Université Claude Bernard Lyon 1
University of New Orleans
National Science Foundation
International Research Experiences for Students

RESEARCH IN CATALYSIS AND PHOTOCATALYSIS IN LYON, FRANCE – SUMMER 2018

Exciting research positions for undergraduates are available in catalysis and photocatalysis in Lyon, France. The Université Claude Bernard Lyon 1 and l'Institut de recherches sur la catalyse et l'environnement de Lyon, IRCELYON (The Institute of Research on Catalysis and the Environment of Lyon) are established European centers of excellence for catalysis and photocatalysis research. Selected undergraduate students will participate in pre-travel virtual orientation programs, an on-site orientation in Lyon, research in catalysis or photocatalysis in Lyon, and additional enrichment activities in Lyon. Post-program follow up activities will also occur, and travel funds will be available for presenting research results at a regional or national conference in the US.

FULL TIME POSITIONS BEGIN MAY 23, END JULY 27, 2018,* AND ARE ACCOMPANIED BY A STIPEND OF $5000. HOUSING, MEAL, AND TRAVEL COSTS ARE ALSO INCLUDED.

College students <u>entering</u> the sophomore, junior, or senior year in Fall 2018 are eligible, but strong preference will be given to students with prior research experience. No French language skills are required, but a willingness to learn is necessary. Consideration of applications will begin by Jan. 26, 2018. To apply, submit the materials listed below. Program open to US citizens and permanent residents who will not hold a bachelor's degree prior to Aug. 1, 2018. Notification of acceptance to the program will be made via e-mail as early as Feb. 16, 2018. To apply, submit these items:

- Application Form: Click Here to Preview Form; Click Here to Apply
- Three letters of recommendation
- An unofficial college transcript (official transcript will be required if accepted to program)

Have letters and transcripts sent to be *received* by **Jan. 26, 2018** to the e-mail address below.

Liz Sigler
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University of New Orleans
2000 Lakeshore Drive, ADA 1005
New Orleans, LA 70148
cur@uno.edu

This program is supported by the National Science Foundation

*All program dates are tentative

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Program Participants Will Receive:

- $5000 Stipend
- Round-trip transportation from US to Lyon
- Housing in Lyon
- Meal allowance
- International health insurance
- French cell phone during program
- Lyon metro pass
- Funding to present research findings at a US conference (contingent on sufficient research progress)

Program Participants Must Commit To:

- Three afternoon virtual training sessions (Mar. 17, Apr. 14, May 19*)
- Obtaining a valid US passport prior to March 23 (expiration date no earlier than Jan. 31, 2019)
- Completing 30 minutes per week of French familiarization with Duolingo February through May
- Arriving in Lyon on May 24* (departing US on May 23)
- Attending all orientation programs in Lyon, France
- Participating in full time research activities on site at UCBL
- Participating in all scheduled enrichment activities in Lyon
- Presenting an end of program poster at UCBL on July 26*
- Participating in a post-program virtual workshop (afternoon of Aug. 11*)
- Completing program evaluation forms
- Sharing your experience with fellow students

No Prior French Language Skills Required

Preference Given to Students with Previous Research Experience and Demonstrated Responsibility

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Available Research Projects:

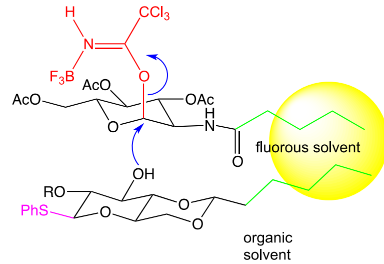
Photocatalytic Degradation of Organic Micro-Pollutants and Identification of Carboxylic Acid Based Intermediates Using HSTrap/GC/MS, Dr. Jean-Marc Chovelon, Professor. Heterogeneous photocatalysis is an advanced oxidation process (AOP) for water treatment, where semiconductors acting as photocatalysts are exposed to UV irradiation. During irradiation, a multi-step process occurs, involving the formation of reactive species such as hydroxyl radicals ($HO^{\bullet}$) and holes (h^+), which are able to oxidize and mineralize almost all organic compounds. This process could be a promising technique for removing organic micro-pollutants from water. This technique is especially promising for pharmaceutical and personal care products, which are not destroyed efficiently in conventional wastewater treatment plants. However, before complete mineralization, many intermediates are generated, and identification of these intermediates is required for better understanding and control of the process. Usually, techniques such as LC/MS/MS or GC/MS are used for first or second generation intermediates, but only few methods have been proposed for the detection of small acids appearing mainly at the end of the reaction. In this project we will utilize an HSTrap/GC/MS (headspace coupled with GC and mass spectrometry) method, which is commonly used for non-polar volatile substances in water. As small acids lack sufficient volatility to be analyzed directly by HSTrap, a derivatization step is required. In this project the student will first optimize the derivatization step as well as the analysis by HSTrap/GC/MS for determination of different small acids. Then, starting from the photocatalytic degradation of one pollutant compound, the student will identify as many small acid products as possible.

Evaluation of Novel Nanoporous Hydrophobic Materials for VOC Treatment, Dr. David Farrunsseng, UCBL1-CNRS Researcher, Head of the INGENIERIE team of IRCELYON, 2016 International Catalysis Award Recipient. In this project, summer research participants will prepare new nanoporous hydrophobic materials using well developed protocols. For example, we can **prepare a new type of catalytic material consisting of single metal nanoparticles embedded in a silicalite-1 mono-crystal. This type of well-defined “ship-in-a-bottle” catalyst paves the way for more academic studies and practical applications of shape, size, and product selectivity for a wide range of catalytic systems in terms of catalyst composition and reaction mixtures.** After preparation, materials will be characterized with techniques such as adsorption of probe molecules, microscopy, and X-ray diffraction. Next, the prepared materials will be tested for their ability to capture volatile organic compounds (VOC) and to degrade model pollutants. Through variation of a number of experimental parameters, the most effective photocatalytic materials will be identified. Dr. Farrunsseng currently leads a group at IRCELYON consisting of 10 full time researchers and engineers and approximately 20 students. Involved in several European funded programs, he has overseen formal research programs for undergraduate researchers, PhD and masters students for 15 years.

Supported Perovskites for Air Pollutant Abatement, Dr. Anne Giroir-Fendler, Professor, Vice President UCBL1 International Student Mobility, President of International Relations for the Faculty of Sciences and Technologies, and acting Director of the Characterization and Remediation of Pollutants Team of IRCELYON. The student will work on synthesis and characterization of new perovskite supported materials. High temperature synthetic methods will be used to prepare supported perovskites. For example perovskite-type oxides of $LaMnO_3$ were synthesized by a citrate sol-gel method in the presence of an oxide support. The physicochemical properties of the $LaMnO_3$ supported materials will be characterized by inductively coupled plasma atomic emission spectroscopy (ICP-AES), thermogravimetric and differential thermal analysis (TGA/DTA), N_2 adsorption–desorption, X-ray diffraction (XRD) and high resolution transmission electron microscopy with energy dispersive spectroscopy (HRTEM-EDX). Their catalytic performances, especially those related to the catalyst stability, will be evaluated in air pollutant abatement (unburned hydrocarbon, soot, nitrogen oxides) at high temperature in a dedicated lab able to reproduce real mixtures emitted by automobiles and trucks. To this aim, three consecutive catalytic cycles will be performed for each catalyst to evaluate stability. Special attention will be given to identifying strong metal-support interactions between the perovskite and the support. Finally dual bed mode catalytic tests will be performed to study the perovskite-oxide support interactions. Dr. A. Giroir-Fendler has mentored many undergraduate researchers in successful projects. She has also hosted several high school students in both summer and academic year research programs and more particularly she is chairwoman of the International Catalysis Training School (ELITECAT 2013, 2015 and 2017).

Fluorous Solvent Droplet Catalysis in Fluorous Tag Oligosaccharide Synthesis, Dr. Peter Goekjian (Professor) with Dr. David Gueyrard (Assistant Professor). The *Laboratoire Chimie Organique 2* was established in 1962 by Prof. Gerard Descotes and has been among the top carbohydrate chemistry groups for the past 50 years. The strong push towards defined carbohydrate antigens and structurally defined synthetic vaccines is driving the need to accelerate oligosaccharide synthesis for vaccine development. Getting the most out of fluorous tag technology can make a significant contribution to this effort. The undergraduate students will prepare glycosyl donors and acceptors bearing fluorous chain tags of different lengths. The students will investigate whether any rate acceleration is observed in the presence of a heterogeneous organic-fluorous solvent system. Precursors and products will then be separated by fluorous phase countercurrent chromatography.

Hypothesis: Fluorous tagged carbohydrate precursors will concentrate on the surface of fluorous solvent droplets, leading to elevated local concentrations and rate enhancements for the bimolecular coupling reaction. Students will learn advanced synthetic chemistry procedures, traditional and novel chromatography procedures (e.g. countercurrent chromatography), analysis of complex NMR spectra, as well as principles of stereoselective and regioselective synthesis. NMR (2 x 300 MHz in "hands on" service, 400 and 500 MHz in operated service) and MS (ESI, DESI, APCI, cryospray, EI, CI, LC/MS, GC/MS, MS^n) facilities will be utilized. Countercurrent chromatography equipment is available in collaboration with Alain Berthod of the *Institut de Chimie Analytique.* Pr. Peter Goekjian is a US citizen living and working in France, and he has hosted many US undergraduate researchers while in the US or in France.



Photocatalytic Efficiency of Luminous Textiles for Pesticide Removal, Dr. Chantal Guillard, Director of Research IRCELYON. In recent years a growing interest has emerged in biorecalcitrant pollutants such as drug residues, pesticides, and herbicides present in small quantities in water but very refractory to conventional methods of wastewater treatment. Heterogeneous photocatalysis using TiO_2 is one of the advanced oxidation process (AOPs), which has the advantage of being effective at room temperature without further addition of chemical oxidant. However, it is necessary to optimize the contact between catalyst/pollutant and light, limit the volume of the setup, and minimize the energy consumed**.** Commercial photocatalytic materials require the use of external light sources, leading to important constraints on volume of setup and resulting in scattering of light. In this context, the use of photocatalytic luminous textile as photocatalyst carrier and light source provides a pathway to optimize the contact between photons and TiO_2, improving the ratio of treated volume/catalyst surface and decreasing the energy costs. The objective of this study is to evaluate the capability of this photocatalytic luminous textile to remove imidachloprid, which is a systemic insecticide in the family of neonicotinoids, which are widely used for pest control in agriculture, termites, and protection of trees from boring insects. Treatment of imidachloprid and its removal from waste streams is important due to its toxicity to bees. The kinetics of disappearance, the fate of chlorine and nitrogen atoms, the total organic carbon, and the intermediate compounds formed during its degradation in the presence of this new photocatalytic material will be determined and the quantum yields evaluated by characterizing the absorbed light.

Photocatalytic Production of Valuable Compounds from Wastewater, Dr. Chantal Guillard, Director of Research, IRCELYON. Heterogeneous photocatalysis has become a comprehensively studied area of research during the past three decades due to its practical interest in applications including water and air decontamination, anti-fogging surfaces, and other waste treatment applications. While the field of heterogeneous photocatalysis for pollutant abatement and mineralization of contaminants has been extensively investigated, a new research avenue related to the selective conversion of waste or low-value materials to value-added materials has recently emerged as a promising alternative that can utilize solar light for the production of valuable chemicals and fuels. The objective of this project is to evaluate the efficiency of different photocatalysts to produce valuable products such as aromatics and olefins from biomass. Model molecules originating from biomass such as polysaccharides, sugars, and phenolics will be used and intermediate products evaluated to establish the transformation mechanisms.

Phospholipids and Designed Fluorophores for the Detection of Peptides Synthetized on and within Giant Vesicles, Dr. Peter Strazewski, Professor with Dr. Michele Fiore, Associate Professor. The *Laboratoire Chimie Organique 2* has integrated an additional specialty to the one of carbohydrate chemistry: Systems chemistry of biomolecules, being the joint effort of prebiotic and supramolecular chemistry to find the roots of Darwinian evolvability in synthetic chemical systems. We use phospholipidic giant vesicles as dynamic compartments for the enclosure of synthetic peptides and RNA, both of which can act as important biocatalysts. One sub-project is to observe the effect of phospholipids on the oligomerization of lipophilic random-sequence peptides, as well as on the conjugation of defined lipophilic peptides with synthetic RNA or hybrid DNA-RNA fragments. Understanding the behavior of vesicles can lead to important advances in catalytic processes, such as ribosomal petpidyl transfer reactions. The student will learn how to hydrate phospholipids and similar amphiphiles to form giant vesicles, how to carry out simple organic syntheses on lipid precursors, and how to synthesize 'clickable' fluorophores according to our protocols. The lab techniques include thin-layer chromatorgraphy, extraction, column chromatography, and pipetting, centrifuging, and lyophilization of aqueous lipid vesicles. The analytics will be carried out in part by central services (ESI mass spectrometry, 500 MHz NMR spectroscopy) and in part by the student who will be trained by us (300 MHz NMR routine spectrometer, infrared spectroscopy, fluorescence microscopy). All spectra and images will be treated and analyzed by the student. Both Dr. Strazewski and Dr. Fiore have mentored many undergraduate researchers of international backgrounds in successful projects.

Analytical Methods for Monitoring Photocatalytic Conversions, Dr. Emmanuel Vulliet, CNRS Researcher. Our research focuses on the development of analytical methods, based on mass spectrometry, to study the behaviour of organic micro-pollutants in environmental matrices (liquid, solid, biota) including treatment effluents. Our strategy includes the development and optimization of all steps of the analytical protocol, i.e. sampling, sample preparation, chromatographic separation, detection by targeted and untargeted mass spectrometry, and data analysis. These methods allow one to quantify traces of micropollutants in different matrices and to also identify potential degradation/transformation products formed during natural degradation in the environment or induced by photolysis or photocatalysis. The undergraduate student will be involved in the identification of transformation products formed during photocatalytic degradation by utilization of liquid chromatography coupled to tandem mass spectrometry. The student will learn how to analyze a liquid sample and interpret mass spectra (type of adducts, fragmentations) in order to provide potential chemical structures for the transformation products.