


IMT Mines Alès
École Mines-Télécom


LA SCIENCE & LA CRÉATIVITÉ POUR INVENTER UN MONDE DURABLE

NOUS RECRUTONS

PhD Position in

physico-chemical materials

Institution	IMT Mines Alès (Ecole Nationale Supérieure des Mines d'Alès) & ENSAM (Ecole Nationale Supérieure des Arts et Métiers)
Main job assignment	Teaching and Research of Materials C2MA (Alès) & Mechanical and Materials Processes and Engineering PIMM (Paris)
Administrative residence	2 periods of 18 months : Alès (Gard, Occitanie) & Paris (Seine, île de France)
Starting date	01/07/2025

1. Context

The Institut Mines-Télécom (IMT), a major institution within the meaning of the Education Code, is a public scientific, cultural and professional institution (EPSCP) placed under the principal supervision of the ministers responsible for industry and digital technology. It is the largest group of engineering schools in France, with 11 public engineering schools spread across the country, which train 13,500 engineers and PhDs each year. The ITM employs 4,500 people and has an annual budget of €400M, 40% of which comes from its own resources. IMT has 2 Carnot institutes, 35 industrial chairs, produces 2100 A rank publications annually, 60 patents and carries out 110M€ of contractual research.
Created in 1843, IMT Mines Alès currently has 1,400 students (including 250 foreigners) and 380 staff. The school has 3 research and teaching centers of high scientific and technological level, which work in the fields of materials and civil engineering (C2MA), environment and risks (CREER), artificial intelligence and industrial and digital engineering (CERIS). It has 12 technological platforms and has 1,600 partner companies.

2. Research project

Title: Evaluation of the consequences of oxidative degradation on ABS recycling and development of solutions to optimize the efficiency of oversorting.

Keywords: Recycling, ageing, ABS, degradation, physico-chemistry.

Context:

Faced with the ecological emergency, the recovery of secondary raw materials from Waste Electrical and Electronic Equipment (WEEE) is a major challenge for the production of industrial parts from recycled plastics. However, the quality of recycled materials varies due to the complexity of sorting and the presence of additives, which complicates their recovery. Among these materials, styrenic polymers such as ABS have great potential, but their industrial implementation is hampered by the variability of their composition and structure, which affects their mechanical and thermal properties. In order to improve the cost-effectiveness of recycling, it is crucial to improve sorting and recycling processes to obtain recycled plastics with properties close to those of virgin plastics. The sorting of black plastics, which represent 40 to 60% of flows, is particularly problematic. Technologies such as triboelectricity and MIR spectroscopy

show promising results, but remain limited in their ability to efficiently sort these materials. In addition, while the ideal purity of recycled materials is important, it does not necessarily guarantee their performance, as chemical aging or the presence of impurities can alter their properties. Recent research has shown that monitoring the degradation status of plastics, such as ABS, is key to determining whether a material should be recycled or disposed of. The evaluation of accelerated aging and photo-oxidation of ABS provides a better understanding of the impact of these phenomena on the quality of recycled materials. This work offers avenues for improving the management of the recycling and recovery of plastics by considering their state of chemical degradation.
As a result, to optimize the recovery of recycled plastics, it is necessary to continue to improve sorting and recycling techniques, and to better understand the impact of aging on material properties to ensure their performance and efficient reuse.

Objectives:

As the aging of polymers, especially ABS, induces structural modifications that can affect their mechanical properties and limit their recyclability, the objective of this study is to develop a rapid and non-destructive method to assess the state of degradation of ABS samples and to correlate this result with destructive analyses in order to predict their suitability for mechanical recycling.

These will involve:

- Establish correlations between surface and depth analyses: for example, by quantitative correlation between the results obtained by MIR/NIR spectroscopy and by AFM microscopy.
- To determine the suitability for material recovery by developing models to predict the mechanical recyclability of an ABS sample based on its state of degradation.
- To optimize recycling processes by providing methodological tools to optimize recycling processes by sorting materials according to their quality and identifying the most suitable recycling treatments.
- To determine a state of thermo and photo-oxidative degradation in mass (surface = > core) of ABS from oversorted waste electrical and electronic equipment[1] (volume of degraded material).

This project will ultimately make it possible to evaluate the consequence of this mass degradation on the remixing of oxidized and non-oxidized ABS, and therefore to interfere with the effectiveness of oversorting through preventive, palliative and curative scenarios:

- Preventive strategies through early detection of oxidized materials.
- Palliative methods through the compatibilization of mixtures.
- Curative treatments to remove the oxidized layer. Finally, we will formulate and characterize ABS MPS in order to evaluate their quality and potential for use.

3. Team supervision and PhD registration

Research and teaching center: C2MA, IMT Mines Alès for 18 months then PIMM, ENSAM de Paris for 18 months
Research Unit: PCH
Doctoral school: Attached to the doctoral school of ENSAM in Paris

4. Candidate profile

This position is open to candidates who meet the administrative requirements for access to a doctorate at the Institut Mines-Télécom et des Arts et Métiers (ENSAM).
The candidate must hold a master's degree or an engineering degree in physical chemistry of materials and have solid experience in the development and physico-chemical, thermal and mechanical characterization of thermoplastic polymers, acquired during end-of-studies internships in companies or in laboratory research activities. Additional expertise in the field of plastics recycling will be a major asset.
The candidate must demonstrate autonomy in the management of the project and the production of deliverables (writing reports, oral presentations, publications, etc.). Rigorous organization, initiative, the ability to work in a team, and a strong scientific curiosity are essential to succeed in this position.

[1] *Oversorting is an operation used to sort a family of materials from several classes of material (e.g. oversorting of ABS polymer within a deposit exclusively of WEEE plastics that has been previously sorted).*

5. References

- C. Signoret (2016-2019). *Valorisation de Matières Premières Secondaires thermoplastiques en mélange issues de tri spectroscopique Moyen InfraRouge en ligne*. Co-direction : D. Perrin, P. Ienny. Co-encadrement : A.-S. Caro-Bretelle, J.-M. Lopez-Cuesta. Thèse Université de Montpellier – Soutenance le 03 octobre 2019 à l'IMT Mines Alès.
- L. DELARUE (2021-2024). *Elaboration et formulations de plastiques recyclés ABS et PS de haute performance à partir de polymères issus de séparation triboélectrique*. Co-direction : D. Perrin et A.-S. Caro-Bretelle. Co-encadrement : P.-J. Liotier et P. Ienny. Thèse Université de Montpellier – Soutenance le 02 décembre 2024.
- C. Signoret, A.-S. Caro-Bretelle, J.-M. Lopez-Cuesta, P. Ienny, D. Perrin. MIR spectral characterization of plastic to enable discrimination in an industrial recycling context: I. Specific case of styrenic polymers, Waste Management (2019), 95, 513-525.
- C. Signoret, M. Edo, A.-S. Caro-Bretelle, J.-M. Lopez-Cuesta, P. Ienny, D. Perrin. MIR spectral characterization of plastic to enable discrimination in an industrial recycling context: III. Anticipating impacts of ageing on identification, Waste Management, 109 (2020) 51–64.
- C. Signoret, M. Edo, D. Lafon, A.-S. Caro-Bretelle, J.-M. Lopez-Cuesta, P. Ienny, D. Perrin. Degradation of styrenic plastics during recycling: Impact of reprocessing photodegraded material on aspect and mechanical properties, Journal of Polymers and the Environment (2020), 1-23.
- C. Signoret, A.-S. Caro-Bretelle, J.-M. Lopez-Cuesta, P. Ienny, D. Perrin. Alterations of plastics spectra in MIR and the potential impacts on identification towards recycling, Resources Conservation and Recycling, 161 (2020) 1049802.
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- A. Alkhuder, A.-S. Caro, M. Gervais, A. Guinault, P. Ienny, D. Perrin, C. Sollogoub. Origin of an intermediate peak in DMTA analysis of multilayer ABS/PC samples, Journal of Applied Polymer Science (2023), e54926. https://doi.org/10.1002/app.54926.
- L. Delarue, M. Pucci, P.-J. Liotier, A.-S. Caro, P. Ienny, D. Perrin. Correlation Between AFM Characterizations and Dynamic Mechanical Testing to Assess the Ductile-to-Brittle Transition During ABS Photodegradation. Polymer Degradation and Stability (2024), 229, pp 110945.

6. Application and Contacts

- ***Administrative conditions for application:***

  The position offered by IMT Mines Alès and ENSAM Paris (PIMM laboratory) is a 36-month, full-time, fixed-term contract, a public law contract under the provisions of the ENSAM management framework, PhD student profession.

- ***Conditions for the location of thesis work:***

  Two periods of 18 months, divided as follows: 18 months at the C2MA of IMT Mines Alès and 18 months at the PIMM laboratory of ENSAM in Paris.

- ***How to apply:***

  Applications (CV and cover letter) should be sent exclusively to:

  ENSAM : Dr. GERVAIS Matthieu - matthieu.gervais@lecnam.net

  IMT Mines Alès : Pr. PERRIN Didier - didier.perrin@mines-ales.fr

  Administrative aspects: Mme Anne-Catherine Denni - anne-catherine.denni@mines-ales.fr

- ***Recruitment process:***

  Closing date for applications : 15/05/2025

  Desired start date : 01/07/2025