

## **M1 (or equivalent) internship offer: Recycling of electronic devices printed on paper substrate – Up-scaling of a hydrometallurgical silver recovery process using numerical simulation and its life cycle impact assessment**

### **Internship context:**

This internship offer is part of ANR REVeBIO project including four French academic partners namely: LGP2 (Grenoble), LEPMI (Grenoble), ISCR – ENSCR (Rennes) and RAPSODEE (Albi). The project is focused on the “End-of-life of electronic devices printed on cellulosic substrates”, with a special focus on “Recycling and valorization of biosourced materials and functional inks”. The REVeBIO project aims to address the following scientific and technical challenges:

1. To adapt the conventional separation processes used for graphic paper recycling to this new material.
2. To develop a battery of analyses in order to fully characterize the fractions originating from the separation process (fibrous fraction, a solid mineral reject and a liquid reject containing soluble materials) and to monitor the fate of value-added products.
3. To extract efficiently the metals (namely silver) from the generated waste stream.
4. To produce new eco-sorbents (biochars) made from REVeBIO process waste for the treatment of refractory molecules dissolved in waste waters.
5. To develop new eco-absorbent materials from REVeBIO waste fractions for the elimination of liquid and gaseous pollutants emitted by the pulp and paper industry.

### **Internship description:**

A complete pathway for silver recovery from printed prototypes has been recently developed in LEPMI laboratory in collaboration with LGP2 laboratory. This pathway is based on leaching of the reject fraction generated during the cyclonic separation of cellulosic fibers and Ag inks and mineral fillers. The leaching step is followed by Ag microparticles synthesis. This synthesis pathway is based on several precipitation, purification and reduction steps. Depending on the applied experimental conditions different morphologies and granulometry of synthesized Ag particles may be obtained.

Up to now, the process was only developed on a lab scale basis. In order to be able to study its environmental impacts using life cycle assessment methodology, its up-scaling to an industrial level is necessary. However, this up-scaling is not achievable in a laboratory. In order to generate the data necessary for the life cycle assessment (LCA), the process line will be up-scaled numerically using USIM-PAC software tool. USIM-PAC is a steady-state process modeling and simulation software used to design, analyze and optimize industrial processes. The output data of this simulation will be then used as LCA inlet data.

In the second part of the internship the environmental impacts of the developed processes will be assessed using SimaPro software tool with a special attention given to energy consumption of the process and identification of the so-called hot-spots.

Based on the LEPMI and LGP2 recent work, the candidate will simulate the entire recycling line including printed prototypes pulping, hydrocyclone separation, reject fraction leaching and Ag particles synthesis.

The internship will therefore involve 3 successive stages:

- 1) Literature review of recent advances in silver recycling from various matrixes and in process simulation coupled to LCA.
- 2) Simulation of the recycling line using USIM-PAC software.
- 3) Assessment of the environmental impacts using SimaPro software.

### **Internship location:**

The candidate will work under the supervision of L. SVECOVA and M. LUPSEA, specialized in recycling processes development. The research work will be performed at Electrochemistry and Physical Chemistry of Materials and Interfaces Laboratory (LEPMI, <https://lepmi.grenoble-inp.fr/>) located at Grenoble University Campus (Saint Martin d'Hères). Interactions with the consortium members, namely N. REVERDY-BRUAS and N. MARLIN (Laboratory of Process Engineering for Biorefinery, Bio-based Materials and Functional Printing - UMR 5518, Grenoble INP-UGA, <https://lqp2.grenoble-inp.fr/en>), experts respectively in printed electronics and recycling processes will be organized regularly.

**The internship will start in April 2025 for a duration of 3 to 4 months.**

### **Skills to acquire and/or develop:**

The candidate should be in master 1 - or equivalent - and have a solid knowledge in inorganic chemistry, solution chemistry, analytical chemistry and unit operations. The knowledge of numerical simulation methods and LCA methodology will be a real advantage. The candidate should be able to work independently. Writing skills will also be required.

During the internship, the candidate will develop the knowledge of:

- LCA methodology and the use of SimaPro tool.
- Unit operation simulation using USIM-PAC software tool.

### **How to apply?**

Send your CV, motivation letter and master transcript (marks) to:

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**The deadline to apply is 29/02/2025**