

2 teaching assistant/PhD student positions in the Chemical Engineering department of the University of Liège

Research subjects to choose among:

- 1. Development of a photocatalytic process for hydrogen production**
- 2. Design of an intensified reactor for the continuous synthesis of solids**
- 3. Design of membrane-electrode assemblies for fuel cells**
- 4. Reactive extraction of valuable metals from waste in urban mining**

The Department of Chemical Engineering of the University of Liège, Belgium, (<https://www.chemeng.uliege.be>) has an opening for 2 teaching assistant/PhD student positions.

We offer a two-year working contract, starting on September 15th 2020, renewable up to two times, with a monthly salary of approximately 2000 EUR, after taxes and social security.

Duties

Globally, the workload is split between research (2/3 of the time) and teaching assistant (1/3). During the first year, the share devoted to education is generally higher.

Research :

Depending on your tastes and background, you are part of a team of approximately twenty persons (PhD students, senior researchers, technicians and professors) in the NCE (Nanomaterials, Catalysis & Electrochemistry) or PEPs (Products, Environment, and Processes) laboratories.

You will find at the end of this announcement a brief description of the 4 PhD thesis subjects that are proposed.

Teaching assistant :

You are part of a team of about ten persons (teaching assistants and professors) supervising the first- and second-year chemistry and thermodynamic lectures in the engineering curriculum (taught in French to about 200-300 students). Specifically, you help preparing and supervising exercises and laboratory sessions, as well as correcting the exams. The supervision of exercises and laboratory sessions of a third lecture in the “Chemistry and materials sciences” sector among lectures in Chemical Engineering (study of reactors), Transport phenomena and Chemistry and inorganic materials is also entrusted to you (between 15 and 30 students).

Profile

You have a Master’s degree in engineering, physics, chemistry or materials sciences. You may also apply if you have a different Master’s degree but you can testify to interests and abilities in those fields.

You are attracted to both teaching and research and you wish to carry out a PhD thesis.

A working knowledge of both French and English is required.

Information

For any question, please contact Marie-Noëlle Dumont (mn.dumont@uliege.be) regarding the teaching assistant part, and regarding the research part, please contact Benoît Heinrichs for subject 1 (b.heinrichs@uliege.be), Dominique Toye for subject 2 (dominique.toye@uliege.be), Nathalie Job for subject 3 (nathalie.job@uliege.be) and Andreas Pfennig for subject 4 (andreas.pfennig@uliege.be).

Submission of applications

Applications must be sent as soon as possible by email to the secretariat of the department of Chemical Engineering (secretary.chemeng@uliege.be).

The complete file will include

- a motivation letter including in particular the choice of the research subject
- a resume

Research topics

1. Development of a photocatalytic process for hydrogen production

Supervisor : Benoît Heinrichs (b.heinrichs@uliege.be)

Research on renewable hydrogen production is becoming a global initiative to try to reduce the use of hydrocarbons in the energy and chemical sectors. Currently, hydrogen is mainly produced on a global scale by steam reforming of natural gas ($\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow \text{CO}_2 + 4\text{H}_2$). An alternative option to produce hydrogen is electrolysis which allows the water dissociation ($2\text{H}_2\text{O} \rightarrow 2\text{H}_2 + \text{O}_2$) using electrical energy. It is nevertheless possible to produce hydrogen from water dissociation through direct use of solar energy : this is the photocatalytic decomposition of water. This technology is currently not possible on a large scale due to the too low activity of the photocatalysts and therefore the too slow kinetics of the reaction. According to several studies, the use of composite photocatalysts characterized by a heterojunction between two semiconductors could make it possible to greatly increase the activity and therefore to foresee an extrapolation of this hydrogen production pathway at an industrial scale.

The first step of the project consists in the development of a composite photocatalyst with optimal nanostructure and composition to maximize the production of hydrogen. This is followed by the design of the photoreactor, with sunlight simulator, for implementing the hydrogen production reaction, as well as studying its kinetics and mechanism.

2. Design of an intensified reactor for the continuous synthesis of solids

Supervisor : Dominique Toye (dominique.toye@uliege.be)

Chemical processes intensification aims at meeting the industrial demand for faster and more efficient production tools, along with a reduced environmental impact. In the field of chemical reactors, one promising idea is the transition to continuous

synthesis processes in tubular reactors possibly micro or meso-fluidic, whose geometry allows the optimization of local reaction conditions. Until now, this type of intensified reactors were mainly developed for fluid phases reactions.

In the case of reactive processes involving solids (synthesis of inorganic products, treatment of solid reagents), the challenge is to circulate the solid particles and control mixing and heat transfer in the presence of the solid phase.

The objective of the thesis is to design a intensified reactor for the continuous synthesis of high such as zeolites. The project includes an experimental part and a modelling part. The experiments will aim to characterize the mixing and transport phenomena in a liquid-solid suspension implemented in different reactor geometries. The modelling component, based on the population balance approach, will aim to describe and analyze the coupling of the different chemical and physical phenomena and their impact on the final properties of the product.

3. Design of membrane-electrode assemblies for fuel cells

Supervisor : Nathalie Job (nathalie.job@uliege.be)

Fuel cells are electrochemical devices that convert hydrogen and oxygen into electricity and water. As in any electrochemical device, the oxidation (of hydrogen) and reduction (of oxygen) reactions take place at separate areas, namely at the anode and the cathode. The two electrodes are separated by an electrolyte to allow for ionic charge transfer: in PEM (Proton Exchange Membrane) fuel cells, the electrolyte is made of a proton-conducting polymer membrane (Nafion®). A PEM fuel cell electrode is a complex medium composed of Pt/carbon catalyst particles, interparticle voids and Nafion®, leading to limitations induced by the electrode structure.

The goal of the project is to manufacture and characterize membrane-electrodes assemblies (MEAs) with different catalytic layer compositions/structures in order to better understand the various limitations in the catalytic layer. To do so, model catalytic layers with different profiles will be deposited on the Nafion® membrane by robotic spray from inks containing carbon or carbon-supported Pt nanoparticles. By comparing the performance of several types of layers, it will be possible to decouple the effect of the various limitations, especially the diffusional and proton conduction losses.

4. Reactive extraction of valuable metals from waste in urban mining

Supervisor : Andreas Pfennig (andreas.pfennig@uliege.be)

A large fraction of valuable metal components contained e.g. in electronic waste is currently not recovered, partly because of the complexity of the separation processes required. Reactive extraction is one of the most promising processes to separate and purify such valuable components like precious and rare-earth metals in the context of a circular economy. Based on existing experience, a new separation strategy that allows separation and simultaneous purification of several components in a single extraction process shall be implemented. This would greatly simplify the overall process. Design basis are our single-drop lab-cells and a drop-based simulation tool. In the simulations, the drop-population balances are solved in a rather intuitive way which avoids complex math. The required lab equipment and the simulation tool are available but need adjustment to account for the specifics of

this project. The process shall be developed to a degree that it can be presented to our industrial partners, which shall be basis for licensing and filing a patent. On the scientific level, mass-transfer models shall be optimized to better characterize the relevant systems and the simulation tools improved.