Toulouse Biotechnology Institute
Bio & Chemical Engineering

PhD offer
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Understanding and mastering the controlled oxidation of plant cell walls towards biomass valorization

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Funding: TIRIS - SCALING UP SCIENCE PROGRAM

CONTEXTE

Biomass degradation is the first essential step to enable a sustainable use of resources that do not compete with food supply. Recent discoveries in the domain of degradation of lignocellulose (LC) have underlined the important role of reactive oxygen species (ROS) in the early process, mainly but not only. Additionally, biomass oxidation is involved within a both multi-component and multi-parameter system. Therefore, the nature and the mechanism of action of ROS are still unknown. The GREENNESS project aims to better understand and control cellulose oxidation to unblock an efficient use of LC. To do so, the work will rely on a Carbohydrate Binding Module (CBM) targeting insoluble cellulose, modified with a covalently grafted catalyst that generates ROS in a spatially and temporally controlled manner. The project will join the CIMES team from TBI, an expert in enzyme engineering, and BIBAC team from Softmat, specializing in ROS chemistry.

WORK PROGRAM

This PhD project is part of a collaborative research initiative involving two laboratories: the Toulouse Biotechnology Institute (TBI, Toulouse) and the Chemistry of Colloids, Polymers & Complex Assemblies laboratory (SoftMat, Toulouse). Each laboratory will host a PhD student, with the two projects addressing distinct yet complementary aspects of the controlled oxidation of plant cell walls to facilitate the enzymatic deconstruction of lignocellulosic biomass. At the core of this strategy, the SoftMat PhD project will focus on the characterization of reactive oxygen species (ROS) generated by porphyrins, while the TBI PhD project will develop and implement these porphyrins within an original assembly involving a cellulose-targeting Carbohydrate-Binding Module (CBM), which provide the spatial proximity. The objective is to investigate how ROS diffusion and spatial proximity to cellulose influence oxidation efficiency. The work at TBI will subsequently involve combining these protein constructs with glycoside hydrolases and applying them to wheat straw in order to evaluate the impact of localized oxidation on enzymatic activity and oligosaccharide release. Working in a dynamic and highly skilled research environment, the PhD candidate will be responsible for producing and purifying the proteins and enzymes required for the project using *Escherichia coli* expression systems. The candidate will also engineer CBM–porphyrin assemblies through protein engineering approaches and characterize them using biochemical, biophysical and enzymological methods, including Raman and infrared spectroscopy, protein purification, colorimetric sugar assays, and HPAEC-PAD analysis. The originality of this project lies in the combination of photoactivatable porphyrins with a CBM and its application. The ultimate goal is to establish relationships between spatial proximity, catalytic activity, and hydrolysis products, thereby enabling a comparison of the respective contributions of chemical and enzymatic oxidation to the deconstruction of lignocellulosic substrates.

PROFILE

Applicants should hold a Master's degree (MSc, equivalent to a French Master 2) in biochemistry, biocatalysis, structural biology, or a related field. Candidates must possess strong expertise in molecular biology, enzymology, and protein biochemistry. An interest in protein structure and organic chemistry will be considered an asset. Proficiency in English, along with strong communication and teamwork skills, is essential. The successful candidate

will work in close collaboration with another PhD student focusing on the chemical aspects of the project.

Beyond these technical qualifications, the candidate is expected to demonstrate a high level of scientific curiosity, critical thinking, and analytical rigor, enabling them to conduct the project to the highest scientific standards.

APPLICATION SUBMISSION

For further information and/or to submit an application, please contact Cédric Montanier (cedric.montanier@insa-toulouse.fr) and Régis Fauré (regis.faure@insa-toulouse.fr). Applicants should send a cover letter, a curriculum vitae (CV), and their Master's degree transcripts **before July 13th, 2026**, for a PhD start date in the last quarter of 2026.

References:

Pelus A, Bordes G, Barbe S, Bouchiba Y, Burnard C, Cortés J, Enjalbert B, Esque J, Estaña A, Fauré R, Henras AK, Heux S, Le Men C, Millard P, Nouaille S, Pérochon J, Toanen M, Truan G, Verdier A, Wagner C, Romeo Y, Montanier CY. A tripartite carbohydrate-binding module to functionalize cellulose nanocrystal. Biomater. Sci. 2021, *9*:7444. https://doi.org/10.1039/D1BM01156A

Bissaro B, Røhr Å, Müller G *et al.* Oxidative cleavage of polysaccharides by monocopper enzymes depends on H_2O_2. *Nat Chem Biol* 2017, *13*:1123. https://doi-org.insis.bib.cnrs.fr/10.1038/nchembio.2470

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