DOCTORAL POSITION IN CHEMICAL ENGINEERING

- Recruitment grade: master degree in chemical engineering or physic-chemical engineering
- Location: Tarbes, France
- Duration: 3 years, starting late September/october 1st, 2021
- Gross Salary Range: 1870 €/month (which includes extra gratification for teaching duties -32h per year)

CONTEXT AND AIMS

TITLE : Biochar performances study for biogas treatment by Adsorption
Keywords: biogas –biochar- trace compounds- adsorption-pyrolysis

CONTEXT:

Biogas, derived from anaerobic digestion of organic matter, is a source of renewable energy with high energy and environmental potential. It is a complex mixture that contains different types of trace compounds, in varying amounts depending on the substrates, which can damage the storage and upgrading units (corrosion phenomena, toxic emissions).
The main objectives of this project are to study and demonstrate the use of digestate obtained from anaerobic digestion of biomass to produce biochar-derived carbon (by pyrolysis) which will be used as a value-added product for adsorption with application to biogas treatment. This project will deal with the study of the phenomena of selective adsorption of the constituents of a synthetic biogas on different types of biochars-derived carbon and adsorbents in order to purify the biogas. This study will focus on the optimization of the pyrolysis process (by identifying the best operation parameters) to produce the most adapted biochars-derived carbon for the target applications (biogas cleaning) and the study of adsorption phenomenaand multicomponent equilibrium adsorption (adsorption isotherms/ breakthrough curves). The model biogas studied will be a reconstituted mixture whose composition and the conditions of pressure and temperature will be close to real conditions. The results of this work will allow selecting profiled new biochars-derived carbon and adsorbents for the treatment of biogas in order to optimize their storage conditions and treatment.

THESIS ABSTRACT:

The main objective of this thesis project is to study the use of biochar-derived carbon for the adsorption of gases under real conditions to solve biogas upgrading and cleaning which will result in an innovative process for gas treatment or/and storage. This new biochar-derived carbon will be produced from organic matter obtained from anaerobic digestion (AD) **by pyrolysis** with the goal of finding cheap and eco-friendly precursor materials and implementing the synthesis procedures that will produce a higher yield and optimized material with enhanced adsorption capacities. In this sense, this ambitious project is targeting an adsorption efficiency study in a circular economy concept.
In order to improve the understanding of the adsorption phenomena on such a product and the physicochemical mechanisms involved (adsorption kinetics, surface reactions, etc), more fundamental studies must be carried out. They require the implementation of experiments on pilots already available in the laboratory. The aim will be to determine under real conditions: (i) the adsorption of the target gases ofa biogas mixture, (ii) adsorbent selectivity and / or separation factor. Numerical modelling of heat and mass transfers ofthe adsorption process will be investigated to estimate the limiting stepsaccording to the characteristics of the biochar itself depending on the pyrolysis conditions. Indeednon-negligible heat transfer could also occurbecause of important concentration of the CO2.Finally, this project would focus on two predominant target gases in biogas: CO_2 and CH_4 (with presence of other trace gases/compounds).

WORKING CONDITIONS

Laboratory : Laboratoire de Thermique, Energétique et Procédés (LaTEP) UPPA

This proposed work research is part of the development of research activities of the team “Processes for the Environment” of the Laboratoire de Thermique, Energétique et Procédés (LaTEP) of the University of Pau, Tarbes site and Pau site. At present, these activities concern the implementation of air treatment processes and the thermochemical conversion of waste and biomass. This research group has an expertise about the study and the use of coupling of air treatment processes (biofiltration in synergy with the complementary adsorption technique), optimisation of chemical engineering process and has an international visibility in these fields.
In addition, this study is a part of E2S project entitled: ” Study of BioChar derived from solid digestate anaerobic digestion (methanisation) for biogas treatment and air treatment by ADsorption (BioCAD)”.

Web site : http://latep.univ-pau.fr	
Localisation address: LaTEP (UPPA)-STEE Site Universitaire de Tarbes	
Starting Date: september/october 2021	**Duration: 3 years**
Thesis Director: Cécile Hort/ Vincent Platel	
Gross Salary Range: 1870 €/month (which includes extra gratification for teaching duties -32h per year)	

MISSION-MAIN ACTIVITIES

TASKS:

1. Literature review (adsorbents, bio-adsorbents, adsorption, activation, pyrolysis, modeling)
2. To develop new biochar-derived carbon with physicochemical characteristics perfectly mastered (texture, structure, morphology, functionalities).
3. To understand the mechanisms used in the preparation of these materials.
4. To study the influence of the operating parameters of pyrolysis on the adsorption properties of the new biochar-derived carbon.
5. To improve scientific knowledge of gas adsorption and physicochemical mechanisms involved under real conditions especially for these renewable gases (i.e. biogas) in order to understand the interactions of this new adsorbent with its environment.
6. To evaluate the selectivity or separation factor of the biochar-derived carbon used to gases (i.e. biogas) upgrading and clean up.
7. To model of heat and mass transfers in adsorption process (Python language)

METHODOLOGY:

To achieve the objectives, several steps will be considered:
Step 1: literature review – the choice of gas mixture representative of the biogas and the different biochar-derived carbon to be studied will be performed and validated. Bibliographic review on methanization and digestate origin, composition, pre-processing and valorization routes with a focus on thermochemical and adsorption processes. This first step, after equipment acquisition if necessary, will consist to test equipments (i.e. chromatography analyzers, adsorption and breakthrough curves pilots under pressure and temperature conditions close to real conditions). This step will aim to establish and validate the experimental protocols and analytical techniques before the achievement of the breakthrough curves and adsorption isotherms for the different biochar-derived carbon.
Step 2: Pyrolysis analysis
To identify the optimal operational parameters of pyrolysis technology for controlling the amount, composition and quality of the biochar-derived carbon with a particular focus on changes of the biochar-derived carbon characteristics (ash content, elemental composition, higher heating value, pH, cation exchange capacity, water holding capacity and surface functional groups) by tunning the pyrolysis process (temperature, heating rate, atmosphere).
Step 3:
Determination of adsorption isotherms (adsorption capacities) from an experimental manometric device and study of the selectivity of the new biochar-derived carbon.
Step 4: achievement and analysis of breakthrough curves for the different selected biochar-derived carbon. According to the results obtained, achievement of breakthrough curves on biochar-derived carbon and adsorbents mixtures could be considered.
Step 5: modeling of adsorption process using models obtained from literature depending on limiting steps. This will make possible to propose the sizing of a prototype equipped with a new biochar-derived carbon filter in the biogas upgrading process.

EXPECTED RESULTS:

1. To develop a new use of biochar-derived carbon and adsorbents for the treatment of target gases (i.e. biogas).
2. The identification of the optimal operational parameters of pyrolysis technology for controlling the amount, composition and quality of the biochar-derived carbon with a particular focus on changes of the biochar-derived carbon characteristics (ash content, elemental composition, higher heating value, pH, cation exchange capacity, water holding capacity and surface functional groups) by tunning the pyrolysis process (temperature, heating rate,

atmosphere).

3. To characterize the physicochemical properties of biochar-derived carbon and adsorbents to improve adsorption phenomena of biogas.
4. To have a better comprehension of the phenomena of adsorption mechanism of storage/treatment of a target gases.
5. The new biochar-derived carbon study will be free of emissions of by-products (i.e. desorption), and no other kind of residue could be produced.
6. Assessment of adsorption capacity and selectivity of the developed bioadsorbents with regards to specifications to achieve pipeline quality biomethane.
7. Providing an alternative solution to the management of energy demands based on fossil fuels.

RESEARCH COLLABORATIONS:

This research activity will also be undertaken with Institut des Sciences des Matériaux de Mulhouse (**IS2M), UMR CNRS 7361/Carbon and Hybrid Materials team (CMH)**

The Mulhouse Materials Science Institute (IS2M) is a CNRS-University of Upper Alsace mixed research unit The general objective of the Institute is to advance the knowledge front and transmit expertise in the field of Surfaces and Interfaces**,** Functionalization and Porous Materials**.** CMH team activities are focused on the synthesis, functionalization and characterization of carbon-based materials for energy and environmental applications.
https://www.is2m.uha.fr/en/about-us/

Possibility of collaboration with **Universidad Tecnológica de Pereira (UTP, Colombia)** (project ECOS Nord under evaluation)

FUNDING

This doctoral position is funded by the project E2S-UPPA (Energy Environment Solutions) whom core scientific domain focuses on Environment and Energy to meet challenges related to the energy transition, geo-resources,aquatic habitats and the environmental effects of natural and anthropogenic changes (https://e2s-uppa.eu/en/index.html)

APPLICANT'S PROFILE

The ideal candidate should hold a Master degree in chemical engineering or physico-chemical engineering with knowledge of inter-facial phenomena. Previous experience in environmental process with an experience in gas analytical techniques and modelling (computer programming). The candidate should have a strong interest in renewable energy. He/she is passionate for environmental issues, rigorous and highly motivated. The candidate must have a good English level and the capacity to work autonomously.
Proficiency in English is mandatory for both oral and writing communication.

APPLICATION-EVALUATION CRITERIA

Application file assessment: selection committee.
Candidates will first be selected based on their application file.
Those selected after this step, will then be interviewed.
Application files will be evaluated based on the following criteria:
- grades and ranking during your Master degree, steadiness in your academic background
- the candidate's motivation, scientific maturity and curiosity
- english language proficiency and capacity to work autonomously
- candidate's ability to present her/his work and results
- work experience similar to an internship in a laboratory – or likewise; previously achieved research work (reports, publications).

REQUIRED DOSSIER

Send an e-mail with your candidature containing:

- CV
- Cover letter detailing candidate's motivations
- Master degree grade transcripts and ranking
- Reference letter
- Contact details of at least two referees, from your work environment, who can be contacted for further reference

Please submit your application by the following email address with the title “Doctoral application”: cecile.hort@univ-pau.fr, vincent.platel@univ-pau.fr. **Please attach the following documents as a single pdf file**: the **deadline** for submitting the application **is June 27, 2021.** For more details, please visit our websites: http://e2s-uppa.eu/en/index.html

SUPERVISION AND CONTACT

Supervisory team: LaTEP, Cécile Hort, Sabine Sochard, Frédéric Marias, Vincent Platel
For additional information and proposal, please contact: **cecile.hort@univ-pau.fr** and **vincent.platel@univ-pau.fr**