

ICCF, équipe MPS et équipe Photochimie

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Evaluation of the Biostability of Medical Devices: Development of a New Photochemical In Vitro Simulation Strategy and Trace Analysis

Context & Challenges: Engineering for Health

Polyurethane (PU) is a strategic polymer used in high-performance implantable medical devices (MDs), found in various applications such as central venous or implantable port catheters, urinary or nephrostomy catheters, insulating sheaths for cardiac or neurostimulation leads, and many others. Its long-term durability in biological environments is strongly influenced by its resistance to oxidative stress.

The technological bottleneck: Current standardized protocols (ISO 10993-13) struggle to isolate and quantify degradation products due to their extremely low concentrations. The main challenge of this PhD is to break away from conventional approaches by developing a photochemistry-based strategy to simulate and accelerate the oxidative ageing of materials in solution, in a controlled manner representative of biological processes.

Scientific Missions & Objectives

The PhD candidate will be at the heart of an interdisciplinary project with the following objectives:

- *Engineering of a simulation protocol:*

Develop a photo-assisted oxidation process enabling the constant generation of hydroxyl radicals in solution, mimicking the oxidative stress encountered in vivo, particularly through the activity of immune system cells.

- *Optimization of the analytical window:*

Improve an experimental protocol for monitoring degradation products in solution, overcoming current detection limitations.

- *Multi-scale characterization:*

- Trace analysis: Identification and quantification of released molecules using chromatography coupled with high-resolution mass spectrometry.

- Materials expertise: Monitoring mass loss, mechanical properties, cracking, and chemical modifications of the polymer (FTIR, Raman, XPS, SEM).

- *Clinical Validation & Correlation:*

Compare the chemical signatures of artificially aged samples with those of explanted clinical devices to validate the strategy and determine reliable acceleration factors.

Candidate Profile: The Analytical Engineer

We are seeking a candidate with a Master's degree (MSc) or Engineering degree in analytical chemistry (preferred), or chemistry/materials science. Experience in solution-phase analytical techniques and organic compound detection is required. Interest in polymer physico-chemistry, chemical degradation mechanisms, and strong methodological rigor will be essential for handling normative procedures and advanced analytical equipment (LC-MS/MS and GC-MS/MS).

Working Environment

The candidate will join the MPS-DMIC2 team at the Institut de Chimie de Clermont-Ferrand, renowned for its expertise in extractables and leachables analysis, and will work in direct collaboration with specialists in photochemical degradation. This project offers a unique opportunity to develop a dual expertise in biomedical engineering and advanced analytical chemistry.

Added Value for the Candidate

This PhD opens pathways to strategic careers in industrial R&D, regulatory expertise for Medical Devices, or academic research at the chemistry–health interface.