PROPOSITION DE THESE – CONTRAT ANR / OPEN PHD POSITION – ANR FUNDING

Fonctionnalisation par plasma froid atmosphérique de cathéters urinaires pour leur conférer des propriétés antibiofilms / Urinary catheter antibiofilm chemical functionalization by cold atmospheric plasma

General information

- **Workplace** : Orsay, France
- **Doctoral School** : Molécules, Matériaux, Instrumentation et Biosystèmes (2MIB)
- **Speciality** : Chemistry
- **Research units for co-direction** : Institut de Chimie Moléculaire et des Matériaux d'Orsay (ICMMO/SM2ViE) - Laboratoire de Physique des Gaz et des Plasmas (LPGP/DIREBIO). Both units are Restricted Regime Zones (RRZ; Zones à Régime Restrictif – ZRR).
- **Thesis co-supervisors** : Caroline AYMES-CHODUR (ICMMO) / Stéphane PASQUIERS (LPGP) / João SANTOS SOUSA (LPGP)
- **Financial support :** from 01-09-2025 to 31-08-2028 – ANR funding (ANR-24-CE19-3863).
- **Desired level of education :** Master's degree in the fields of Materials Science / Analytical Chemistry; basic knowledge or previous experience in Polymer Science and/or Plasma physics. Interest in medical devices would be appreciated. Fluency in spoken and written English is essential.

Summary of the PhD project

- **Keywords :**

Polymers chemical functionalization, Polymers surface chemistry, Analytical Chemistry, Pulsed plasma jets, Cold atmospheric plasmas, Physics of Plasmas, Public health

- **Research project**

The presence of biofilms in urinary catheters and their tolerance to antibiotic treatments with the potential development and dissemination of multi-drug resistant (MDR) bacteria is well admitted. Despite the progress in developing these medical devices, Catheter-Associated Urinary Tract Infections (CAUTI) are still the most common type (30%) of healthcare-associated infection reported. Alternative strategies are therefore necessary, as this is a real public health problem. Considering that 16 to 25% of hospitalized patients worldwide will have a urinary catheter inserted at least once during their stay, this highlights the urgent need to find more efficient antibiofilm coatings to prevent CAUTI, especially in the case of long-term catheter insertion.

The **SM_2ViE team of ICMMO** has been working for years on the functionalization of different material surfaces by grafting bio-sourced molecules [1–5]. Modifying polymeric surfaces in biomedical-oriented research has attracted attention precisely to introduce chosen functional groups onto surfaces. As greener chemistry methods are being developed, SM_2ViE has been exploring the possibility of using plasma-activated surfaces to functionalize the catheters. Indeed, plasma activation is a good green alternative to chemically grafting antibacterial molecules [6]. The originality of the present research project is the association of the knowledge of a research team (SM_2ViE) on the chemical and polymer functionalization with that of another research group (**LPGP / DIREBIO**), which develops nanosecond pulsed cold atmospheric plasma jets (ns-CAPJ) [7, 8]. Indeed, this kind of plasma has the advantages of being cold (gas temperature < 40°C), working at atmospheric pressure, and, above all, being able to propagate through a several-centimetre-long tube [9], such as the urinary catheters (that can reach a length of 40 cm). Hence, CAPJ can generate active functional

groups directly in the inner surface of a long tube. The cold atmospheric pressure plasma treatment is a soft surface activation technology used in different industries since it is environment-friendly, easy to generate and control, and suitable for in-line processing. A third associated research team (**I2BC / MBCM**) will conduct the microbiological tests on the modified surfaces in order to evaluate their antibacterial properties.

In this project, we will consider the PDMS surface modification by means of plasma activation and further chemical functionalization with bio-sourced molecules extracted from natural sources. The ICMMO group has so far shown the feasibility of grafting chemical species after plasma treatment on PDMS [10]. The generation of the plasma in catheters will be then studied and intensified camera imaging (ICCD) will be used to monitor the spatio-temporal dynamics of the plasma. The LPGP group is equipped with a high-resolution mass spectrometer (FT ICR system) [11], which will be used to assess the action of the plasma on the tubes surfaces, through the detection of the organic species resulting from this action and coming out of the catheter in the gas flow. The goal is to identify and quantify those molecular species to get insight into the physico-chemical processes involved in the plasma-tube interaction. The analysis of the grafting process will be conducted through analytical tools available at the ICMMO (ATR-FTIR, XPS, AFM, SEM, contact angle measurements, NMR,…) or through collaborations (ToF SIM, confocal laser-scanning microscopy,…).

- **References**

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Required skills

The PhD student will work within the two teams (ICMMO/SM2ViE & LPGP/DIREBIO) and her/his work will be mainly experimental.

Application

The candidate should provide a detailed CV, a cover letter, and all the transcripts of academic marks from the baccalaureate to M2.

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