NOUS RECRUTONS

PhD Position in physico-chemical materials

Institution	IMT Mines Alès (Ecole Nationale Supérieure des Mines d'Alès) & PELLENC ST (Pertuis – 84), France
Main job assignment	Teaching and Research of Materials C2MA (Alès)
Administrative residence	36 months : Alès (Gard, Occitanie, France)
Starting date	01/10/2025

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: Recovery of automotive plastics (ELVs) and electrical electronic equipment (WEEE) by optimizing the recycling of polypropylene-based polyolefins from ELVs and WEEE. Contributions of NIR/MIR hyperspectral sorting and oxidative degradation analysis

Keywords: Recycling, aging, hyperspectral sorting, PP, formulations

Context:

The automotive sector generates several hundred thousand tonnes of plastic waste each year on a European scale, mainly during the end-of-life of End-of-Life Vehicles (ELVs). Among the different families of polymers used in vehicles, polyolefins, in particular polypropylene (PP), account for nearly 40% of on-board plastics. These materials are massively used in parts such as bumpers, dashboards, interior linings, technical boxes or wheel arches, due to their low density, competitive cost and good mechanical properties.
Polypropylene is often used in filled form (with talc, calcite, glass fibers) to improve its rigidity, temperature resistance and fire behavior. It can also be modified by copolymerization with polyethylene (PP-PE) or by incorporation of ethylene

propylene rubber (PP-EPR) or EPDM, in order to improve its impact resistance and flexibility, especially for external parts subject to impact.
However, this diversity of formulations makes the sorting and recycling of automotive plastic fractions particularly complex. The presence of mineral additives, stabilizers, pigments (especially carbon blacks) and copolymers changes the spectral, thermal and mechanical properties of materials, making it difficult to accurately separate them and preserve their functional value. As a result, a large part of these plastics, although technically recyclable, are now undervalued or incinerated.

However, the potential benefits of recycling these plastics are major:

- Reduction of dependence on fossil resources (PP is a petrochemical derivative),
- Reduction of the carbon footprint of finished products (recycling PP consumes about 88% less energy than producing it virgin),
- Reduction of production costs for manufacturers integrating high-quality recycled plastics,
- Response to increasing regulatory pressure (ELV Directive, recycled content requirements in automotive parts, taxation on virgin plastics, etc.),
- Creation of a local and circular recycling ecosystem, in conjunction with deconstruction centres, sorters and parts manufacturers.

To fully exploit the recycling potential of polyolefins from the automotive industry, it is therefore essential to control the variability of flows and to have advanced sorting technologies capable of distinguishing between formulations, copolymers and aging states.
With this in mind, the collaboration with PELLENC ST, a leader in the development of optical sorting systems by NIR and MIR hyperspectral imaging, makes it possible to raise the quality of sorting by detecting the subtle differences between virgin, filled, copolymerized or degraded PP. Coupled with a detailed analysis of oxidative degradation, this approach paves the way for not only chemical, but also functional sorting, based on the intrinsic properties of the materials.

Objectives:

In this context, the collaboration with the company PELLENC ST is essential to carry out the project. Indeed, the technological contribution of PELLENC ST's industrial sorting machines and its know-how as a privileged partner with IMT Mines Alès in the sorting and recovery of ELV and WEEE deposits for nearly 20 years, will make it possible to strengthen the capacity for polymer differentiation and to detect more finely variations related to oxidation, the nature of the fillers or the presence of copolymers.
The integration of data from accelerated aging and photo-oxidation tests of PP makes it possible to study the evolution of the spectral signatures associated with degradation, with the aim of refining sorting algorithms and reducing identification errors. Indeed, the detection of the state of chemical degradation is a key criterion for judging the reusability of a material, beyond its chemical purity or nominal identification.
The expected results of this combined approach aim to significantly improve the quality of recycled fractions, to produce single-component plastics with performances close to virgin materials, and to secure their integration into industrial production chains. This work thus contributes to the evolution of sorting standards, by integrating the physico-chemical dimension of ageing as a key criterion in the recycling or disposal decision.

The ageing of polymers, in particular PP-based polyolefins (PP homo and PP-PE copolymer), induces structural modifications, in particular degradation by chain splitting, which can affect their mechanical properties and limit their recyclability. The objective of this study is to develop non-destructive methods to evaluate the degradation state of PP samples and to correlate this result with destructive analyses in order to predict their suitability for mechanical recycling and to propose catalogues of secondary raw materials perfectly adapted to the end user.

These will involve:

- To 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 evaluate the suitability for material recovery through the development of models to predict the mechanical recyclability of a PP sample based on its state of degradation.
- To determine a state of thermo and photo-oxidative degradation in mass (surface = > core) of PP from waste electronic electrical equipment oversorted[1] (volume of degraded material).

---

[1] *Oversorting is an operation that makes it possible to sort a family of materials from several classes of material (e.g. oversorting of PP polymer within a deposit exclusively of WEEE plastics or ELVs previously sorted).*

It will also be necessary to identify the potential benefits associated with certain residual additives, present in the recycled fractions, which can improve certain functional properties such as thermal stability or fire behaviour. This project could pave the way for the formulation and characterization of secondary raw materials (SRMs) based on recycled PP, whose quality and potential for use will be evaluated according to functional, mechanical and safety criteria (including reaction to fire).

This project will ultimately make it possible to evaluate the consequence of this mass degradation on the remixing of oxidized and non-oxidized PPs more or less degraded, 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 PP-based polyolefin MPS in order to evaluate their quality and potential for use.

3. Team supervision and PhD registration

Research and Teaching Centre: C2MA, IMT Mines Alès
Research units: PCH and DMS
Doctoral school: Attached to the Balard Chemical Sciences doctoral school in Montpellier

4. Candidate profile

This position is open to candidates who meet the administrative conditions necessary for access to the doctorate at the Institut Mines-Télécom.
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.

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.
- 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, 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.
- 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 the company PELLENC ST is a fixed-term contract of 36 months, full-time, a public law contract under the provisions of the management framework of IMT Mines Alès, PhD student.

- ***Conditions for the location of thesis work:***
  A period of 36 months with stays entirely financed by the thesis project at the company PELLENC ST.

- ***How to apply:***
  Applications (CV and cover letter) should be sent exclusively to:
  IMT Mines Alès : Prof. PERRIN Didier - didier.perrin@mines-ales.fr
  PELLENC ST : Dr. ESTEVE David d.esteve@pellencst.com
  Administrative aspects : Mme Anne-Catherine Denni - anne-catherine.denni@mines-ales.fr

- ***Recruitment process:***
  Closing date for applications : 01/07/2025
  Desired start date : 01/10/2025