



## Ecole Doctorale - 104

Sciences de la Matière, du Rayonnement  
et de l'Environnement

**ESTABLISHMENT** : Lille University - FST

**Laboratory(ies) of affiliation** : Unité de Catalyse et de Chimie du Solide (UCCS)

**Scientific field, Speciality:**

- DS2 Dense media, materials and components
- DS2 | Diluted media and fundamental optics
- DS3 | Earth and Universe Sciences
- DS3 | Earth, fluid envelopes
- DS4 | Theoretical, Physical and Analytical Chemistry
- DS4 | Organic, Inorganic and Industrial Chemistry
- ✳  DS4 | Materials chemistry
- DS5 | Molecular and Cellular Aspects of Biology
- DS8 | Energy, heat, combustion
- DS8 | Mechanics of solids, materials, structures and surfaces
- DS10 | Food Biotechnology, Food Science, Physiology
- DS10 | Biology of the environment, organisms, populations, ecology
- DS10 | agronomics sciences

**Thesis director:** Daviero-Minaud, Sylvie, Professor, sylvie.daviero@univ-lille.fr

**Co-director:** Colmont, Marie, Lecturer, marie.colmont@centralelille.fr

**Co-supervisor (non HDR):** (Name, First name, position, e-mail)

**Affiliate programme(s):** Interreg France-Wallonie-Flandres

**Planned (co)-funding** : obtained

<b>Title of the thesis</b> : Pyrochemical recycling of 2nd and 3rd generation solid oxide fuel cells
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### THESIS SUBJECT (ABOUT 1/2 PAGE)

This thesis subject is part of the CLUED-O project (CLEan energy with sustainable 3rd generation solid Oxides cells) of the Interreg France-Wallonia-Flanders project, whose objective is to develop a high-performance 3rd generation solid oxide fuel cell (SOFC), operating at  $T < 650\text{ }^{\circ}\text{C}$  in fuel cell mode but also usable in electrolysis mode.

The materials used for the various cell components (electrodes, electrolyte, connectors, etc.) contain strategic elements (rare earths: Ce, La, Gd, Y, etc., strontium, cobalt, nickel, zirconium, etc.) included in the European list of critical elements, which must be recovered and recycled at the end of the life of the systems that use them. To do this, CLUED-O is considering life cycle analysis and the development of a cell recycling process from their





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design stage. Thus, the study of a recycling process will be considered from the beginning of the project on 2nd generation SOFC cells from the first part of the project designed from commercial half-cells, in order to have defined at the end of the project the optimized treatment conditions that will be transposed to the innovative 3rd generation cells designed during the project.

Currently, no effective process has yet been developed for SOFC recycling. In recent years, two European projects have been developed for recycling using hydrometallurgical processes (HYTECHCYCLING Grant 700190 and BEST4Hy, completed in 2019 and 2023 respectively), but they remain at the laboratory stage (TRL 3). They require complex manual processing steps (scraping, mechanical separation, etc.) upstream of the various chemical processing steps, and the latter require acid solutions and complexing molecules that must be recovered and then recycled.

The objective of this thesis project is to develop an alternative pyrochemical treatment to currently considered hydrometallurgical treatments, using molten salts as the reaction medium. The use of molten salts would simplify the treatment process by reducing the number of necessary steps, notably by eliminating mechanical treatments and ensuring the most efficient molten salts possible for SOFC cell decomposition, while respecting environmental and industrial constraints regarding the nature, quantity, and toxicity of effluents, as well as limiting energy costs.

Molten salts have been selected as reaction media due to their very high reactivity with materials and their physicochemical properties (high solvating power, high thermodynamic stability, high electrical and thermal conductivity, etc.), allowing great versatility of processes depending on the desired end products. In addition, their stability makes it possible to consider their recyclability after use.

The PhD student will be involved in every stage of the project and will be expected to develop autonomy, creativity, analytical and synthesis skills, and a sense of teamwork. He/she will use analytical and characterisation techniques in both analytical and materials chemistry. He/she will be required to regularly present his/her results and work progress to other members of the consortium. The person applying for this project will need to be motivated by the subject and convinced of its societal impact, have a keen scientific curiosity, and drive to successfully complete each stage of the project. This thesis will be carried out in an international context, in collaboration with various academic and industrial partners, in a field of strong socioeconomic interest. This will enable the person recruited to plan a career opening up access to research or the management of research projects.

**Expected date of recruitment : 01/09/2025**

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**Additional remarks/comments:** *The candidate should possess expertise in solid-state chemistry, inorganic chemistry, and/or inorganic materials.*

*To apply, please email the two supervisors with an up-to-date CV, a letter of motivation, and a summary of academic results (Master M1 and M2 in progress, or equivalent) to confirm the possibility of thesis registration.*

