge processes currently used to treat wastewater. Densification of the biological flocs can occur under certain environmental and operating conditions and results from accumulation extracellular polymers (EPS). The granules formed lead to important improvement of the sludge settling velocity and allow to achieve different reactions in the same biological aggregate leading to a more compact process.
The aerobic granular process provides the opportunity to both treat effluents and produce reusable biopolymers. Indeed, part of the EPS plays a role in the gelation and densification of the microbial aggregates and can therefore be used in agriculture (in the form of hydrogels) or for a variety of applications (cement additives, non-flammable products, etc.). Therefore, one objective could be to conduct granular processes in order to promote an overproduction of polymers of interest. This anticipates a global evolution of the sector of waste and waste water treatment from the pure curative towards a treatment associating a valuation approach. As great amounts of biopolymers can be produced from a urban wastewater, this new approach constitutes a major opportunity for a circular economy logic.

The integrated design and implementation of these granular sludge systems requires the simultaneous management of processes from a hydraulic, physico-chemical and microbiological point of view that govern the formation and growth of granules. The following factors are known to be involved in granulation and hydrogel accumulation: the configuration of the reactors, the characteristics of the feed, hydrodynamics and aeration as well as the environmental parameters (pH, temperature, presence of divalent cations, etc.). Their effects on the physico-chemical properties of the EPS as well as on the microbial composition of the granules have only been partially evaluated.
To date, polysaccharides produced and excreted (ePS) appear as the main constituents responsible for the granular structure (Lin et al, 2010 Seviour et al 2009). In addition, the hydrogel properties of these EPS depend on the chemical structure of the polymer (molecular weight, charges, degree of substitution, etc.) which also depends on the operating conditions. These properties must be optimally controlled so that a treatment plant can become a production plant of molecules of industrial interest!

Lin, YM, Kreuk, M, van Loosdrecht, MCM and Adin A. (2010) Characterization of alginate-like exopolysaccharides isolated from aerobic granular sludge in pilot-plant. Water Research 44, 3355-3364.
Seviour T., Pijuan M., Nicholson T., Keller J., Yuan Z. (2009a). Understanding the Properties of Aerobic Sludge Granules as Hydrogels. Biotechnology and Bioengineering, 102, (5), 1483-1493

OBJECTIVES OF THE PHD

The objective of the thesis will be to study and understand the key microbial and process factors to optimize the biopolymer production while treating an urban wastewater. For example, research questions could be:
- How can we identify the role of certain micro-organisms in the accumulation of EPS?
- Can we influence the accumulation of EPS by modifying the operating conditions?
- How can we enhance the characteristics of EPS to obtain a hydrogel that is interesting for agriculture?

The work will involve:
- the operation of a lab-scale reactors for treatment and ePS production. The reactors will be operated in a continuous mode. An experimental plan will be carried out to determine the main factors influencing the biopolymer production.
- the polymer characterization will be performed using a panel of relevant analytical techniques (FTIR, HPSEC, fluorescent labelling, MS, ...) but also rheological measurements. Characterization of microbial populations will also be conducted.
- in association with other researcher, a model describing the production of ePS will be used.

CANDIDATE RESEARCH PROFILE

• Engineer in process or bioprocess engineering, baccalaureate level +5.
• Motivation for experimental work and pilot monitoring in real conditions.
• Interest in bioreactor modeling (help with specific supervision will be provided on this point).
• Interest and aptitude for teamwork.
• Rigor and precision in analytical work and data analysis.
• A motivation for environmental issues.
• Ease of writing, especially in English.

CONDITIONS

Funding: INSA - SAIC Thesis contract (Minimum net salary envisaged: €1,700/month)
Duration: 3 years
Start: September or October 2024
Location: Equipe Symbiose du pôle Génie Microbien et Bioprocédés, Laboratoire TBI, INSA, 135 Avenue de Rangueil, 31077 Toulouse Cedex 04
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https://www.toulouse-biotechnology-institute.fr/poles/equipe-symbiose/

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