Available Georgia Tech Lyon IRES Projects-Summer 2021:

Project Area 1. Design and synthesis of functional molecular architectures for optimized molecular recognition- Dr. Julien Leclaire. Visiting undergraduate researchers may choose to work in one of three thrust areas in the LeClaire group. [i] The first of these focuses on the synthesis and characterization of disulfide-based cyclophanes modified with functional groups for specific molecular recognition applications. For example, molecular hosts are designed to target specific peptide sequences that may lead to peptide sequence sensing applications. A second area of interest is the synthesis, characterization, and analysis of self-assembled nanomaterials based on carbon dioxide for selective extraction of rare metals from mixtures. Finally, the group explores the synthesis and characterization of amphiphilic cyclodextrins derivatives (CDs) for the encapsulation of anti-cancer drugs. Additional cytotoxic properties and transport analysis are performed via collaboration with the Faculty of Pharmacy of Debrecen in Hungary and the group of Dr. Ildiko Backskay,

Project Area 2. Development of innovative nano-phosphors for LED applications- Dr. Stephane Daniele. The group has developed and patented a cost-effective chemical solution process to obtain a unique self-assembling mesospheric ZnO-polyacrylic acid hybrid system that has intense and stable visible emissions. [ii,iii,iv] This structure has shown to be an efficient scatterer, resulting in high UV absorption (90%), which allows remarkable external quantum efficiencies of up to 70% in the absence of earth rare metals. By combining the nanophosphor in a silicone matrix and a commercial UV LED, the device produces cold white light for potential use in commercial LED displays. A project suitable for IRES student consists of developing core-shell objects that allow an optimal dispersion of the nanophosphors in silicone resins. Working in a multidisciplinary environment that combines organometallic chemistry and materials chemistry, the student will aim to optimize the coating step by modifying synthesis parameters (precursor concentration, pH, temperature, etc.) while maintaining an excellent quantum yield of the nanophosphor.

Project Area 3. Metal free selective oxidation of sulfides. Dr. Laurent Vanoye and Dr. Alain Favre-Réguillon. The selective oxidation of sulfides is a challenging and technologically important process as sulfoxides and sulfones are widely applicable intermediates used in the synthesis of fine chemicals, bioactive compounds, agrochemicals, and ligands for transition metal asymmetric catalysis[v,vi,vii]. Sulfoxidations have traditionally employed strong oxidants, (e.g. nitric acid or potassium permanganate) which suffer numerous drawbacks. However, such oxidations may also be achieved using alternative and sustainable technologies. The group has recently shown that the metal-free aerobic oxidation of aliphatic aldehydes give the corresponding peracids in high yields. [viii,ix] The research group seeks to use these peracids to selectively convert thioesters to either the corresponding sulfoxide or the sulfone. The aim of this research is to develop a set of generally applicable conditions that will allow access to both compounds simply by tuning the amount of peracids used. The IRES student will investigate the synthesis of peracid and their use in the oxidation of sulfide. Analysis of these processes will make extensive use of GC, GC-MS, and other analytical techniques to allow the student to study the kinetics of the reactions.

Project Area 4. Preparation of Double Emulsions. Dr. Nida Othman and Dr. Noureddine Lebaz. [x,xi,xii,xiii] A double emulsion is a supramolecular structure whereby a small droplet of a liquid is suspended in a larger droplet of an immiscible liquid. These emulsions are important in the food, cosmetic, pharmaceutical, and chemical industries. The quality of the double emulsion is determined by the ratio of the sizes of the inner and outer droplet, and the inner phase encapsulation efficiency. An IRES student will investigate the parameters that influence the size and encapsulation efficiency of the double emulsion, including the type and concentration of surfactant and other additives. The work is experimental and involves food grade-quality mineral oil and surfactants.

Monitoring the formation of the emulsions will introduce students to the use of a Mastersizer® to measure the droplet size distribution, conductometry to evaluate the release rate, and microscopy to observe the morphology of the droplets.

Project Area 5. Synthesis of fluorinated organic compounds. Dr. Fabien Toulgoat and Dr. Thierry Billard. Compounds with a -CF_3 group attached to a heteroatom have received growing interest over the past few years due to distinct chemical and physical properties. Fluorinated organic compounds are used in a wide variety of applications such as pharmaceuticals, agrochemicals and water-repelling materials. The synthesis of fluorinated organic compounds can be challenging. IRES participants will work on new methods developed at CPE to introduce of trifluoromethoxy groups using mild reaction conditions. Drs. Toulgout and Billard are focused on developing a new synthetic route to introduce fluoroalkylseleno groups (R_FSe) via nucleophilic substitution reactions with various alkyl halides.[xiv] An IRES student will synthesize trifluromethyl- and perfluoroalkyl-selenoted derivatives and perform analyses by ^{1}H and ^{13}C NMR, GC-MS, and FTIR.

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