*PhD position in chemical engineering*

**Development of safe, intensified and sustainable pRocEss for the vAlorization of lignocellulosic bioMass (DREAM)**

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Duration: 3 years (Beginning between September and October 2022)

Salary: 1500 euros/month

Supervisor: Sébastien Leveneur (sebastien.leveneur@insa-rouen.fr)

Location: LSPC-INSA Rouen Normandie with the possibility to spend 6-12 months abroad.

Keywords: Kinetic modeling, heterogeneous catalyst, biomass valorization.

The Climate crisis pushes us to develop new industrial processes consuming less energy (essentially fossil ones), emitting fewer pollutants and greenhouse gases, and being accepted by citizens. The use of renewable raw materials (such as biomass) and energies will help us in this transition. At industrial scale, the use of biomass for the production of chemicals and fuels already exists. One can cite bioethanol production from sugar cane or biodiesel from vegetable oils. Nevertheless, these raw materials may incur the Food vs. Fuel dilemma, competing with the food sector. One should keep in mind that the world food price crisis (2007-2008) is also linked to these raw materials (first-generation biomass), extensively used for biofuels production. Second-generation biomass, such as lignocellulosic biomass, will avoid such a competition, representing an excellent alternative feedstock. Lignocellulosic biomass (LCB) may be a valuable ally in the production of chemicals, fuels and materials, being an abundant, renewable and carbon-fixing resource. In this context, its conversion to value-added chemicals and fuels has become increasingly widespread. LCB's structure, which is mainly constituted of bio-polymers: lignin, cellulose and hemicellulose, can be made accessible by fractionating it in its constituting elements. The Reductive Catalytic Fractionation (RCF) process, using hydrogen, is a promising process because it preserves the lignin structure.[1] This process combines a solvolytic extraction of lignin with a catalytic reduction by hydrogen favoring the lignin depolymerization into valuable aromatic platform molecules. Besides, the other constituting elements, i.e., cellulose and hemicellulose are not damaged and they can be depolymerized to simplest sugar monomers, i.e. glucose, fructose. The solvolysis of these latter sugar monomers leads to several promising bio-additives and bio-fuels, such as levulinic acid, alkyl levulinates and gamma-valerolactone.[2]

Renewable energy sources can be used in lignocellulosic biomass valorization, such as green hydrogen in RCF process, and their use could sustain our chemical industries and develop the mix-energy. Although these raw materials are greener (renewable) than their fossil counterparts, they are not free from the risk of accidents. Consequently, the design of a sustainable process cannot ignore the need to identify, assess and reduce risk, therefore it requires a specific risk assessment for these bio-refinery.

Biomass valorization and utilization sectors are vital in the Normandy region, as well as the renewable energy sector. To contribute to the mix-energy, the use of green hydrogen in the region is supported by politics and industrials. Hydrogen is essential for the valorization of biomass[1] and its use in the transformation of agricultural and forest wastes in chemicals, biofuels, or materials will strengthen a green industrial sector in the Normandy region.

This doctoral thesis will be linked to RIN Normand ARBRE (Sébastien LEVENEUR | Institut national des sciences appliquées de Rouen (insa-rouen.fr)), which investigate the Normandy's biomass valorization by green hydrogen from wind energy.
This thesis will also be linked to Métropole Rouen PROMETEE (Sébastien LEVENEUR | Institut national des sciences appliquées de Rouen (insa-rouen.fr)), which wishes to evaluate biomass valorization processes on the innovative tetraptych Society-Industrial Risk-Environmental impact-Cost evaluation. PROMETEE stands for Processes to valoRize nOrman bioMass from renEwable energies: ciTizen sciencE and process safEty.
This doctoral thesis will be funded by Région Normandie and Métropole Rouennaise.

This doctoral thesis will develop an industrial process for producing a renewable monomer from the gamma-valerolactone (GVL) platform molecule issued from cellulose and hemicellulose hydrolysis.[2] The lack of engineering study slows down industrial development. The first step will study the hydrolysis of cellulose and hemicellulose produced from the Reductive Catalytic Fractionation (RCF). The second step will be the hydrogenation for the production of GVL[3,4], and its further transformation into a promising monomer. The optimum operating conditions based on sustainability criteria (cost evaluation, environmental and industrial risks) will be selected based on experimental data. The environmental impact will be done in collaboration with Prof. Valeria Casson Moreno (Bologna University, Italy).

The milestones are:
-Hydrolysis of cellulose and hemicellulose issued from RCF process: catalyst screening and kinetic modeling;
-Production of renewable monomer from cellulose and hemicellulose hydrolysis products: kinetic and calorimetry study;
-Risk assessment and cost evaluation of this process in strong collaboration with Prof Casson Moreno.

To ensure the success of the thesis, the following international collaboration will be used:
-Heterogeneous catalyst: Prof. Grenman (Åbo Akademi, Finland) and Prof. Maugé (LCS, Caen)
-Process simulation: Prof. Stateva (Bulgarian Academy of Science) and Prof. Errico (University of Southern Denmark)
-Process safety: Prof. Valeria Casson-Moreno (Bologna university, Italie).

**Requirements:**

-Master thesis in chemical engineering (or provisional certificate);
-Experience in experimental work and solid background in analysis;
-The candidate should have some knowledge in kinetic modeling and/or process simulation softwares ;
-Fluent in English;
-The PhD student might have the opportunity to make a scientific visit to one of the international laboratories mentioned above;

-This thesis will be in strong connection to PROMETE project. Thus, the Ph.D. student must also be open-minded to participate in citizen science activities.

**How to apply and get further information:**

The candidates should send a detailed curriculum vitae, a motivation letter, transcript of record (Bachelor and Master), other valuable documents (recommendation letters, awards,..). **These documents must be sent before the 7th of May 2022 at sebastien.leveneur@insa-rouen.fr**

**Assessment**

INSA Rouen Normandie is labeled "HR Excellence in Research" by the European Commission as part of the implementation of the Human Resources Strategy for Researchers (HRS4R).

The candidate assessment is a two-step evaluation. The candidates will be evaluated by a jury of three researchers (including Sébastien Leveneur).

In the first step, the jury will evaluate the different applications based on the provided documents. The selection of the candidates for the second step (i.e., interview) will be done based on the quality of their chemical engineering and chemistry education (courses and marks), their abroad experience in research or other activity, their language skills and mainly English, the relationship between their master thesis and this doctoral thesis, their scientific publication (article and/or communication on congresses), their recommendation letters and the quality of their resume and motivation letter.

In the second step, the selected candidates (from the first step) will pass an interview. This interview can be done online by video conference calls. The interview procedure will last ca. 30 minutes per candidate, and the candidate will present themselves and describe their research activities. The evaluation will be done based on their presentation, quality of their responses, and motivation to do this thesis.

**References:**

(1) Rinaldi, R. *Catalytic Hydrogenation for Biomass Valorization*; Rinaldi, R., Ed.; Energy and Environment Series; Royal Society of Chemistry: Cambridge, 2015. https://doi.org/10.1039/9781782620099.
(2) Di Menno Di Bucchianico, D.; Wang, Y.; Buvat, J.-C.; Pan, Y.; Casson Moreno, V.; Leveneur, S. Production of Levulinic Acid and Alkyl Levulinates: A Process Insight. *Green Chem.* **2022**, *24* (2), 614–646. https://doi.org/10.1039/d1gc02457d.
(3) Delgado, J.; Vasquez Salcedo, W. N.; Bronzetti, G.; Casson Moreno, V.; Mignot, M.; Legros, J.; Held, C.; Grénman, H.; Leveneur, S. Kinetic Model Assessment for the Synthesis of γ-Valerolactone from n-Butyl Levulinate and Levulinic Acid Hydrogenation over the Synergy Effect of Dual Catalysts Ru/C and Amberlite IR-120. *Chem. Eng. J.* **2022**, *430*, 133053. https://doi.org/10.1016/j.cej.2021.133053.
(4) Capecci, S.; Wang, Y.; Delgado, J.; Moreno, V. C.; Mignot, M.; Grénman, H.; Murzin, D. Y.; Leveneur, S. Bayesian Statistics to Elucidate the Kinetics of γ-Valerolactone from n-Butyl Levulinate Hydrogenation over Ru/C. *Ind. Eng. Chem. Res.* **2021**, *60* (31), 11725–11736. https://doi.org/10.1021/ACS.IECR.1C02107.