#### COLLEGE ED MATIERE MOLECULES DOCTORAL MATERIAUX & PAYS DE LA LOIRE GEOSCIENCES

### DESCRIPTION D'UN PROJET DE THÈSE FINANCÉ -ÉCOLE DOCTORALE « Matière, Molécules, Matériaux & Géosciences »

**Title of the thesis:** Development of new strategies for the global chromatographic analysis of trace polymers in natural environments

Subject : Analytical chemistry

Three keywords : Polymers, environment, derivatization

**UMR CNRS :** Institut des Molécules et Matériaux du Mans (IMMM), UMR-6283 CNRS, Le Mans Université.

Last name, first name of director of thesis (HDR essential) : MARTEL Arnaud

e-mail : arnaud.martel@univ-lemans.fr

Last name, first name of thesis co-supervisor 1 (if applicable ): LAGARDE Fabienne

Adresse mail : Fabienne.lagarde@univ-lemans.fr

Name, first name of co-supervisor of thesis 2 (if applicable ): BOUDAH Samia

Adresse mail : Samia.BOUDAH@loreal.com

**Contact(s) (postal address) :** Arnaud MARTEL, Institut des Molécules et Matériaux du Mans (IMMM), UMR-6283 CNRS, Le Mans Université, Avenue Olivier Messiaen, 72085 Le Mans Cedex 9

# Une fois complété, merci d'enregistrer ce document au format pdf avec le nom suivant :Nom du Directeur thèse\_Unité.pdf

ED 3MG - Direction : Le Mans Université - Avenue Olivier Messiaen - 72085 Le Mans Cedex 09 Tél : 02.43.83.37.41 / 06.05.19.08.00 Mail : ed-3mg@doctorat-paysdelaloire.fr Site Web : <u>https://ed-3mg.doctorat-paysdelaloire.fr/</u>

# **4** DESCRIPTION SCIENTIFIC OF PROJECT OF THESIS

#### Description of subject: context, objectives, methodology (1 page maximum)

**Background:** The aim of this work is to develop alternative methods for the analysis of trace polymers in surface water in order to meet the challenges posed by the assessment of biodegradability according to OECD 309. This standard, although proposing a robust framework, relies heavily on <sup>14</sup>C radiolabeling, a costly and complex technique.

Methodology: The thesis proposes a two-step approach:

Extraction and Concentration: Use of solid phase extraction (SPE) methods specific to each polymer class to concentrate samples and thus improve the sensitivity of the analysis. This is essential for trace analysis.

**Post-treatment analysis:** After the extraction step, two main strategies are considered, depending on the nature of the polymer:

- Pyrolysis-GC-MS: An established technique for the analysis of many polymers, allowing the identification of degradation products.
- Decomposition into monomeric units: This approach aims to break down the polymer into its basic units, which are easier to analyze by GC-MS or GC-MS/MS after derivatization. Chemical derivatization (transesterification, acetylation, ozonolysis, etc.) will improve the volatility and detectability of monomers and degradation by-products.

**Objectives:** The thesis therefore proposes an innovative approach combining Solid Phase Extraction (SPE) and specific chemical transformations to allow more accessible analysis than as carried out for OECD 309: ¬Alternative to radiolabeling: Using analytical methods such as pyrolysis-GC-MS and decomposition into GC-MS/MS analyzable monomers, the thesis aims to eliminate 14C. This is a major advantage in terms of cost, simplicity and safety. OECD 309 encourages the development of such alternatives.

- Improvement of the sensitivity for trace analysis: SPE extraction allows the concentration of polymers present in trace amounts, improving the sensitivity of the analysis. This is critical for environmental studies where concentrations are often very low. OECD 309 emphasizes the importance of low concentrations to reflect realistic environmental conditions.
- Understanding the Degradation Mechanisms: Breaking down polymers into monomers and analyzing by-products will help identify metabolites and better understand degradation pathways. OECD 309 encourages the identification and quantification of transformation products, especially for slow degradation species.
- Adaptability to various classes of polymers: By adapting SPE extraction and chemical transformation techniques to each type of polymer, the thesis proposes a more versatile approach than the single use of radiolabeling.
- Potential for OECD 309 validation: The developed methods can be validated by comparing the results obtained with those of radiolabeling according to the criteria of the standard. This would pave the way for wider use of these alternative methods.

#### Environment of the PhD position

This thesis is proposed within the framework of the TANDEM thesis scheme for the region's CIFRE theses. The region will decide on the awarding of funding in the coming months. The thesis will be carried out within the framework of a collaboration initiated with L'Oréal through the CIFRE thesis. The thesis work will be carried out primarily at the Institut des Molécules et Matériaux du Mans (IMMM), with some analyses conducted at L'Oréal. The company will provide the biodegradation samples, and all SPE optimization and derivatization steps will be carried out at IMMM. IMMM is one of six mixed research units associated with the CNRS (UMR-6283 CNRS) at Le Mans University. The Institute employs 61 teacher-researchers, 9 CNRS researchers, 25 engineers, technicians, and administrative staff. In addition, there are approximately 50 PhD students, around 30 Master's students, and an annual flow of around ten postdocs and around 20 visitors and visiting professors. IMMM's research activities are divided into four priority scientific themes: The following areas are of particular interest: organic synthesis

(SO), inorganic materials (MI), the physics of confined systems (PSC), and polymers (POL). IMMM is equipped with a wide range of cutting-edge platforms and instrumentation for the synthesis and characterization of materials and molecules, including chromatography and mass spectrometry (see http://immm.univ-lemans.fr/fr/index.html). Consequently, comprehensive studies can be conducted on site, as outlined in the proposed thesis.

#### How to apply

If this topic is of interest to you, please let us know.

To apply, please visit https://theses.doctorat-bretagneloire.fr/3mg/campagne-2025. The application must include the following documents (in French or English): 1) A detailed curriculum vitae, 2) a letter detailing the internship(s) carried out in a research laboratory or in industry, explaining the reasons for the application and specifying the post-doctoral career plan, 3) copies of master's and engineer's diplomas, transcripts (mention requested) and ranking for each academic year of master's (M1 and M2) or engineer's school. The candidate is required to submit the names of references along with their contact information, including their laboratory, email address, and telephone number. Alternatively, the candidate may provide letters of recommendation from these references.

#### Skills scientific and technical for candidate:

The ideal candidate will possess a Master's degree or engineering degree in the field of chemistry or chemical analysis. The ideal candidate will possess a strong interest in a thesis project that integrates analytical development, chemical transformation steps, and the use of coupled mass chromatography equipment (GC-MS, GC-MS/MS, Pyr-GC-MS, LC-Q-TOF, etc.). To successfully complete this PhD project, the student must demonstrate dynamism, rigor, scientific curiosity, and a general knowledge of chemistry.

A solid understanding of coupled-mass chromatography and solid-phase extraction techniques will be essential. The ideal candidate will possess a strong interest in and comprehensive understanding of organic and polymer chemistry.

#### **4** SUPERVISION OF THE THESIS<sup>1</sup>

Name of the host lab :	Name of the host team :
Institut des Molécules et Matériaux du Mans (IMMM), UMR-6283 CNRS	"Synthèse Organique" (SO) and « Physique des Interfaces et des MésoStructures »
Name of director of the lab :	Name of the team leader:
Pr. Philippe DANIEL	Pr. Anne-Sophie CASTANET (SO)/Dr Fabienne Lagarde (PIMS)
Coordonnées du directeur de l'unité :	Coordonnées du responsable de l'équipe :
philippe.daniel@univ-lemans.fr	anne-sophie.castanet@univ- lemans.fr/fabienne.lagarde@univ-lemans.fr
Director of thesis	
Last name, first name : Martel, Arnaud	
Position: Professor	
HDR: 2010	
Employer : Le Mans université	
Rate of doctoral supervision in the present subject: xx%.	
Rate of doctoral supervison (supervisors and co-supervisors): 90%.	
Number of PhD supervision: 2	

<sup>1</sup> Dans l'ED 3MG, si 1 scientifique dans la direction de la thèse = 100% d'encadrement doctoral ; si 2/3 personnes impliquées dans l'encadrement de la thèse, un taux de 40% minimum est exigé pour l'HDR directeur et 30% pour les autres encadrants.

PhD Co-supervisor 1	
Last name, first name : Lagarde Fabienne	
Position : Maître de conférences	
HDR: □yes ⊠no	
Employer : Le Mans université	
Doctoral school of attachment : ED3MG	
Supervision rate in le present project : 30%	
Supervision rate in courses (directors/co-directors/co-supervisors): 70%	
Number of directors/co-directors/co-supervisors of thesis in progress : 2	

#### PhD Co-supervisor 2

Last name, first name : BOUDAH Samia

Position : Team leader in laboratories of Analytical technologies for Environmental & Life Sciences

HDR: □yes ⊠no

Employer : L'Oréal

Doctoral school of attachment :

Supervision rate in le present project : 10%

Supervision rate in courses (directors/co-directors/co-supervisors): 10%

Number of directors/co-directors/co-supervisors of thesis in progress :1

Partner (if funding CIFRE, private...)

Last name, first name : COTTIN Guillaume

Position : Head of environment fate laboratories

Company : L'Oréal

Rate of doctoral supervision in the present project: 20%

Current doctoral supervision rate (directors/co-directors/co-supervisors): Number of

directors/co-directors/co-supervisors of thesis in current :0

## **4** FUNDING FOR THESIS

Origin(s) of funding of the thesis : Région, L'Oréal

Gross salary : 2200 €

State of funding of the thesis : Application submitted

**Date of start/duration of funding of thesis :** 1<sup>st</sup> October 2025