UNIVERSITY OF LEICESTER

Research Opportunities at the School of Chemistry

There are two different schemes across Chemistry, Engineering and Maths:

1. 6 Dalian University of Technology/University of Leicester PhD scholarships funded by CSC (CSC provides stipend and UoL provides international fee waiver)
2. 7 DUT-UoL Collaborative PhD Studentships
   (DLI provides 20,000 RMB and University of Leicester provides international fee waiver. Only available to DLI students)

We are not considering applications for the two funding sources separately. Shortlisting for interview will be carried out purely on the basis of quality and aptitude for the PhD project for which you have applied. Only at the point of interview and appointment of successful candidates will we begin to consider funding source. If you get through to the interview, you will be asked about your funding preference (only to be considered for CSC, only to be considered for DUT, preference for CSC but also consider DUT, preference for DUT but also CSC, or no preference) and then we will allocate projects at that stage.

A formal application to the University of Leicester is essential (this can be carried out here https://le.ac.uk/study/research-degrees/funded-opportunities/cse-dut-partnership) and the **deadline for applications is: 5th January 2026**. Please choose two research projects and make it clear on your application form which is your first and which is your second choice research project. We will be holding **online interviews from Monday 2nd to Monday 9th February 2026**, so please check your email account regularly to find out if you have been selected for an interview. You should receive an email inviting you to interview by Monday 26th January 2026.

With your application, please provide:

- CV
- Degree certificates and transcripts of study already completed and if possible transcripts to date of study currently being undertaken
- Personal statement
- Evidence of English language, only if applying from Dalian University of Technology
- In the references section, please enter the contact details of two academic referees in the boxes provided or upload reference letters if already obtained
- In the funding section, please state **DUT 2026 scholarship**
- In the research proposal section, please provide the names of the **project supervisors and the project titles** you want to be considered for. You can select up to 2 projects. List both in order of preference. (a research proposal is not required)

We have a number of different research projects available in organic chemistry, inorganic chemistry and physical chemistry. Please take a look through the 12 different research projects which are available in the School of Chemistry.

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Organic Chemistry

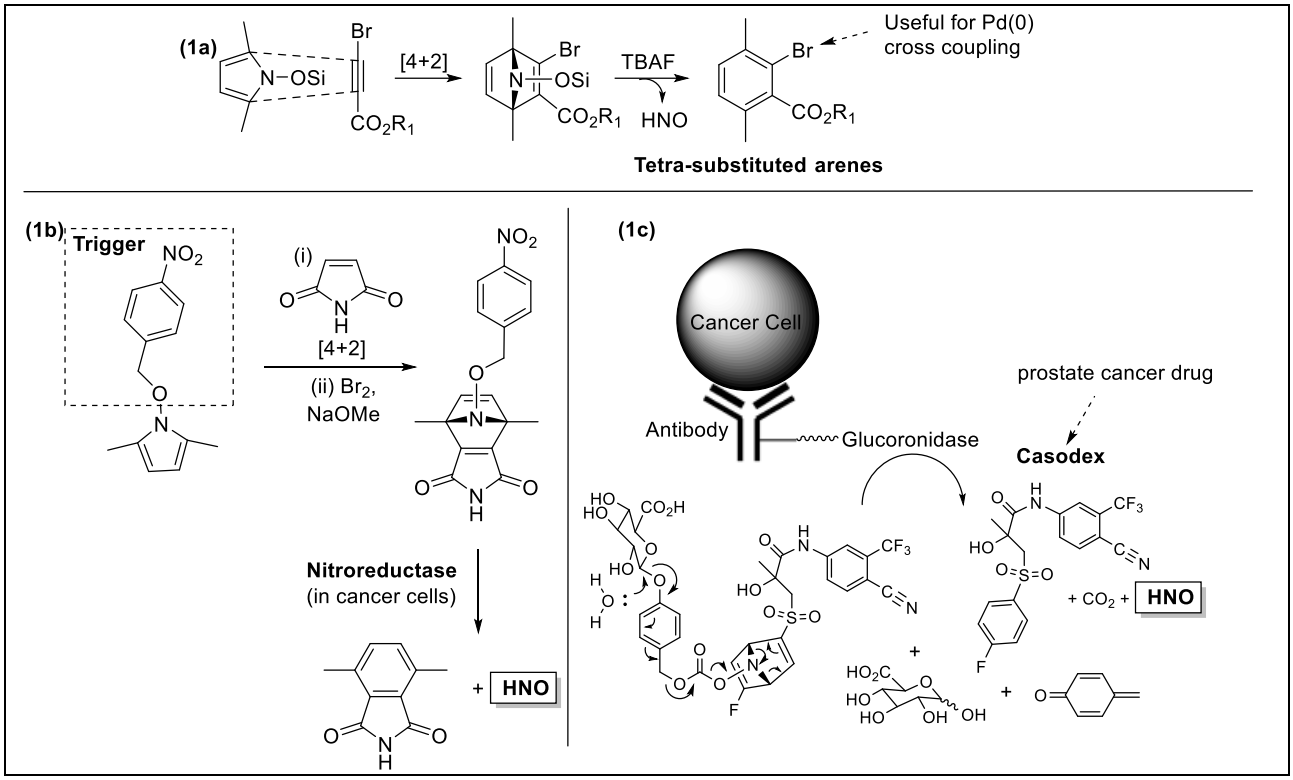
1. HNO Problem delivering drugs to cancer cells

Prof. Steve Bull – sdb45@leicester.ac.uk

Project Title	HNO problem delivering drugs to cancer cells	
Project Highlights:	1.	Gain key skills and experience in modern synthetic organic chemistry, prodrug design and compound characterisation.
	2.	Gain interdisciplinary skills in medicinal chemistry, chemical biology, drug discovery and antibody technology
	3.	Work in a cutting-edge biomedical research group on a real-world drug discovery programme of relevance to the pharmaceutical industry.

Project Overview (Maximum 350 words)

The Bull group has recently developed novel Diels-Alder reactions of O-silyloxy-pyrroles with dienophiles to produce bicyclic [4+2] azanorbornadienes (ABDs) that can be deprotected/aromatised to produce functionalised aromatic products and the reactive oxygen species nitroxyl (HNO) (**Scheme 1a**). This PhD project will build on this new synthetic methodology to develop novel prodrug constructs for delivering nitroxyl to cells, with HNO known to be toxic to cells in high concentrations. There is currently much debate about the role of nitroxyl in cells, however, attempts to elucidate its biological functions are currently complicated by lack of a good method of delivering nitroxyl to cellular systems. We will achieve this by preparing protected N-oxy-azanorbornadiene (ABD) scaffolds that contain triggerable fragments (e.g. an O-silyl ether) that can be deprotected by an external stimulus (e.g. F^-) to release HNO in cellular systems. Selectivity for cancer cells will be achieved using a nitrobenzyl protected ABD construct, with nitroreductases that are overexpressed in cancer cells selectively reducing the nitro group to an amino group to release HNO in cancer cells (**Scheme 1b**). Alternatively, we will develop novel Antibody Directed Enzyme Prodrug Therapies (ADEPT) systems that will employ an antibody bound glucuronidase enzyme to hydrolyse the sugar protecting group of on an ABD scaffold to release both HNO (toxic at high concentration, membrane permeable) and a potent anti-cancer drug (e.g. Casodex) to selectively kill cancer cells (**Scheme 1c**). This PhD project will provide excellent training for a student who is interested in a career in medicinal chemistry or chemical biology in academia or Pharma.


(1a)
[4+2]
TBAF
HNO
Useful for Pd(0)
cross coupling
Tetra-substituted arenes
(1b)
Trigger
(i)
[4+2]
(ii) Br2,
NaOMe
Nitroreductase
(in cancer cells)
+ HNO
(1c)
Cancer Cell
Antibody
Glucoronidase
prostate cancer drug
Casodex
+ CO2 + HNO

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2. *The Synthesis of Novel Proximity-Inducing Molecules to Rewire Gene Expression*

Dr. **James Hodgkinson** – jthodgkinson@leicester.ac.uk

Project Title	The Synthesis of Novel Proximity-Inducing Molecules to Rewire Gene Expression	
Project Highlights:	1.	Gain key skills and experience in modern synthetic organic chemistry, compound design and compound characterisation.
	2.	Gain interdisciplinary skills in chemical biology, including cell culture, western blot and RNA-seq.
	3.	Work in an exciting research area directly relevant to real-world drug discovery and the pharmaceutical industry.

Project Overview (Maximum 350 words)

Background: Epigenetic regulatory proteins play a crucial role in controlling DNA transcription and gene expression.[1] These proteins operate within multi-protein complexes that translocate to DNA and are essential for normal cell development and physiology.[2] Their dysregulation is implicated in diseases such as cancer, making them validated drug targets.[3] Proximity-inducing molecules, often referred to as heterobifunctional molecules, are compounds composed of two distinct protein-binding ligands connected by a linker.[4] The most well-known examples are proteolysis targeting chimeras (PROTACs),[5] which recruit a target protein to an E3 ubiquitin ligase, leading to its selective degradation via the proteasome. The Hodgkinson group has extensive experience in this area, particularly in targeting HDACs with PROTACs. [6-10]

In this studentship, we propose to develop and synthesise an entirely new class of proximity-inducing molecules designed to modulate DNA transcription and gene expression. This approach expands the potential of proximity-inducing technologies beyond protein degradation to directly influence epigenetic regulation. The project will involve the synthesis of bifunctional molecules that recruit epigenetic multi-protein complexes, typically involved in transcriptional repression, to novel genomic locations beyond their native functions. Following synthesis, these molecules will be evaluated in cells using a range of techniques to assess their impact on transcriptional regulation.

Aim: The main aim of this project is to identify the first proximity-inducing molecules capable of relocating epigenetic transcriptional complexes to alternative genomic locations, thereby modulating DNA transcription.

Significance: This is blue skies, fundamental research. HDAC complexes are key epigenetic regulators of gene expression, and repurposing their genomic activity represents a completely novel and new approach. Given that these complexes are validated drug targets, the project has clear potential for future applications in drug discovery.

Skills and experience you will gain: This studentship is a fantastic opportunity to build hands-on expertise in organic synthesis, while deepening your understanding of medicinal chemistry and chemical biology. You'll be gaining valuable experience that will prepare you for a successful career in pharmaceutical R&D or academic science.

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3. Precision deconstructive functionalisation of biologically active amines: Towards new amine-based chemical space, activity and function

Dr. Alex Pulis – a.pulis@leicester.ac.uk

Project Title	Precision deconstructive functionalisation of biologically active amines: Towards new amine-based chemical space, activity and function	
Project Highlights:	1.	Discovers efficient synthetic methods for *N*-based molecules relevant to drug discovery
	2.	Utilises unexplored reactivity of boron-based catalysts
	3.	Borders on the traditional realms of organic and inorganic synthesis and therefore provides a unique training opportunity

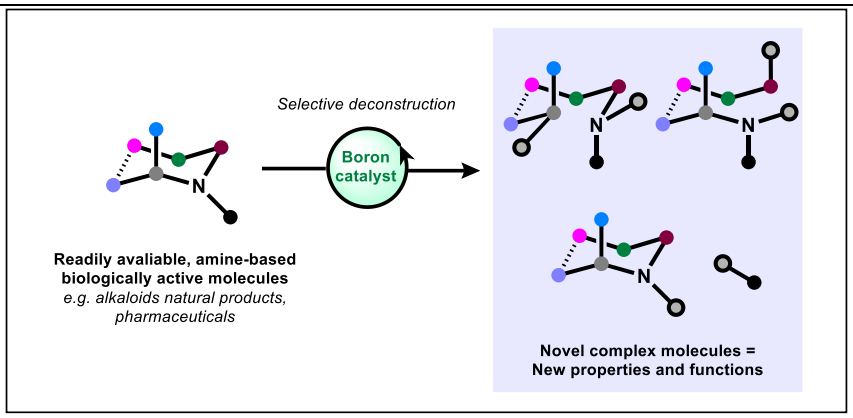
Project Overview (Maximum 350 words)

Introduction

The importance of chemical synthesis is perhaps most visible in its ability to generate molecules for drug discovery. In the realm of drug discovery, molecules that contain nitrogen atoms have a central role.[1] It is therefore of strategic importance that researchers can efficiently generate diverse collections of nitrogen containing molecules for vital structure-activity relationships. However, synthetic methods that allow for the precise control in the formation of complex amines are currently lacking and science is currently unable to deliver the required range of structural diversity.

Project outline

Dr. Pulis' research explores the fascinating and wide-ranging reactivity of boron-based catalysis. This project will build upon our recent publications describing the boron-catalysed modification of amines.[2] We will utilise the unique mode of activation provided by boron-based catalysts to selectively deconstruct readily available amines and form novel complex molecules with new properties and functions. Amine based pharmaceuticals and alkaloid natural products will be converted into new structures via the direct and selective cleavage of nitrogen-carbon bonds. There are a variety of applications for this deconstructive approach to synthesis. For example, the synthesis of noroxymorphone (used to treat substance abuse, including opiate addiction) from morphine involves a challenging demethylation that currently uses hazardous reagents. Our boron catalysed approach would operate under mild conditions and utilise safe reagents. We will also develop deconstructive functionalisation reactions where multiple C-C and C-N bonds are formed at the expense of one C-N bond, ultimately unlocking new properties and functions of molecules that were previously impossible to form.



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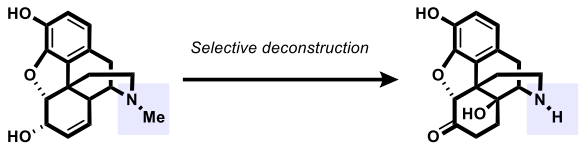

Morphine
analgesic, substance of abuse

Noroxymorphone
a treatment for opiate abuse

Training

This exciting project borders the traditional realms of organic and inorganic synthesis and therefore a successful candidate will receive high level training in a broad mix of topics and techniques including catalysis, advanced synthetic techniques and the use of state-of-the-art analytical methods.

After completion of the PhD, you will be ready to forge a successful career in either industry or academia.

References

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4. Late Stage Trifluoromethylation of Amines, Thioethers and Ethers

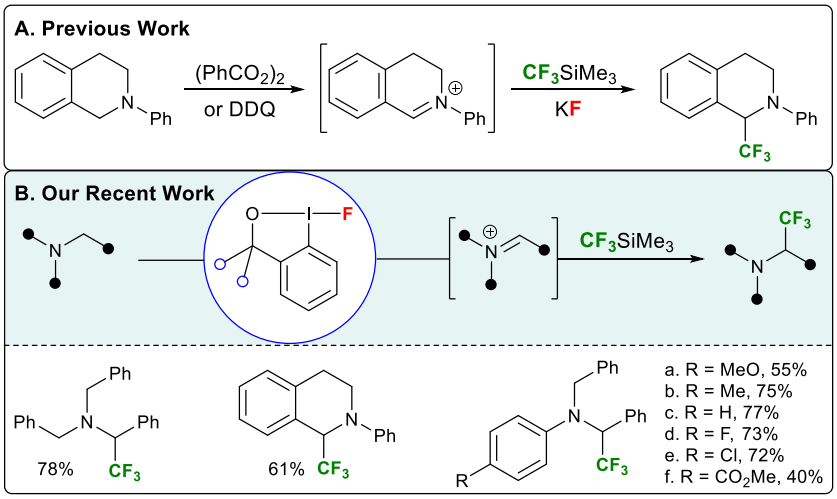
Dr. Alison Stuart – alison.stuart@leicester.ac.uk

Project Title	Late Stage Trifluoromethylation of Amines, Thioethers and Ethers	
Project Highlights:	1.	Develop new synthetic methodology for the late-stage functionalisation of amines, thiols and ethers to form trifluoromethylated products relevant to medicinal chemistry.
	2.	Perform mechanistic studies by multinuclear NMR spectroscopy and DFT calculations to understand and control the reactions.
	3.	Provide excellent training for a research career in either academia or industry (e.g. in medicinal chemistry, process chemistry, agrochemistry, as well as in fine and speciality chemicals)

Project Overview (Maximum 350 words)

Introduction

The importance of fluorinated compounds in modern technology cannot be overstated with wide-ranging applications in liquid crystals, agrochemicals, pharmaceuticals and materials science. In medicinal chemistry the incorporation of fluorine is a common design strategy in the drug discovery process because fluorinated groups can improve the properties of drug candidate molecules such as metabolic stability, lipophilicity and pharmacokinetics. Consequently, an estimated 20% of drugs marketed in the last 20 years contain at least one fluorine atom or a trifluoromethyl group. There is therefore still a demand for developing more efficient trifluoromethylation procedures, especially for late-stage functionalisation of drug candidate molecules.



Scheme 1. α-Functionalisation of amines with trifluoromethyl groups

The direct α-trifluoromethylation of amines has only been reported successfully with tetrahydroisoquinoline derivatives which were reacted with either benzoyl peroxide or 2,3-dichloro-5,6-dicyano-benzoquinone (DDQ) to generate the iminium intermediate *in situ* and CF_3SiMe_3/KF to form the nucleophile (Scheme 1A). In our recent work, we have developed a new approach for the direct *a*-functionalisation of amines with trifluoromethyl groups using hypervalent iodine(III) reagents (Scheme 1B). The hypervalent iodine(III) reagent plays two different roles, wherein it oxidises the amine to form an iminium salt *in situ* and it also activates the Ruppert-Prakash reagent, CF_3SiMe_3, to produce the α-trifluoromethylated amine. This method is

operationally simple, uses mild reaction conditions and tolerates various functional groups, including halogens, ethers, thioethers and esters.

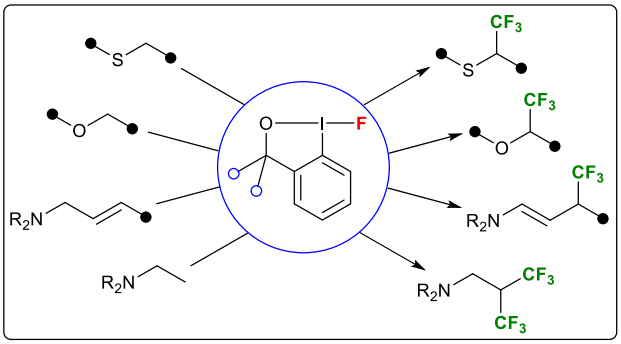
Research Aims

The three main objectives of this research project are:

O1: To develop a catalytic α-trifluoromethylation of amines by generating the hypervalent iodine reagent *in situ* and to use it as a catalyst rather than as a stoichiometric reagent.

O2: To apply this new synthetic methodology to the direct α-functionalisation of thioethers and ethers with trifluoromethyl groups (Scheme 2).

O3: To further enhance the scope of this new method by trifluoromethylating amines selectively at the β- and γ- positions (Scheme 2).



Scheme 2. Proposed new research

This is a synthetic organic research project which will focus on new methodology development and will lead to publications in high-impact journals. The successful candidate will gain hands-on-experience in catalysis, reaction design, target synthesis, and modern analytical techniques using state-of-the-art equipment (multinuclear NMR, stopped-flow NMR, mass spectrometry, chromatography).

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Inorganic Chemistry

5. Understanding Nature-inspired electrocatalysts for CO_2 sequestration

Dr. Phil Ash – philip.ash@leicester.ac.uk

Project Title	Understanding Nature-inspired electrocatalysts for CO_2 sequestration	
Project Highlights:	1.	Produce smart 'materials' using both natural and bio-inspired catalysts to produce chemical building blocks from atmospheric CO_2 and other gases
	2.	Experimentation and computational modelling to provide a more detailed understanding of energy transfer in biology, and implement these lessons in novel catalyst design
	3.	Work at large-scale national and international research facilities

Project Overview (Maximum 350 words)

In order to limit the effects of global climate change, it is critical that global carbon emissions are reduced dramatically, and new methods for carbon capture are discovered. In a world that shows few signs of lowering appetites for energy consumption, smart new technological solutions are required to both produce cleaner, carbon-free energy and to actively sequester atmospheric carbon dioxide.

Nature is expert at CO_2 uptake and usage. Naturally-occurring enzymes can convert CO_2 into useful synthetic building blocks, for example as part of amino acid production, with high efficiency. A number of bio-inspired catalysts have also been reported based around naturally-occurring minerals. A variety of chalcogenides (S, Se, or Te-containing minerals) have structures that are very similar to the active site of enzymes capable of a number of electrocatalytic reactions, including CO_2 reduction. The enzymes themselves are unlikely to be technologically practical from an economic perspective, so in this project we aim to 'reverse engineer' enzyme functionality into both natural minerals, and smart inorganic materials based on natural mineral structures, in a novel approach to bio-inspired inorganic geochemistry.

Deep eutectic solvents, which can be thought of as a specific class of ionic liquid, represent low-toxicity, cheap, and reusable media for synthesis of metal sulfide materials. In this project you will explore the production of 'artificial' minerals in deep eutectic solvents, and characterise their performance as electrocatalysts for environmental applications. You will investigate methods for one-pot and post-synthesis introduction of catalytic amino acids and prosthetic groups inspired by the active site structure of enzymes, and use these to fine-tune catalyst performance. Both 'native' and 'non-native' reactivity will be explored, in order to unlock new synthetic chemistry from ancient and affordable metal sources.

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6. Lanthanide metal clusters for molecular magnetism

Dr. Fabrizio Ortu – Fabrizio.ortu@leicester.ac.uk

Project Title	Lanthanide metal clusters for molecular magnetism	
Project Highlights:	1.	Activation of strategic small molecules (CO, CO_2, H_2, N_2)
	2.	Applications in molecular magnetism and spintronics
	3.	Direct collaboration with Dalian University of Technology (Prof. Yinshan Meng)

Project Overview (Maximum 350 words)

Background. Small molecule activation (SMA) is a pillar of the chemical industry. The activation and transformation of CO, CO_2, H_2 and N_2 is vital for the industrial production of numerous commodity chemicals that sustain modern society (global market worth >$600 billion). Reagents and catalysts involved in these transformations classically require expensive, toxic and scarce metals, thus posing significant challenges towards the long-term sustainability of chemical manufacturing. To tackle these challenges, other approaches must be investigated, including the employment of earth-abundant and non-toxic metals – such as rare earth metals. Our research group studies the fundamental chemistry of main group and f-block metals and their application in sustainable synthesis. Most rare earth metals have very low toxicity and remarkable reactivity, which has already led to numerous applications in SMA.

Aims. As part of this project, we will develop new rare earth reagents stabilised using sterically demanding organometallic and nitrogen-based ligands. In preliminary work, we have already shown that such complexes can deliver facile activation of CO_2 and CS_2, leading to the transformation of these basic feedstocks into more complex organic molecules. We have also demonstrated that it is possible to use SMA to form multimetallic rare earth clusters, which are of great interest for their potential applications in molecular magnetism. In this project we will build on these exciting preliminary results and produce a large family on new rare earth compounds and test their reactivity with a range of small molecules, targeting both useful synthetic transformation and multimetallic clusters with interesting magnetic properties.

Methodology. using *state-of-the-art* anaerobic methods (e.g. glovebox, Schlenk line) and a suite of characterisation techniques (multinuclear NMR, X-ray diffraction, UV-vis-NIR spectroscopy, photoluminescence). Additionally, this work will be complemented by comprehensive magnetic studies (EPR and SQUID) to evaluate potential applications of the new materials in molecular magnetism in collaboration with Prof. Yinshan Meng at the Dalian University of Technology.

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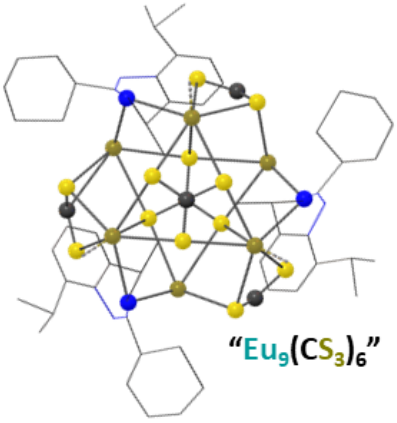
Lanthanide metal clusters for molecular magnetism

- *Conversion of small molecules (CO, CO_2, H_2) into useful synthetic products*
- *Molecular magnetism and spintronic applications*
- *UoL/DUT collaboration*



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7. Manganese Catalysis as a Sustainable Path to Bioactive Compounds

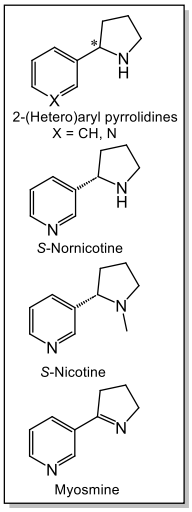
Dr. Greg Solan – gas8@leicester.ac.uk

Project Title	Manganese Catalysis as a Sustainable Path to Bioactive Compounds	
Project Highlights:	1.	To exploit the earth abundance, cost effectiveness and health benefits of manganese in catalyst design.
	2.	To employ inventive strategies to produce chiral manganese catalysts. The findings will offer a transformative roadmap for green chemistry.
	3.	To apply these catalysts to the synthesis of chiral 2-(hetero)aryl pyrrolidines: species ubiquitous in alkaloid natural products, bioactive molecules and pharmaceuticals.

Project Overview (Maximum 350 words)

Introduction

Chiral 2-(hetero)aryl pyrrolidines represent prominent structural motifs that feature extensively in bioactive molecules, alkaloid natural products and pharmaceuticals. Of note, *S*-nicotine extracted from tobacco, is one of the most important bioactive natural products with a current usage that is >1000 tons p/a. Due to the medicinal potential of nicotine and related alkaloids (*e.g.*, treating Parkinson's disease, dementia and depression), considerable effort has been spent in the development of effective routes to chiral precursors that can be utilised to synthesise them. With respect to *S*-nornicotine, several strategies have been reported for its asymmetric synthesis. However, these methods are often complicated by the need for multiple steps and/or the reliance on expensive catalysts/starting materials. By contrast, a more attractive and direct approach involves the asymmetric hydrogenation (AH) of 2-(3-pyridyl)pyrroline (myosmine) with hydrogen sources, owing to the availability of the precursor and the inherent process economy. Nonetheless, to date this particular transformation has proved difficult to achieve since the precious metal catalysts employed (typically Ir-based) have a tendency to undergo deactivation on account of the coordination ability of the pyridine moiety in the substrate.



Herein, we make use of catalysts based on the 3*d* metal, manganese, since it is not only earth abundant but is also advantageous from an economic and health standpoint. Moreover, our recent research has shown that precisely designed chelating ligands can activate Mn(I) complexes towards AH reactions with catalytic TOF's that can rival or even surpass that of the precious metal catalysts, while allowing appreciable functional group tolerance. Hence, this project will build on our experience in this area by designing chiral Mn catalysts that can facilitate not only the direct conversion of myosmine to *S*-nornicotine, but also the AH of various substituted derivatives.

PhD Project objectives

i) The synthesis of well-defined chiral Mn catalysts [1st/2nd year], and

ii) The application of these chiral Mn catalysts to the AH of a range (hetero)aryl-appended cyclic *N*-alkyl imines [2nd/3rd year].

To explore the impact of the chiral chelating ligand on the effectiveness of the Mn catalyst to impart enantiocontrol, we aim to synthesise a range of chiral chelating ligands differing in their steric/electronic profile. Following coordination to Mn, these complexes will be assessed initially for the AH of myosmine to *S*-nornicotine. The degree of enantioinduction and conversion will then be used to inform the subsequent ligand design. A full suite of spectroscopic techniques will be used to characterise the Mn catalysts as well as the chiral amine products.

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In short, this cross-disciplinary programme will see the development of inexpensive and 'smart' chiral Mn catalysts that can mediate the formation of chiral α-(hetero)aryl pyrrolidines. There will be opportunities to cultivate industrial partners that will be actively pursued.

Key references: [1] Solan *et al*., *J. Catal.* 2023, **418**, 40. [2] Solan *et al*., *ChemCatChem* 2024, **16**, e202301567. [3] Solan *et al*., *J. Org. Chem.* 2024, **89**(17), 12318. [4] Solan *et al*., *J. Catal.* 2024, **436**, 115601. [5] Solan *et al*., *Dalton Trans.* 2023, **52**, 10574. [6] Solan *et al*., *Org. Lett.* 2025, **27**, 2564-2568.

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8. Phosphorescent Iridium(III) Complexes as miRNA Delivery Vehicles for Cancer Stem Cell Therapy

Dr. **Rama Suntharalingam** – k.suntharalingam@leicester.ac.uk

Project Title	Phosphorescent Iridium(III) Complexes as miRNA Delivery Vehicles for Cancer Stem Cell Therapy	
Project Highlights:	1.	Synthesis and characterisation of phosphorescent iridium(III) complexes
	2.	Determine the photophysical and biophysical properties of the phosphorescent iridium(III) complexes
	3.	Conduct biological studies in cancer stem cell systems to determine efficacy of the iridium(III) complexes as miRNA delivery vehicles, and elucidate the mechanism of action of the iridium(III) complexes

Project Overview (Maximum 350 words)

Despite significant advances in cancer therapy, fatal incidences of tumour recurrence are still common. Cancer relapse is strongly related to the existence of cancer stem cells (CSCs), a sub-population of cancer cells defined by their ability to self-renew, differentiate and form secondary and tertiary tumours.[1] Due to their remarkable differentiation and self-renewal capacity, CSCs display resistance to conventional chemotherapy and radiotherapy. Standard drugs coupled with surgery effectively reduce tumour mass; however, residual CSCs remain and trigger tumour regrowth. Therefore, to eradicate cancer and prevent its recurrence, chemotherapeutics must have the ability to remove the entire population of cancer cells, including CSCs. Therapeutics capable of selectively killing CSCs and disrupting the microenvironment (niche) supporting these cells are the subject of intense current research, however, there is still no clinically approved drug that specifically removes CSCs.

The goal of this project is to synthesise water soluble, iridium(III) complexes with branched polyamine backbones capable of delivering miRNA into CSCs. miRNA are small noncoding RNAs typically 20-28 nucleotides in length that have been shown to play a role in RNA-silencing and post-transcriptional regulation of gene expression in CSCs.[2] miRNAs that can inhibit the translation of protein(s) involved in the maintenance and regulation of CSCs will be selected for delivery. Specifically, miR-199a and miR-200a will be delivered as they target proteins critical for cell migration and metastasis (namely, CD44, ZEB2, and CD133) in certain CSCs.[3,4] In addition to miRNA delivery, the inherent photophysical properties of the iridium(III) complexes will enable bio-imaging, and thus, validation of delivery. This project is highly multidisciplinary, and will involve chemical synthesis and characterisation, photophysical and biophysical methods, mono- and 3D-layer cell culture, and sophisticated biologicals techniques. Examples of the methods to be undertaken can be found in the references below.[5-8] In the short-term this project will extend the boundaries of medicinal inorganic chemistry by combining nucleic acid chemistry and photophysics with metallodrug development to delivery therapeutically active miRNAs to CSCs. The long-term outcomes of the project could lead to new strategies that can achieve extended tumour remission in cancer patients.

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Physical Chemistry

9. Sustainable electrochemically switched ion-exchange systems for water remediation and selective recovery of agrochemicals and metals

Prof. Rob Hillman – arh7@leicester.ac.uk

Project Title	Sustainable electrochemically switched ion-exchange systems for water remediation and selective recovery of agrochemicals and metals	
Project Highlights:	1.	(Co-)polymer design for selective ESIX ion extraction from solution
	2.	Ion- and solvent exchange dynamics under potentiodynamic control
	3.	Proof of concept scale-up including solution mass transport control

Project Overview (Maximum 350 words)

Sustainable agriculture (UN SDG 2) and clean water (UN SDG 6) are critical global societal challenges. This project focuses on energy efficient water remediation (addressing clean water provision directly) and recovery of valuable "contaminants" (sustainability of agrichemicals and metals from battery technology).

Diverse electrochemical techniques (ISEs, ASV, DPV, SWV, EIS) are widely used for solution analysis, but are neither separation technologies nor scalable. Traditional ion-exchange polymer membranes extract ions from solution, but are uneconomical for large scale application and regeneration creates chemical waste. Electrochemically switched ion-exchange (ESIX) uses a redox-active polymer ion-exchanger: applied potential alters polymer charge, facilitating reversible extraction/ejection of ions. Flow control alternately yields pure water and concentrated contaminant streams. The low power requirement is consistent with renewable energy sources.

This project develops ESIX for selective ion removal/recovery. Cationic polymers will extract anionic species (nitrate, phosphate, fluoride); polymer reduction results in anion ejection to a concentrated waste stream for sustainable recovery. Anionic polymers will be used in mirror image fashion to extract cations, typified by hydrated metal cations from Li ion battery production or re-cycling (e.g. NMC or LFP systems). The project will address fundamental (small scale) and engineering (scale-up) aspects of film thickness (redox capacity), polymer/solution contact time, and cycle life. Chemical engineering challenges are associated with film permeation, solution mass transport control and film mechanical stresses.

Recent work shows selectivity (separation factor) and dynamics (throughput) are highly sensitive to polymer and partitioning ion solvation characteristics. The project will explore the facility to manipulate polymer solvation by copolymerization and substitution chemistry. Electrochemical techniques provide overall control (via applied potential) and measurement (via current or charge). Film morphology will be determined by microscopy (3D microscopy, SEM, AFM). Spatially integrated film solvent population and variation with polymer redox (charge) state will be determined using acoustic wave measurements; for thicker films the experiment yields film viscoelastic properties. Spatial resolution of solvent population will be determined using neutron reflectivity with H/D isotopic substitution of polymer and/or solvent in flow-through cells. Specular/non-specular reflectivity will provide vertical/lateral spatial resolution. Experimental data will be supported by finite difference simulations and techno-economic evaluation.

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10. Exploring the Molecular Mechanism of the Biological Clock Using Optical and Spectroscopy Methods

Prof. Andrew Hudson – ah242@leicester.ac.uk

Project Title	Exploring the Molecular Mechanism of the Biological Clock Using Optical and Spectroscopic Methods	
Project Highlights:	1.	**Chemical control of circadian timing:** Use of haem as a chemical probe to modulate the biological clock.
	2.	**Advanced molecular spectroscopy:** Application of UV-visible absorption and fluorescence methods to characterise the molecular dynamics of haem binding to clock proteins.
	3.	**Optical force analysis:** Use of optical force spectroscopy to measure the mechanical effects of haem binding on clock proteins.

Project Overview (Maximum 350 words)

Our aim is to apply advanced spectroscopic and optical methods to understand the molecular mechanism of the circadian clock – nature's intrinsic, self-regulating oscillator that governs rhythmic changes in human physiology and behaviour over a 24-hour cycle. Disruption of this timing system is linked to sleep disorders, metabolic disease, and neurodegeneration, making it crucial to understand the molecular mechanisms that impact on the clock's timekeeping.

Our particular interest lies in uncovering how the timekeeping of the biological clock is modulated through small-molecule interactions with key clock proteins. Specifically, we are exploring how haem, an organo-transition metal complex, influences the activity and structural dynamics of these protein components. Haem consists of an iron ion centrally coordinated within a heteroaromatic porphyrin ring in a near-square-planar geometry. The iron centre can form additional coordinate bonds at its vacant axial positions with Lewis basic amino acid side chains, enabling it to crosslink residues within or between protein domains. Such binding can trigger substantial conformational rearrangements that alter protein function, potentially tuning the oscillatory behaviour of the circadian machinery.

To characterise these molecular interactions and their functional consequences, this project will employ a suite of complementary physical techniques. UV-visible absorption spectroscopy will be used to monitor haem binding and redox state changes, while time-resolved fluorescence methods will probe the dynamics of molecular interactions including binding affinities and kinetic parameters. Furthermore, optical force spectroscopy will be applied to measure the mechanical properties of protein-DNA complexes and the effect of haem-induced structural modulation.

Together, these approaches will yield a detailed picture of how haem-protein interactions influence the molecular mechanics of the circadian clock. By integrating optical and spectroscopic data, we aim to provide new insight into the chemical regulation of biological timekeeping, offering potential strategies for pharmacological control of circadian rhythm-related disorders.

UNIVERSITY OF LEICESTER

11. Development of new catalysts for precision manufacturing

Prof. **Sergey Piletsky** – sp523@leicester.ac.uk

Project Title	Development of new catalysts for precision manufacturing	
Project Highlights:	1.	Synthesis of gold nanoparticles with catalytic properties is an important research topic for diagnostic and chemical synthesis applications.
	2.	We have developed new protocols for integrating gold nanoparticles with substrate-selective polymeric shells – highly desirable catalysts for chemical manufacturing.
	3.	The proposed work will be delivered by collaborative efforts of world-leading groups with expertise in molecular imprinting and catalysis.

Project Overview (Maximum 350 words)

Molecular imprinting is the technique of imparting molecular recognition properties in a cross-linked synthetic polymer by polymerisation in the presence of a molecular template. The resultant materials are known as molecularly imprinted polymers (MIPs) and have applications in separations, assays, sensors and catalysis and are often referred to as “plastic antibodies”. Preparation of the materials as nanoparticles (nanoMIPs) have many advantages, as they can be used as direct replacements for antibodies. We have recently pioneered a solid phase approach to the synthesis of nanoMIPs which is compatible with automation and allows production of nanoparticles with high affinity and specificity. We were able to integrate synthesised nanoMIPs with catalytic gold core turning them into hybrid with recognition and catalytic functions. These materials are highly desirable for chemical manufacturing of enantiomeric drug precursors.

Project Aim: In this project it is proposed to prepare nanoMIPs with gold cores and investigate their utility in precision manufacturing. These particles will be synthesised using grafting-from approach and by solid phase synthesis. The candidate will receive training in modern methods of polymer synthesis, separation, molecular imprinting, nanoparticle characterisation, and chemical catalysis.

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12. Al Speciation in Chloroaluminate Liquids; Sustainable Aluminium Batteries Beyond the State of the Art

Prof. Karl Ryder – ksr7@leicester.ac.uk

Project Title	Al Speciation in Chloroaluminate Liquids; Sustainable Aluminium Batteries Beyond the State of the Art	
Project Highlights:	1.	Developing a new combined approach to spectroscopic and electrochemical probes for metal ion structure
	2.	Correlation of metal ion structure with rheology and electrochemical performance
	3.	Battery testing: Bringing together (1) and (2) above; informed design, fabrication and testing of high-performance Al-based rechargeable coin cells. Taking Al-ion beyond current state of the art.

Project Overview (Maximum 350 words)

This project will seek to bring to bear a combination of spectroscopic tools (FT-IR, ^{27}Al, ^{31}P NMR, ESR and Raman microscopy), together with electrochemical analysis and cell testing to understand the structural speciation of the Al^{3+} ion in chloroaluminate electrolytes and to take the current application in rechargeable aluminium batteries beyond the current state of the art.

Lithium-ion battery technologies continue to dominate the market for mobile charge storage required to sustain ubiquitous modern technologies including laptop computers, phones, portable electronics and electric vehicles (EV). [1] However, Li metal is difficult to extract from it's ore, using huge quantities of water and energy often to the detriment of indigenous regional cultures. The global supply chain for Li metal is also highly vulnerable to geopolitical factors. Hence the continued global reliance on Li-technology is not sustainable. Much research effort has focused on alternatives such as sodium-ion and aluminium-ion systems. Auminium is an especially strong candidate since the theoretical energy density of it's redox reaction is closer to lithium than any other metal in the periodic table. Despite this, Al metal is very reactive and reduction of Al^{3+} is both energetically difficult and air and moisture sensitive. Nevertheless, many prototype Al battery cells have been developed using chloroaluminate ionic liquids and analogues, the latter based on systems that originated in Leicester [2], but limited understanding of the detailed chemistry is holding these back. The electrolytes are the critical component of such cells, and here they are based on an acid-base interaction between $AlCl_3$ and a Lewis base such as urea, acetamide, acetamidine or guanidine [3,4]. A critical balance must be achieved in this interaction to optimise the liquid rheology and the electrochemically driven ligand exchange steps associated with reversible reduction of the Al^{3+} ion to metallic Al. This interaction is determined by the speciation of the Al^{3+} ion.

Here the aim of the project is to use a combination spin-probes such as $OPEt_3$ for ^{31}P nmr (as well as ^{27}Al nmr) and functionalised TEMPO derivatives in ESR to elucidate features of both liquid micro rheology as well as the structure of the Al^{3+} ion. Additionally, in-situ Raman microscopy in collaboration with a group in Madrid [5]. These structural insights will be translated into prototype coin cell design, fabrication and electrochemical testing to improve performance and life-cycle of current Al-based rechargeable cells.

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