PROCESS INDUSTRIES: NET ZERO
CENTRE FOR DOCTORAL TRAINING

# Directory of Expertise

Newcastle University

University of York

UKRI Engineering and Physical Sciences Research Council

# Contents

# Introduction to the PINZ CDT:

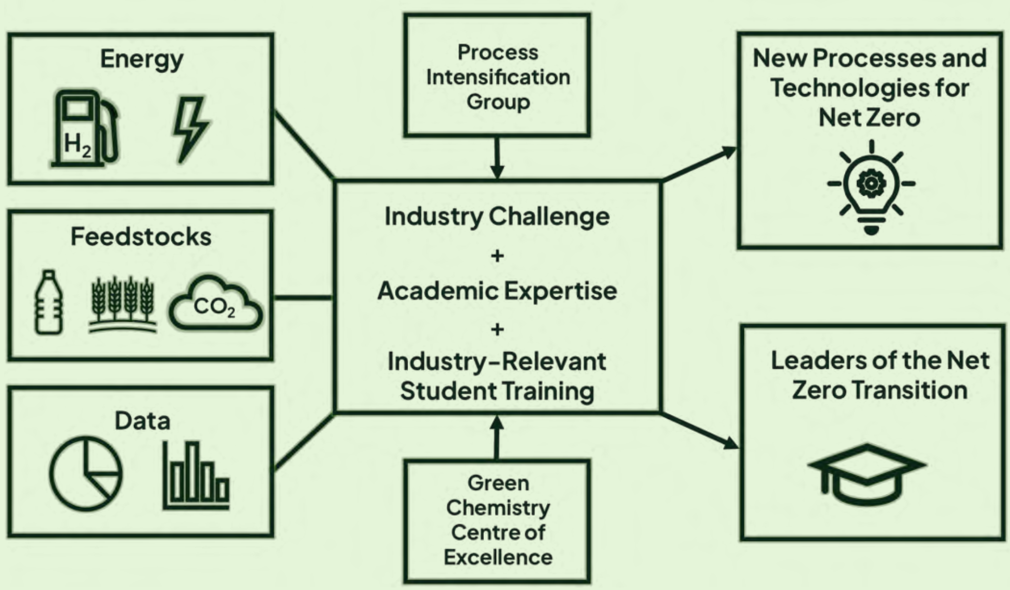
# Our Mission

To achieve Net Zero, process industries must radically transform how they manage energy, feedstocks, and data. Incremental improvements are insufficient, and step-change advances in efficiency and environmental impact are essential. The **Process Industries: Net Zero CDT (PINZ)** will address this challenge by training five cohorts of experts in **Process Intensification and Green Chemistry**, equipping them with the unique skills to design revolutionary processes, technologies, and chemistries. These graduates will lead the global Net Zero transition, driving low-carbon businesses and supply chains and supporting the UK's Net Zero Strategy, which aims to create ~500,000 low-carbon jobs within seven years.

Delivering this vision requires a **Centre for Doctoral Training (CDT)**: a critical mass of multidisciplinary researchers and industrial partners to foster innovation across sectors and provide comprehensive training. PINZ will build strong academic-industry collaborations, combining expertise in process engineering, biological and chemical sciences, and data analytics to co-create transformative research.

PINZ unites two world-leading groups: **Newcastle University's Process Intensification Group** and the **University of York's Green Chemistry Centre of Excellence (GCCE).** Established in 2005 and led by **Professor Adam Harvey**, Newcastle's group pioneers process intensification methods, focusing on reaction, separation, heat exchange technologies, and applying these principles to equipment design and process synthesis.

The GCCE, led by **Professor Helen Sneddon**, is an international flagship for sustainable chemical research, with over 20 years of experience. Its 60-strong team collaborates with chemical, energy, food, and pharmaceutical industries to deliver innovative solutions for a circular economy. Together, these centres will train future leaders to accelerate the process industries' Net Zero transformation.



# Professor Kamelia Boodhoo

## Newcastle University

kamelia.boodhoo@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/kameliaboodhoo.html


## Research Overview

Kamelia Boodhoo is Professor of Intensified Chemical Processing and Director of Chemical Engineering at Newcastle University.

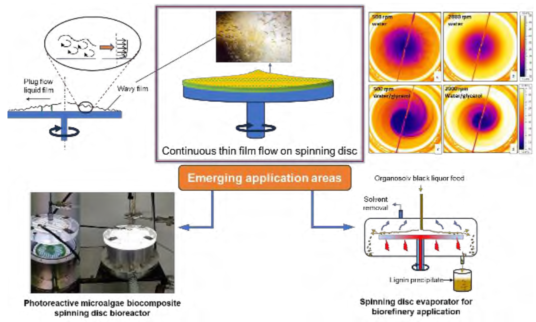
Her research activities focus on the development and characterisation of continuous flow technologies with particular emphasis on thin film flow technologies. These include rotating technologies such as the spinning disc reactor and micro/meso-channel reactors amongst others. These technology developments have been applied to polymerisation, crystallisation, nanoparticle processing, photocatalytic processing, biocapture of CO2 and purification in biorefinery processing. She has published over 100 journal and conference papers and book chapters in these areas.

She is the Lead Editor of "Process Intensification for Green Chemistry: Engineering Solutions for Sustainable Processing", published by Wiley-Blackwell in 2013. She is an Executive Editor of Elsevier's premier journal dedicated to Process Intensification, "Chemical Engineering and Processing: Process Intensification".

## PINZ Interests

**Renewable and Sustainable Feedstocks**: My most recent projects have focused on intensifying bio-based processes using the hemicellulose fraction of lignocellulosic biomass from e.g. paper and pulp industries, particularly around upstream purification of HMCs. Both antisolvent precipitation of HMC sugars and evaporative precipitation of lignin have been studied, highlighting the potential for resource and energy-efficient processes to be applied in the biorefinery industry. Combining green chemistry concepts with process intensification is of particular interest here.

**Renewable Energy**: I am also interested in using renewable solar energy to drive chemical or biological reactions using CO2. Work is ongoing on designing efficient photocatalytic reactor technologies to efficiently harness visible light energy. Electrification of processes utilising sustainable feedstocks is also being developed.

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# Professor Duncan W. Bruce

## University of York

duncan.bruce@york.ac.uk

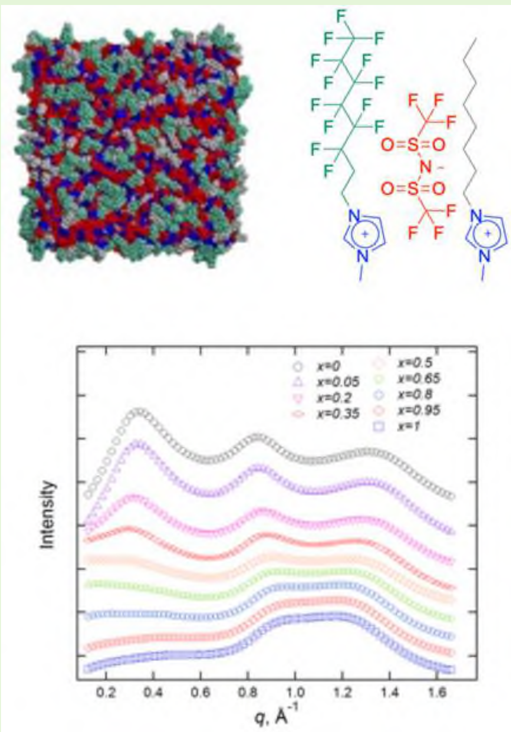
01904 324085

https://www.york.ac.uk/chemistry/people/dbruce/

## Research Overview

Duncan Bruce is a Professor of Materials Chemistry, with diverse research interests. An inorganic coordination chemist with knowledge of photocatalysis by training, he has developed significant expertise in the synthesis and properties of liquid crystals, especially those containing transition metals.

His group has made significant contributions in areas of LC behaviour including the biaxial nematic phase, polycatenar materials, cubic phase formation and emissive LCs for OLED applications. They have also shown the use of metallosurfactants for the liquid crystal templating of mesoporous solids containing catalytically or magnetically active metal nanoparticles, for example demonstrating rapid and specific alkene hydrogenation. They developed studies in hydrogen-bonded liquid crystals and were the first to demonstrate LCs formed through the use of halogen bonding. He also has significant expertise in ionic liquids.




## PINZ Interests

With John Slattery, we have been preparing and investigating the properties of mixtures of ionic liquids (ILs) as part of a wider collaboration with McKendrick and Costen at Heriot Watt (see e.g. first two publications in list).

We have studied mixtures as a way to tune physicochemical properties and have characterised the materials using a combination of surface tension as well as X-ray and neutron scattering and reflectometry. In addition, we enjoy an active collaboration with Shimizu and Canongia Lopes in Lisbon who carry out atomistic MD simulations on our systems.

Current attention is focused on the use of IL mixtures in Supported Ionic Liquid Phase (SILP) catalysis where a homogeneous catalyst is dissolved within an IL that is in turn dispersed as a thin film on the surface of a porous silica. These are excellent systems for gas-phase catalysis and pilot-plant systems exist for hydroformylation at TRL7.

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# Professor Antoine Buchard

## University of York

antoine.buchard@york.ac.uk
01904 325539
https://www.buchardgroup.org/

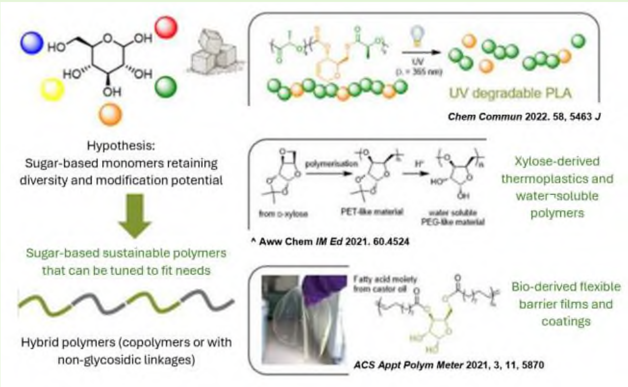
## Research Overview

Because of their environmental persistence and dependence on fossil-based resources, the intensive use of most polymers currently on the market is viewed as unsustainable. One vision for sustainable polymers is that of materials, derived from renewable feedstocks, which exhibit multiple, closed-loop life cycles. Research in the Buchard group aims at the development of such polymers.

Our team specialises in the synthesis of polymers from renewable feedstocks (sugars, carbon dioxide, vegetable oils). We develop synthetic methods to access platforms of bio-derived polymers that are versatile and tuneable (amphiphilicity, crystallinity, degradability and chemical recyclability).

We are also interested in polymerisation and depolymerisation catalysis (using metal complexes and organocatalysts, including in flow processes) to enable more circular materials. Our team also investigate the applications of these new polymers as more sustainable commodity plastics (packaging, rubbers...) and specialty materials (adhesives and coatings, drug excipients, sensors, battery electrolytes...).

**Sugar-derived polymers**




## PINZ Interests

**Renewable Feedstocks**: We are interested in the synthesis of new monomers from renewable feedstocks. One of our privileged feedstock are carbohydrates (e.g., xylose). Sugars are natural, abundant, non-toxic, biodegradable, biocompatible, and highly functionalisable. By incorporating monosaccharide units into synthetic polymer backbones, bio-derived materials with adequate properties can be made, and we work with industrial partners on the application of those bio-derived polymers (e.g., as degradable flexible plastics, drug excipients and bioconjugates, scavenger and sensors for pollutants, and battery components).

**Low Energy Catalytic Processes**: We are interested in controlled polymerisation and depolymerisation catalysis. Developing fast and selective polymerisation catalysts is key to control the structure of polymers and their properties (e.g., to enhance their degradability). Catalysis for polymer chemical recycling to monomers is also vital to improve polymer sustainability, by reducing waste and limiting carbon emissions linked to virgin monomer production. Here, combining experimental and computational (DFT) studies allows us to accelerate the discovery of novel catalysts.

## Publications

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# Dr Gary Caldwell


## Newcastle University

gary.caldwell@newcastle.ac.uk

https://www.ncl.ac.uk/nes/people/profile/garycaldwell.html


## Research Overview

Gary Caldwell is a Senior Lecturer in Applied Marine Biology in the School of Natural and Environmental Sciences of Newcastle University. His research mainly focuses on the biotechnology and bioprocessing of algae (both micro- and macroalgae). His main focus is the application of algae and other marine organisms for environmental bioremediation and ecosystem restoration.

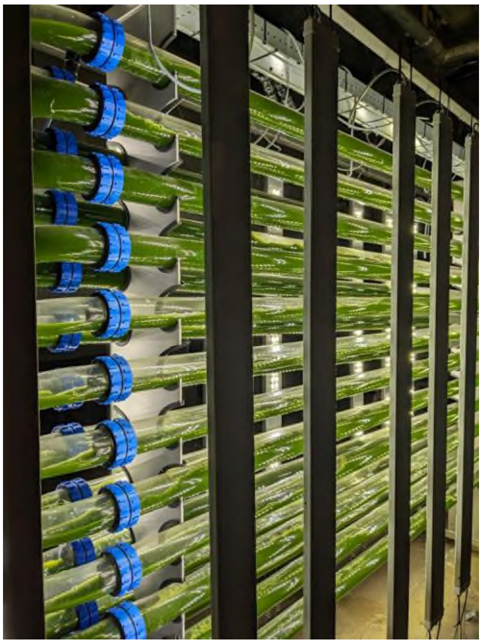
He works very closely with Northumbrian Water Ltd and has developed processes for the capture and recycling of nitrogen (ammonium), phosphorous (phosphate) and carbon ($CO_2$) pollution. His processes include treatment systems with algae in suspension as well as algae that have been immobilised as biocomposites (living materials). He is also working on using marine polychaete worms to remediate metals pollution.

A recent addition to his work is habitat restoration in the Tees estuary to deliver a sustainable and affordable nutrient neutrality strategy for the estuary. He has also worked extensively on the anaerobic digestion of algae; low energy harvesting systems (notably foam flotation); and has worked on developing a process to synthesise selenium nanoparticles using seaweed to target multidrug resistant tuberculosis.

## PINZ Interests

His focus for PINZ is understanding at the molecular, the biological processes behind the algae-based remediation of ammonium-rich effluent from wastewater treatment processes.

This work is being done in collaboration with Northumbrian Water Ltd and has led to substantive infrastructure investment in the Bran Sands treatment plant on Teesside. An aspiration is to eventually transition this suspension-based treatment processes to an immobilised process.



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- Development of a foam flotation system for harvesting microalgae biomass, T Coward, JGM Lee, GS Caldwell, Algal Research 2 (2), 135–144, 2013.

# Professor Victor Chechik


## University of York

victor.chechik@york.ac.uk

https://www.york.ac.uk/chemistry/people/vchechik/


## Research Overview

Victor has a physical organic chemistry background and is interested in all aspects of mechanistic organic chemistry.

He has developed expertise in free radicals and EPR spectroscopy; his group has three EPR machines operating at X and Q-band, equipped with variable temperature units, photolysis setup, and flow systems. He is interested in studying both short-lived radical intermediates and stable free radicals. He has recently developed a new type of traps for free radicals with the products analysed by advanced mass spectrometry.

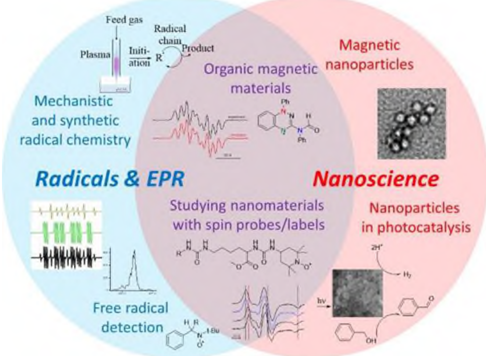
He is also interested in supramolecular chemistry. He often uses stable free radicals as molecular probes for such systems which include soft materials, various supramolecular assemblies, and inorganic nanoparticles. He has worked with self-assembled monolayers that can be considered as models for organic coatings, and has explored radical damage to these systems.

Victor collaborates with other researchers in academia and industry, including process developments. The industrial collaborations are usually focussed in mechanistic radical chemistry.

## PINZ Interests

**Free radical chemistry**: We investigate radical reactions (which are often run under very mild conditions and hence are important for sustainable chemistry) with particular emphasis on detection and characterisation of radical intermediates and development of novel initiation mechanisms. We have developed expertise in trapping of free radicals in different systems for analysis by EPR spectroscopy or mass spectrometry. We are also interested in preventing unwanted radical reactions, for instance by development of novel antioxidants and polymerisation inhibitors.

**Mechanistic chemistry**: We are working on unravelling reaction mechanisms, particularly for (but not limited to) radical reactions. We are interested in reactivity patterns in unusual systems such as supramolecular assemblies, multiphase systems, unconventional and mixed solvents, soft materials etc. We are working on improving our understanding of the mechanisms of autoxidation and radical damage to various chemical systems.

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# Dr Terry Dillon

## University of York

terry.dillon@york.ac.uk

https://www.york.ac.uk/chemistry/people/dillont/

## Research Overview

Terry is a Senior Lecturer in Physical Chemistry, and he leads an experimental research team based in the Wolfson Atmospheric Chemistry Laboratories and the laser laboratories at the Department of Chemistry.

Terry's research is directed towards a detailed understanding of gas-phase chemistry in both indoor and outdoor atmospheres. In WACL, in the chemistry laser facilities and in the new indoor air research labs in York, Terry's research group study the emissions, transformations and fates of the key species in air. We use laser methods, mass-spectrometry, gas chromatography and a host of low-cost sensors in diverse settings such as flash photolysis experiments, fast-flow systems, environmental chambers and even real kitchen environments.

Terry's group have most recently been researching:

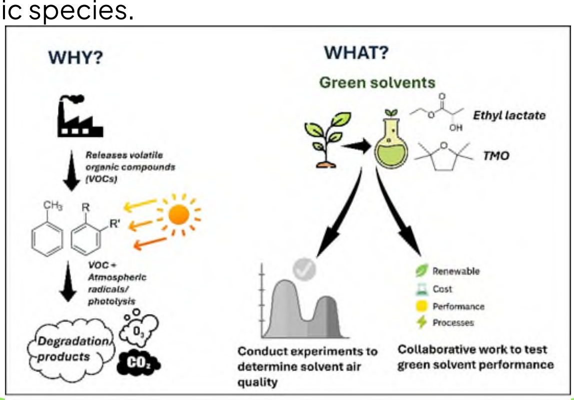
- degradation of new "green" solvents and aroma chemicals;
- photolysis reactions in the atmosphere;
- atmospheric radical lifetimes;
- impacts of cooking and cleaning on indoor air quality and health.

Terry has supervised ten PhD students and dozens more MChem, MSc, MSci, BSc and summer project students at York. He is always keen to meet enthusiastic students and discuss potential projects.

## PINZ Interests

Our involvement with PINZ to date has been to co-supervise a PhD student working on new green solvents. The work in the atmospheric chemistry labs has focused on experiments to best quantify the environmental impact of the solvents as they are inevitably released into the atmosphere.

More generally, we are interested in the environmental impact of processes and in being able to quantify impacts as procedures / materials / reactants / solvents are improved. Key air quality metrics would be Global Warming Potentials (GWP) for long-lived species, Ozone Depletion Potentials (ODP) for substances that could endanger the stratosphere, and Photochemical Ozone Depletion Potentials (POCP) for more reactive volatile organic species.




## Publications

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# Professor Richard Douthwaite

**University of York**

richard.douthwaite@york.ac.uk
01904 324183
https://www.york.ac.uk/chemistry/people/rdouthwaite/

## Research Overview

Richard Douthwaite is Professor of Inorganic Chemistry focused on the synthesis, understanding and application of materials and metal complexes for catalysis using renewable energy.

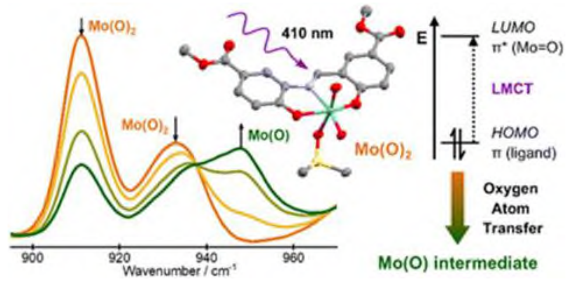
We have a general interest in developing and understanding catalytic reactions driven by light and electricity.

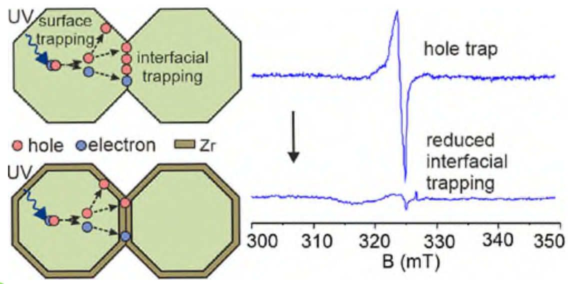
Work entails synthesis, characterization .and testing using a suite of state-of-the-art instrumentation including dynamic environmental-transmission electron microscopy for the study of heterogeneous (photo)catalysts at the atomic scale under gas atmospheres.

## PINZ Interests

**Renewable feedstocks for fuels**. We are currently interested in the valorisation of sustainably sourced biobased feedstocks into biofuels (e.g. kerosene for aviation). We have discovered a new methodology for the synthesis of linear and branched alkanes in water using (renewable) electricity. Previously we also worked on splitting water into dihydrogen and dioxygen using semiconductor photocatalysts.

**Photocatalysis**. Photons can be used to drive chemical reactions that would otherwise require thermal heating by burning fossil fuels. Photons can also access new reactivity manifolds not available by heating. Photocatalytic processes are also being developed in flow.

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# Professor Simon Duckett

## University of York

simon.duckett@york.ac.uk

01904 322564

https://www.york.ac.uk/chemistry/people/sduckett/

## Research Overview

Simon Duckett is Professor of Inorganic Chemistry and Director of the York Centre for Hyperpolarisation in Magnetic Resonance. He develops and synthesises inorganic complexes using both conventional synthetic techniques and innovative photochemical methods. A key focus to his work lies in the design and implementation of advanced nuclear magnetic resonance (NMR) methodologies to investigate chemical processes, including those involving in situ photolysis during NMR data acquisition. His research encompasses catalysis and the synthesis of novel inorganic complexes, frequently incorporating ligands enriched with NMR-active nuclei such as $^{13}$C and $^{15}$N to enhance spectroscopic insight.

In parallel, we explore hyperpolarisation — a powerful technique that enhances the sensitivity of NMR and magnetic resonance imaging (MRI) by several orders of magnitude. By hyperpolarising target molecules, we enable the detection of transient intermediates, low-abundance impurities, and metabolites that are otherwise challenging to observe. Most recently, we have employed hyperpolarised NMR to track synthetic pathways leading to pharmaceutically relevant organic compounds, offering new opportunities for reaction monitoring and mechanistic studies.

## PINZ Interests

Our research group applies advanced nuclear magnetic resonance (NMR) techniques to investigate chemical synthesis, with a particular emphasis on kinetic and mechanistic studies aimed at optimising the efficiency of catalytic processes. We employ photochemical approaches to explore novel reactivity and reaction pathways including the creation of H2. A central focus of our work is the use of para-hydrogen ($pH_2$) to sensitise NMR experiments, enabling the rapid characterisation and quantification of species at extremely low concentrations. The sensitivity enhancements achieved through para-hydrogen-based hyperpolarisation are often so substantial that single-scan $^{13}$C and $^{15}$N NMR spectra can be recorded without the need for isotopic labelling.

Target applications span both organic and inorganic transformations, with a particular emphasis on optimising yields. The ability to quantify low-abundance species in real time facilitates detailed kinetic analysis and precise turnover measurements, thereby providing deep mechanistic insight into catalytic systems. Studies to identify plant oils in mixtures illustrate our methods can be used to examine renewable feedstocks.

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# Professor Ian Fairlamb


## University of York

ian.fairlamb@york.ac.uk

01904 324091

https://www.york.ac.uk/chemistry/people/ifairlamb/
https://fairlamb.group/

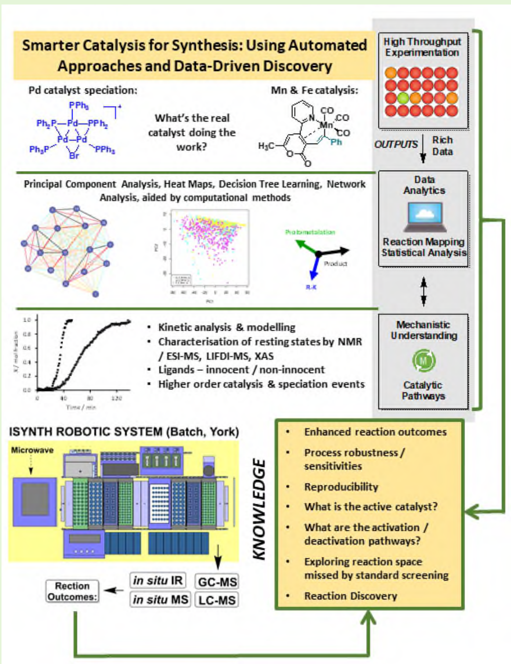

## Research Overview

The Fairlamb group have been recognized by the RSC Corday-Morgan 2016, Horizons Prize 2021 (Team prize with Lynam) and SCI AstraZeneca, GlaxoSmithKline, Pfizer and Syngenta Prize for Process Chemistry Research 2019 awards.

We develop earth abundant and precious metal (pre)catalysts for applications in greener and more sustainable catalysis and chemical synthesis, drawing on mechanistic studies through experiment and theory.

We have significant capability in automated high throughput reaction screening (batch and flow technologies), and the development of new robotic systems, working alongside engineers in both hardware and software. Rich data on chemical reaction outcomes is analysed and improved using data science tools, machine learning and artificial intelligence algorithms.

We further examine reaction mechanisms by kinetic analysis using a variety of traditional methods, including IR/UV-vis, NMR and MS, the former from pico-seconds through to seconds.




## PINZ Interests

Our research can be defined by drawing on mechanistic understanding in catalysis and the development and wider implementation of autonomous robotic systems in synthetic chemistry laboratories. A focus area is on sustainable cross-coupling chemistry catalysed by palladium, manganese and iron-based catalyst systems, drawing on either bio-sourced and/or renewable feedstocks.

We generate high value, rich data on catalytic reaction outcomes, which help drive different desired outcomes, aligning squarely with the three PINZ themes. Whether that be an improved (pre)catalyst system, a lower energy demand and lower cost process, and/or greener and cleaner high yielding outcome. Understanding the 'cradle to grave' for any (pre)catalyst system is critical mapping-out complete reaction profiles and delineating the full signature of a chemical reaction (all products and by-products to 0.05% levels) is a key driver for us, with discovery, optimization and safety in mind.

We are further developing the next generation of robotics and autonomous reactor systems for high throughput experiments, providing robust and reliable data for reaction outcomes.

## Publications


- Deciphering complexity in Pd-catalyzed cross-couplings. Clarke, G.E, Firth, J.D., Ledingham, L.A. et al. Not Commun, 2024,15,3968
- Unveiling Mechanistic Complexity in Manganese-Catalyzed C-H Bond Functionalization Using IR Spectroscopy Over 16 Orders of Magnitude in Time. I. J. S. Fairlamb and J. M. Lynam, Acc. Chem. Res., 2024, 57, 919–932.
- Evidence for Suzuki-Miyaura Cross-Couplings Catalyzed by Ligated Pd3-Clusters: From Cradle to Grave. N. Jeddi, N. W. J. Scott, T. Tanner, S. K. Beaumont and I. J. S. Fairlamb, Chem. Sci., 2024,15, 2763–2777.
- A Dichotomy in Cross-Coupling Site Selectivity in a Dihalogenated Heteroarene: Influence of Mononuclear Pd, Pd Clusters, and Pd Nanoparticles—the Case for Exploiting Pd Catalyst Speciation. N. W. J. Scott, M. J. Ford, N. Jeddi, A. Eyles, L. Simon, A. C. Whitwood, T. Tanner, C. E. Willans and I. J. S. Fairlamb, J. Am. Chem. Sec., 2021, 145, 9682–9693.

# Dr Martin Fascione


## University of York

martin.fascione@york.ac.uk

https://www.york.ac.uk/chemistry/people/mfascione/


## Research Overview

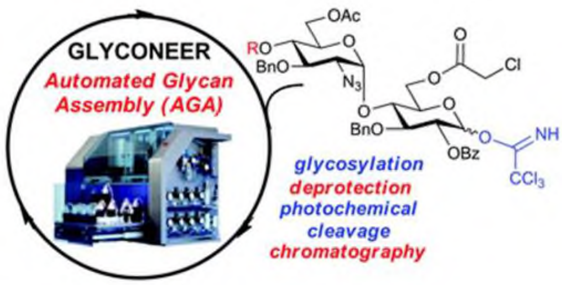
Dr Martin Fascione leads an interdisciplinary glycoscience research group within the York Structural Biology Lab in the Department of Chemistry at the University of York, UK. He works closely with academic collaborators in the chemical biology in Chemistry, the Hull York Medical School and the Centre for Novel Agricultural Products (CNAP) in the Department of Biology, exploring enzymes for the synthesis and breakdown of carbohydrates.

The Fascione Lab studies carbohydrates as the at the interface between chemistry and biology- a field commonly termed 'chemical glycobiology'. Our focus is on deciphering the roles that these biomolecules play in nature, with the overall aim of developing chemical tools to study and perturb their activity. To achieve this we use a combination of chemical, enzymatic and automated synthesis of carbohydrates, enzymology of carbohydrate active enzymes, and novel methods for protein (glyco)bioconjugation.

## PINZ Interests

Our primary interest is in carbohydrates, the most abundant biomolecules on earth, and the primary constituents in the cell wall of plants and bacteria. We are particularly interested in the discovery and characterisation of enzymes that synthesise, modify and breakdown these important biopolymers. We use enzymatic synthesis to build probes to dissect and disrupt these enzymes, but also have significant expertise in the chemical synthesis of complex glycans, and our lab houses the 'Glyconeer' an automated carbohydrate synthesiser, of which only a handful exist worldwide, which eliminates the requirement for multiple purification steps reducing waste and synthesis time.

We are particularly interested in working with partners to explore and expand the capacities of automated synthesis for the production of carbohydrate biopolymers for industrial application, including optimisation of automated synthesis through high-throughput experimentation and multivariate data analysis.




## Publications


- Hollingsworth et al., Synthesis and screening of a library of Lewis deoxyfluoro-analogues reveals differential recognition by glycan-binding partners. Nat. Commun., 2024, 15, article number: 7925
- Walklett et al., The Retaining Pse5Ac7Ac Pseudaminyltransferase KpsS1 Defines a Previously Unreported Glycosyltransferase Family (GT118). Angew. Chem. Int. Ed., 2024, 63 (15), e202318523
- Keenan et al., Reverse thiophosphorylase activity of a glycoside phosphorylase in the synthesis of an unnatural Manβ1,4GlcNAc library. Chem. Sci., 2023,14, 11638–11646
- Flack et al., Biocatalytic Transfer of Pseudaminic Acid (Pse5Ac7Ac) Using Promiscuous Sialyltransferases in a Chemoenzymatic Approach to Pse5Ac7Ac Containing Glycosides. ACS Catal., 2020, 10 (17), 9986–9993
- Budhadev et al., Using Automated Glycan Assembly (AGA) for the Practical Synthesis of Heparan Sulfate Oligosaccharide Precursors. Org. Biomol. Chem., 2019, 7, 1817–1821

# Dr Colin Hare

## Newcastle University

colin.hare@ncl.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/colinhare.html

## Research Overview

Colin Hare is a Senior Lecturer in Chemical Engineering in the School of Engineering at Newcastle University, chair of the IChemE Particle Technology Special Interest Group, and was a member of the EPSRC Early Career Forum in Manufacturing Research from 2016-2020.

His research is focused on discovering fundamental relationships between material properties, process conditions and product performance in powder-based manufacturing processes, using experiments and simulations. Particle simulations using the Discrete Element Method (DEM) are used to directly observe the influence of individual particle properties, and to investigate matters that cannot be easily resolved experimentally, such as determining prevailing stresses in moving powder systems.

He specialises in powder flow, particle breakage, mixing & segregation, particle coating and the discrete element method. He has received funding from the International Fine Particle Research Institute (IFPRI), Corning Inc., GSK, the European Commission and the EPSRC, to research particle breakage, powder flow under low stresses and high strain rates, heat generation and transfer in powders, and powder coating.

He received the Young Researcher Award at the UK Particle Technology Forum 2012 and the IChemE Nicklin Medal 2015.

## PINZ Interests

Many of the world's largest contributors to industrial carbon emissions are processes involving powder handling, such as mining & milling, cement production and steel manufacturing. Achieving net-zero also requires a rapid development in performance and scalability of diverse battery classes, most of which comprise of a solid cathode formed by compressing powders, with all-solid-state batteries manufactured entirely from powders.

There is also a need to develop and improve battery recycling processes and to reduce waste in all powder reduction processes by minimising the fraction that is out of specification. Many other industrial sectors include powders as raw materials, intermediates or products.

In all these cases, my interests are in optimising such processes to dramatically reduce their carbon footprint and minimise waste.

## Publications

- Investigating the effect of temperature on powder spreading behaviour in powder bed fusion additive manufacturing process by Discrete Element Method, S Zinatlou-Ajabshir, C Hare, D Sofia, D Barletta, M Poletto, Powder Technology 436 119468.
- A regime map for dry powder coating: the influence of material properties and process parameters, M Khala, C Hare, V Karde, JYY Heng, Frontiers in Chemical Engineering, 5:1301386, 2023.
- Density and size-induced mixing and segregation in the FT4 Powder Rheometer: An experimental and numerical investigation, M Khala, C Hare, C-Y Wu, M Murtagh, N Venugopal, T Freeman, Powder Technology 390 126-142, 2021.
- Analysis of the dynamics of the FT4 powder rheometer, C Hare, U Zafar, M Ghadiri, M Murtagh, J Clayton, T Freeman, Powder Technology 285 123-127, 2015.
- Prediction of attrition in agitated particle beds, C Hare, M Ghadiri, R Dennehy, Chemical Engineering Science 66, 4757-4770, 2011.

# Professor Adam Harvey

## Newcastle University

adam.harvey@newcastle.ac.uk
https://www.ncl.ac.uk/engineering/staff/profile/adamharvey.html
Personal website: http://pig.ncl.ac.uk


## Research Overview

Adam is the Professor of Process Intensification in the School of Engineering at Newcastle University, Head of the Process Intensification Group and Director of the PINZ CDT.

The Process Intensification Group has over 60 active researchers, including 17 academic staff, and conducts research across a broad range of areas: intensified process technologies (reaction, separation, heat exchange), process data analysis and modelling, and chemical/bioprocess development.

Currently, Prof Harvey's personal research focusses on:

**Flow chemistry:** process development in bespoke 3d-printed reactors; demonstration of conversion of batch processes to continuous, typically resulting in advantages such as: reactor volumes over 100 times smaller; removal of solvents; consolidation of process steps etc; parametric screening

**Biofuels/biomass**: numerous methods of intensifying the production of, and reducing the carbon footprint of biofuel production

**Non-thermal plasmas:** $CO_2$ chemistry; sustainable aviation fuels; direct air capture; degradation of VOCs

## PINZ Interests

1. **Flow Chemistry**: Applications have included: epoxidations; biofuels; saponification; production of lubricants; production of various sustainable (biomass-derived) chemicals.

Within PINZ the key interests are making processes more energy-efficient through conversion of batch to continuous and reducing/removing solvent use

2. **Biofuels/biomass**: more sustainable feedstocks

i. Biodiesel: reactor engineering, conversion to continuous processing; production directly from oilseeds ("reactive extraction") for numerous feedstocks (jatropha; microalgae; pongamia); glycerol chemistry; in situ by-product conversion; heterogeneous catalyst development
ii. Microalgae: conversion to biofuels and other products; efficient separation and reaction
iii. Biobutanol: in situ product recovery
iv. Bioethanol: simultaneous saccharification and fermentation of cellulose

3. **Non-thermal plasma (NTP) reactors**:

i. CCU: capture and reactions of $CO_2$: decomposition, dry reforming etc
ii. Scale-up of plasma reactors: reactor design and evaluation
iii. Degradation of VOCs

## Publications


- Process Intensification: Engineering for efficiency, sustainability and flexibility D Reay, C Ramshaw, A Harvey, Butterworth-Heinemann, 2013.
- Evaluation of the activity and stability of alkali-doped metal oxide catalysts for application to an intensified method of biodiesel production, C.S. MacLeod, A.P. Harvey, A.F. Lee, K. Wilson Chemical Engineering Journal, 135 (1–2), 63–70, 2008.
- Process intensification of biodiesel production using a continuous oscillatory flow reactor AP Harvey, MR Mackley, T Seliger Journal of Chemical Technology & Biotechnology, 778 (2–3), 338–341, 2003.
- Mixing through oscillations and pulsations—a guide to achieving process enhancements in the chemical and process industries X Ni, MR Mackley, AP Harvey, P Stonestreet, MHI Baird, NVR Rao Chemical Engineering Research and Design 81 (3), 373–383, 2003.

# Professor Oliver Heidrich

## Newcastle University

oliver.heidrich@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/oliverheidrich.


## Research Overview

My team investigates climate change strategies and determine the impacts they have on the planet. My research assesses mitigation and adaptation technologies to determine their global impacts on natural resources. With a vision to make the world an even better place, my mission is to help governments, industries, and society understand the environmental and resource implications of their actions (or inactions). My team applies engineering and management methodologies to enhance the sustainability and efficiency of industrial and urban systems.

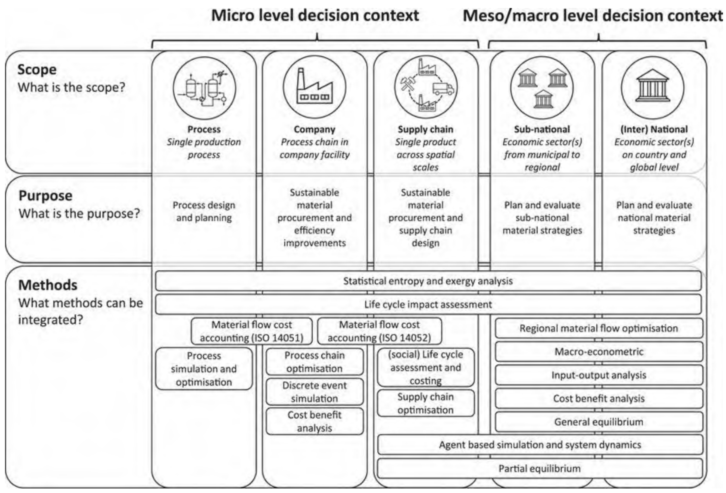
We shape new theories and practical tools to achieve sustainable cities, regions, countries, and the planet through resource modeling, life cycle assessments, material flows, industrial ecology, and standardized management systems. Our projects have been independently rated highly for their impact on knowledge transfer, and I have consulted and delivered training to organisations across sectors—from construction to banking.

**Vision & Focus**

I strive for a future where government, industry, and society recognize the environmental and resource consequences of their actions—or inactions. My team develops assessment methods and decision-support tools to quantify both intended and unintended impacts of climate change interventions.

## PINZ Interests

- Climate change adaptation & mitigation
- Urban planning & infrastructure systems
- Environmental, resource & waste management
- Life cycle assessment & costing
- Standardized management systems




## Publications

- The EU battery carbon footprint rules need urgent attention. MA Rajaeifar, DP Müller, M Hanton, O Heidrich. Nature Energy, 1–2
- Regional rare-earth element supply and demand balanced with circular economy strategies. P Wang, YY Yang, O Heidrich, LY Chen, LH Chen, T Fishman, WQ Chen. Nature Geoscience 17 (1), 94–102
- A dynamic framework to align company climate reporting and action with global climate targets. A Christy, M Elnahass, J Amezaga, A Browne, O Heidrich. Business Strategy and the Environment
- European patterns of local adaptation planning—a regional analysis. A Buzási, SG Simoes, M Salvia, P Eckersley, D Geneletti, F Pietrapertosa, … Regional Environmental Change 24 (2), 1–16

# Dr Anjali Jayakumar

## Newcastle University

anjali.jayakumar@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/anjalijayakumar.html

Personal website: https://anjalijayakumar.github.io/

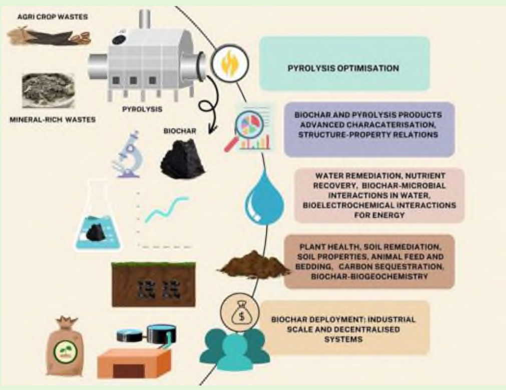

## Research Overview

Anjali Jayakumar is a Lecturer in Chemical Engineering at the School of Engineering at Newcastle University. She envisions to reduce and remove greenhouse gas emissions from the land, agricultural, and industry sector, which together account for over 80% of global emissions. She aims to do this by converting biomass waste into value-added products for clean energy and the environment. She specialises in biochar production and application, where biochar is a multi-functional, carbon-rich product of the thermochemical conversion of biomass and organic wastes under oxygen-deficient conditions. Biochar's long-term carbon sequestration potential has gained it significant attention as one of a handful of Carbon Dioxide Removal (CDR) technologies and is recognised by the IPCC as a carbon-negative technology. The use of biochar supports food, energy, and water security making it impactful for people and the planet. Her research thus contributes to several UN Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation) and SDG 7 (Affordable and Clean Energy).

Her research spans several disciplines including engineering, materials science, environmental science, and chemistry. Committed to climate and social justice, she also engages in practice-based research and teaching alongside climate scientists, policy makers, filmmakers, NGOs, activists, and educators to amplify the impact of sustainable technologies and inclusive solutions.

Some of the project details are given below:

- **Chasing Sustainability - Tales from South Asia:** A collection of films and lesson plans on the multi-faceted impacts and narratives of climate change in South Asia. https://blogs.ed.ac.uk/chasing_sustainability/
- **Char Comics**: A comic strip series aiming to highlight the diverse opportunities and different application scenarios of biochar. https://drive.google.com/file/d/11LbnaqiyJNqUZd1K8hWlvTKF65yEipBu/view?usp=sharing




## PINZ Interests

- **Co-Pyrolysis for Value-Added Products**: We explore the thermal conversion of mixed organic and inorganic waste streams through co-pyrolysis, aiming to maximise yield and quality of high-value outputs such as biochar, syngas, and bio-oil. We work with both community-scale and industrial-scale pyrolysis units to suit different end-user needs while maintaining biochar quality and sustainable production.
- **Biochar for Environmental Remediation and Carbon Sequestration**: We develop engineered biochars for soil restoration, pollutant immobilisation, water purification, and long-term carbon storage. We are also advancing techniques for monitoring, reporting, and verification (MRV) to support participation in carbon credit markets.
- **Structure-Property-Function Relationships**: We combine experimental characterisation and computational modelling to understand how biochar's structural and chemical features influence performance, enabling the design of tailored materials for specific environmental and industrial applications.

## Publications


- Sun, J; Jayakumar, A, G. Díaz-Maroto, C; Moreno, I; Fermoso, J; Masek, O; The role of feedstock and activation process on supercapacitor performance of lignocellulosic biochar, Biomass and Bioenergy, 2024
- Moore, J; Jayakumar, A (equal-first authors); Soldatou, S; Mašek, O; Lawton, L; Edwards, C; Nature-Based Solution to Eliminate Cyanotoxins in Water Using Biologically Enhanced Biochar, ACS Environ Sci. Tech, Oct 2023
- Jayakumar, A; Morrisset, D; Koutsomarkos,V; Wurzer,C; Hadden, R; Lawton, L; Edwards, C; Masek, O; Systematic evaluation of pyrolysis processes and biochar quality in the operation of low-cost flame curtain pyrolysis kiln for sustainable biochar production, (invited) Current Research in Environmental Sustainability, Elsevier, March 2023
- Wurzer, C.; Jayakumar, A.; Mašek, O.; "Sequential Biochar Systems in a Circular Economy," in Biochar in Agriculture for Sustainable Development Goals, Elsevier, May 2022.
- Jayakumar, A; Wurzer Christian, Sylvia Soldatou, Christine Edwards, Linda Lawton, Ondrej Masek, New directions and challenges in engineering biologically-enhanced biochar for biological water treatment, Sci. Total Environ. 2021

# Dr Richard Law

## Newcastle University

richard.law2@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/richardlaw2.html

http://pig.ncl.ac.uk


## Research Overview

Richard Law is a Senior Lecturer in the School of Engineering at Newcastle University. His areas of expertise are Process Intensification, Heat Transfer, Waste Heat Recovery Systems and Compact Heat Exchangers.

Broadly, Richard's research interests centre on intensified transport processes and energy systems, including both fundamental and applied research.

This has led to various interdisciplinary research activities in recent years which span a vast range of areas and potential applications including intensified liquid-phase heat transfer, high-flux electronics cooling, development of 3D printed flow reactors, advanced heat pipe technologies, intensified solids handling processes, intensified carbon capture systems, industrial renewable energy integration, process industry waste heat recovery, waste water treatment and fluidic mixing enhancement.

Past and current industrial collaborators include TWI, HIETA, Boyd Corporation, Northumbrian Water, METZero, Sanofi, Almirall and Torftec.

## PINZ Interests

**Intensified heat transfer technologies**: We are interested in both active and passive forms of heat transfer enhancement, in single phase and phase-change systems. Potential applications related to PINZ includes: heat transfer enhancement in thermal energy stores, development of new heat transfer devices utilising clean energy, and cooling of enabling technologies in the drive to net zero.

**Thermal energy storage at component and system level**: We are interested in thermal energy storage, from the development of new technologies to system-level modelling and optimisation. Potential applications related to PINZ includes: testing and development of new storage materials or mixtures, heat exchanger design and optimisation, and full system optimisation considering transient nature of renewable energy and demand fluctuations.

**Thermal energy recovery and system optimisation**: We are interested in novel means of recovering low-grade thermal energy in industry, including system-level optimisation and technology development (e.g. heat pumps). This includes modelling and experimental activities.

## Publications


- Opportunities for low-grade heat recovery in the UK food processing industry, R Law, A Harvey, D Reay, Applied thermal engineering 53 (2), 188–196, 2013.
- A knowledge-based system for low-grade waste heat recovery in the process industries, R Law, A Harvey, D Reay, Applied Thermal Engineering 94, 590–599, 2016.
- A metal additively manufactured (MAM) heat exchanger for electric motor thermal control on a high-altitude solar aircraft–Experimental characterisation, R Wrobel, B Scholes, A Hussein, R Law, A Mustaffar, D Reay, Thermal Science and Engineering Progress 19, 100629
- Process intensification and integration of solar heat generation in the Chinese condiment sector–A case study of a medium sized Beijing based factory B Sturm, S Meyers, Y Zhang, R Law, EJS Valencia, H Bao, Y Wang, ... Energy Conversion and Management 106, 1295–1308
- Experimental investigation into the feasibility of using a variable conductance heat pipe for controlled heat release from a phase-change material thermal store

# Professor Jonathan Lee


## Newcastle University

jonathan.lee@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/jonathanlee.html


## Research Overview

Jonathan Lee is Professor of Carbon Capture in the School of Engineering at Newcastle University. His research interests are in particular:

- Process Intensification - Rotating Packed Beds and their application to carbon capture processes.
- Microalgae Biocomposites for CO2 capture and utilisation and treating contaminated water streams.
- Biofuel and chemical production from algae
- Micro algae harvesting

Jonathan has specialist expertise in the following areas:

- Rotating packed beds for gas absorption, gas stripping and liquid extraction.
- Multiphase flow in rotating systems.
- Fluid flow/ multiphase flow: Expert in the use of FLUENT software to simulate complex fluid flow problems, in particular solid particle gas flows.
- Biofuels: Transesterification of algal biomass to produce biodiesel.

## PINZ Interests

Intensification of post combustion carbon capture using rotating packed beds. This work includes solvent-based carbon capture, carbon capture and utilisation (CCU) to produce dry laundry ingredients, and CCU using immobilised enzymes in the rotating packed bed.

Liquid distribution in Rotating Packed Beds – The development of a probes and data processing methods to measure liquid distribution within a 1m diameter. The purpose of this work is to prevent liquid maldistribution in large (>0.5m diameter) rotating packed beds.

Work with Northumbria Water and Northumbria University on the use of micro algae Biocomposites to remove phosphate from the final effluent of a sewage treatment works.

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## Publications


- Hendry, J.R., Lee, J.G.M., 2025, "Pilot-Scale Carbon Capture in a Heat-Pipe-Intercooled Rotating Packed Bed", Industrial and Chemical Engineering Research, 64(5), 2872–2879.
- Al-Humairi, S.T., Lee, J.G.M., Harvey, A.P., 2022, "Direct and rapid production of biodiesel from algae foamate using a homogeneous base catalyst as part of an intensified process", Energy Conversion and Management: X, 16, 100284, https://doi.org/10.1016/j.ecmx.2022.100284
- Pichaya In-na, Abbas A Umar, Adam D Wallace, Michael C Flickinger, Gary S Caldwell, Jonathan GM Lee, 2020, "Loofah-based microalgae and cyanobacteria biocomposites for intensifying carbon dioxide capture", Journal of CO2 Utilization, 42, 101348, https://doi.org/10.1016/j.jcou.2020.101348
- Hendry, J.R, Lee, J.G.M., Attidekou, P.S., 2020, "Pressure drop and flooding in rotating packed beds", Chemical Engineering and Processing, 151, Article number 107908, https://doi.org/10.1016/j.cep.2020.107908
- Applied in situ product recovery in ABE fermentation, V Outram, CA Lalander, JGM Lee, ET Davies, AP Harvey, Biotechnology Progress 33 (3), 563–579, 2017.
- Development of a foam flotation system for harvesting microalgae biomass, T Coward, JGM Lee, GS Caldwell, Algal Research 2 (2), 135–144, 2013.
- Alkaline in situ transesterification of Chlorella vulgaris, S Velasquez-Orta, J Lee, A Harvey, Fuel 94, 544–550, 2012.

# Dr Duncan MacQuarrie

## University of York

duncan.macquarrie@york.ac.uk

01904 524555

https://www.york.ac.uk/chemistry/people/macquarrie/

## Research Overview

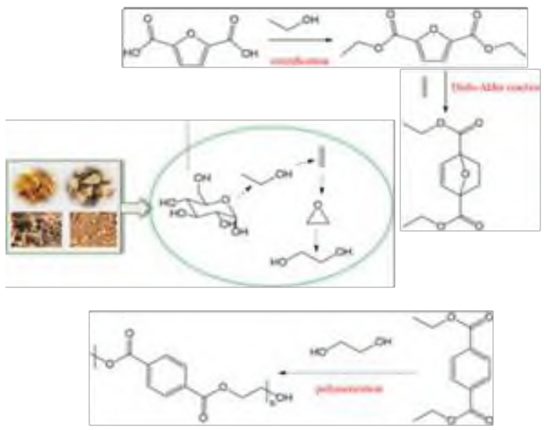
Research in my group focusses on three main areas - development of novel heterogeneous catalysts for organic transformations based on biomass-derived platform molecules, the use of microwaves as a low- energy synthetic technique, and the application of greener solvents.

We develop heterogeneous catalysts based on biomass such as polysaccharides, bio-silicas and even whole plant materials such as seaweeds for a range of clean synthetic processes. Combination of these materials with new solvents including a range of hindered ethers can alleviate the many issues with existing toxic solvents and provide efficient synthetic procedures for a range of chemistries. The use of microwave reactors can, in favourable cases, lead to substantial energy savings and very rapid and selective processes.

## PINZ Interests

Feedstock theme related interests: My work revolves around the valorisation of biomass and the platform molecules that derive from it. The development of heterogeneous catalysts (ideally also bio-derived). Such an approach helps to minimise the environmental impacts of synthesis, by reducing energy requirements, and by simplifying catalyst recovery and reuse, and thus also product isolation. Thus, bio-derived mesoporous carbon supports are used to produce catalysts capable of a range of synthetic transformations, and bio-silicas from a range of plants can be transformed into a range of highly controllable mesoporous silicas, which can then be used as catalyst supports.

Energy theme related interests. As well as the role of catalysts in reducing energy barriers, microwave chemistry can often drastically reduce energy use, leading to faster and more efficient transformations. We have a series of microwave reactors, able to carry out biomass transformations as well as synthetic chemistry. The combination of these with catalysis is a powerful combination.



## Publications


- Synthesis of bio-based diethyl terephthalate via Diels Alder addition of ethylene to 2,5-furan dicarboxylic acid diethyl ester: an alternative route to 100% biobased poly(ethylene terephthalate), J K Ogunjobi, T J Farmer, C R McElroy, S W Breeden, D J Macquarrie, D Thornthwaite, J H Clark, ACS Sust. Chem. Eng, 2019, 7 8183.
- Geminal diol of levoglucosenone as a switchable hydrotrope: A continuum of green nanostructured solvents, M De bruyn, V L Budarin, A Misefari, S Shimizu, H Fish, M Cockett, A J Hunt, H Hofstetter, B M Weckhuysen, J H Clark, D J Macquarrie, ACS Sust. Chem. Eng., 2019, 7, 7878.
- Application of hindered ether solvents for palladium-catalyzed Suzuki-Miyaura, Sonagashira and cascade-Sonogashira cross-coupling reactions S Sangon, N Supanchaiyamat, J Sherwood, D J Macquarrie, P Noppawan, A J Hunt, Org. Biomol. Chem., 2023, 21, 2603.
- Subtle Microwave-Induced Overheating Effects in an Industrial Demethylation Reaction and Their Direct Use in the Development of an Innovative Microwave Reactor, M De bruyn, V Budarin, G S J Sturm, G D Stefanidis, M Radoiu, A Stankiewicz, D J Macquarrie, J. Am. Chem. Soc., 2017, 159, 5431.

# Dr Jonathan McDonough

**Newcastle University**

jonathan.mcdonough@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/jonathanmcdonough.html

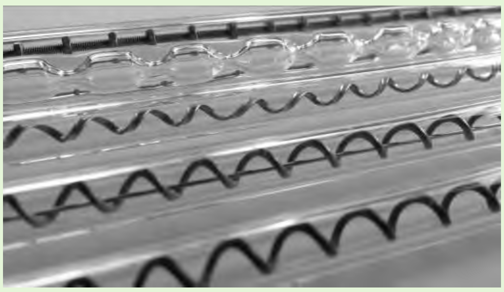
## Research Overview

I am an early career lecturer in Chemical Engineering at Newcastle University. My research interests include reaction engineering, flow chemistry, heat transfer, fluid mechanics, process intensification, fluidisation, carbon capture, and 3D printing. I have ongoing projects in industrial reactor characterisation and development, and I am the lead supervisor of one PINZ PhD student and co-supervisor on three new PINZ students starting in Sep 2025.

Since 2020, I have supervised 10 PhD students (4 to successful completion so far), 2 post-doctoral researchers, and >20 MEng/MSc students. I coordinate the Process Intensification Network (~300 academic and industrial members) and organise its well-regarded yearly industry-academia symposium at Newcastle University.

I am coauthor on the 'Heat Pipes 7th Ed.' textbook and the upcoming 'Process Intensification: Principles and Practice' textbook to be published by the Royal Society of Chemistry in 2025. I have first-authored 13 publications in well-regarded chemical engineering journals like CEJ, CES, and CHERD, and as of July 2025, my papers have been cited >600 times with numerous new publications currently in development.

I have delivered >25 talks including invited plenary lectures and keynotes at international conferences (ECCE, WCCE, EPIC, IPIC), universities (Imperial College London), and online webinars (EFCE, UKNHTC). Finally, I have delivered invited presentations at the annual CHEMUK Expo since 2021; the largest trade show for the UK's Chemical and Process Engineering industries.

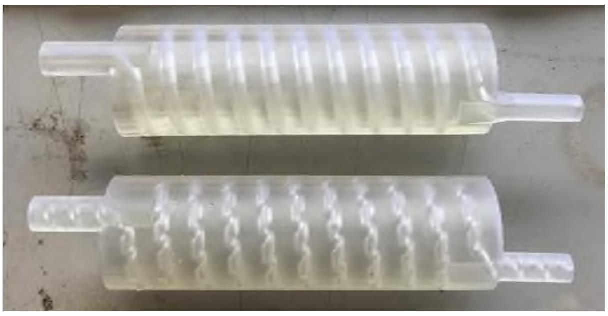


## PINZ Interests

My research vision is to exploit the geometric complexity unlocked by 3D printing to create new chemical reactor designs that will revolutionise flow chemistry, and chemical processes more broadly.

By combining CAD with the geometric freedom of 3D printing, to date I have:

1) created new flow reactor designs that unlock new operating windows for flow chemistry applications, with successful validation across three industrial chemistries with Sterling Pharma, Robinson Brothers Ltd., and Eternis
2) demonstrated that 3D printing can be used to fabricate micro-fluidised beds (1st demonstration in the literature)
3) successfully miniaturised a new commercial intensified reactor concept, known as TORBED, to a diameter of 50 mm for materials screening applications, with ongoing work in carbon capture and direct air capture.



## Publications


- A perspective on the current and future roles of additive manufacturing in process engineering, with an emphasis on heat transfer, JR McDonough, Thermal Science and Engineering Progress 19, 100594, 2020.
- T. Savage, N. Basha, J. McDonough, J. Krassowski, O.K. Matar, E.A. del Rio-Chanona. Machine Learning-Assisted Discovery of Novel Reactor Designs via CFD-Coupled Multi-fidelity Bayesian Optimisation. Nature Chemical Engineering 1, 522–531, 2024.
- Rapid process development using oscillatory baffled mesoreactors–A state-of-the-art review, JR McDonough, AN Phan, AP Harvey, Chemical Engineering Journal 265, 110–121, 2015.
- Micromixing in oscillatory baffled flows, JR McDonough, MF Oates, R Law, AP Harvey, Chemical Engineering Journal 361, 508–518, 2019.
- Fluidization in small-scale gas-solid 3D-printed fluidized beds, JR McDonough, R Law, DA Reay, V Zivkovic, Chemical Engineering Science 200, 294–309, 2019.

# Dr Greg A. Mutch


## Newcastle University

greg.mutch@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/gregmutch.html

https://linktr.ee/gregmutch


## Research Overview

Dr Greg A. Mutch is Royal Academy of Engineering Research Fellow, Senior Lecturer, and Head of Research in Chemical Engineering in the School of Engineering at Newcastle University.

Since completing his PhD in 2016, he has been awarded three research fellowships and three significant EPSRC grants: £18.9M total, £2.6M directly attributed, £0.5M/year (2019–2024). He became Head of Research (Chemical Engineering) at Newcastle University in 2024 and received the 2025 IChemE Warner Medal ("in recognition of an outstanding academic record, complemented by extraordinary outreach work"). He has supervised 14 researchers, and currently leads a team of 10.

His research brings together chemical engineers, chemists, and materials scientists with policy, techno-economic, and energy systems experts, to address the multifaceted challenge of carbon dioxide capture, utilisation, and storage. He has applied this approach to separation processes more generally and is an expert in the characterisation of materials using advanced spectroscopic materials.

More widely, he works across academia, industry, finance, politics, and the third sector on projects spanning research, education, technical consultancy, due diligence, policy development, and public engagement.

## PINZ Interests

In practice, all substances are mixtures. Therefore, separation and purification processes account for 10 – 15% of global energy consumption and 40 – 90% of capital and operating costs in industry today. Pivotal problems in the (intimately linked) climate, energy, and materials sectors will make separation processes even more prevalent than they are today; transformative science and engineering will be required to source and recover materials from ever more dilute and complex mixtures (Figure 1). This is a significant challenge, because as dilution and complexity increases, so does the energy penalty and cost of separation. We will therefore require new separation processes with increased selectivity and lifetime, as well as more efficient delivery, and the use of currently unexploited sources, of energy, to drive such processes.

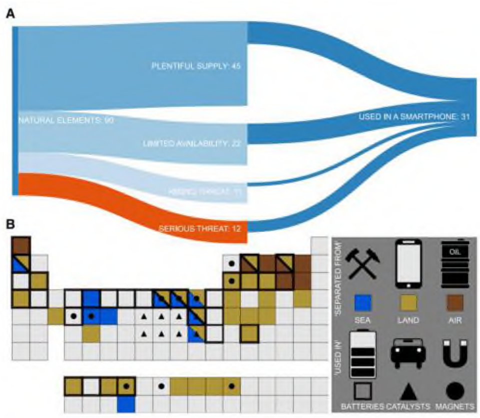



Figure 1 – **(A)** Scarcity of the 90 natural elements and their use in smartphones, as defined by the European Chemical Society Periodic Table (https://www.euchems.eu/euchems-periodic-table/). Scarcity of useful elements will increasingly compel resource recovery. **(B)** The periodic table with examples of elements increasingly targeted for removal or recovery from sea, land, and air and/or required for energy storage and conversion processes. All selected elements are found naturally and/or in wastes as dilute components of complex mixtures.

## Publications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# Professor Avtar Singh Matharu

## University of York

avtar.Matharu@york.ac.uk

01904 524187

https://www.york.ac.uk/chemistry/people/amatharu/


## Research Overview

Professor of Green Chemistry and Deputy Director of the Green Chemistry Centre of Excellence (GCCE). He is Editor-in-Chief of Elsevier Current Research in Green and Sustainable Chemistry and Co-Chair of University of York Staff Race Equality Forum.

Avtar specialises in gaining high additional chemical value from otherwise low-value resources or waste such as unavoidable food supply chain wastes, developing sustainable supply chains and circular economy within the context of biorefineries.

Approximately 15% of food produced globally is lost between harvest (farm) and retail (fork) comprising both avoidable and unavoidable food supply chain wastes (UFSCW).

Many practices, procedures and policies are in place to reduce avoidable losses, and where possible, maintaining nutritional value for human health. UFSCW arise due to primary and secondary processing of food and generates approximately 50–55% losses that may be utilised as animal feed, as compostable matter or for energy production (waste to energy).

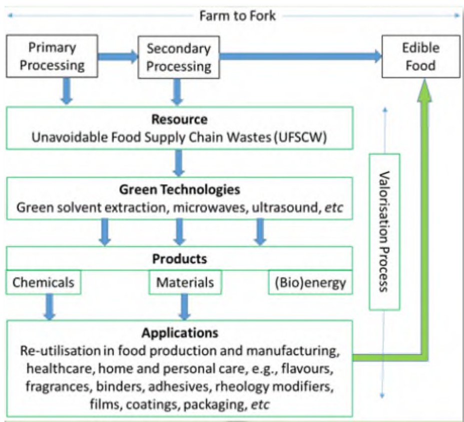
However, UFSCW are a rich source of exploitable biomolecules and biopolymers that present an alternative value proposition beyond just waste to energy

## PINZ Interests

Avtar explores a variety of chemical conversions and processes using biobased heterogeneous catalysts, microwaves and supercritical fluids delivering chemicals and materials of interest in healthcare, food security, and home and personal care sectors.

The use of emergent, enabling green and sustainable technologies (benign solid-liquid solvent extraction, pressurized fluid extraction supercritical fluid extraction, ultrasound-assisted extraction, microwave-assisted extraction, pulsed electric field extraction, and enzyme-assisted extraction) allow for valuable chemical compounds to be extracted efficiently from unavoidable food waste biomass.

UFSCW may be considered as Nature's Periodic Table of biobased feedstocks, delivering a range of diverse applications based on their inherent structure and functionality for a sustainable 21st Century.




## Publications


- Frecha, E., Torres, D., Remon, J., Gammons, R., Matharu, A. S., Suelves, I. & Pinilla, J. L. Catalytic hydrolysis of cellulose to glucose: On the influence of graphene oxide morphology under microwave radiation. J. Env. Chem. Eng., 2023, //,109290.
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- Sharma, A., Mehta, S. K. & Matharu, A. S. Highly Efficient Mesoporous Carbonaceous CeO2 Catalyst for Dephosphorylation. ACS Omega, 2022, 22551–22558.

# Professor Peter O'Brien

## University of York

peter.obrien@york.ac.uk

01904 322535

https://www.york.ac.uk/chemistry/people/pobrien/


## Research Overview

Research in the O'Brien group is focused on the development of new approaches for the sustainable synthesis of organic molecules, especially for applications in the pharmaceutical industry.

Our group has a particular interest in the synthesis of 3D molecules, especially saturated nitrogen-containing heterocycles, and in how to embed 3D molecules more easily into the drug discovery process. We approach this in different ways: synthesis of 3D fragments; elaboration of 2D fragments into 3D lead-like compounds in fragment-based drug discovery; development of methods for sp3–sp2 Suzuki-Miyaura cross-coupling of stereodefined heterocyclic organoboron compounds.

We have also developed organolithium gel technology, which has much potential for safer synthesis, and explored medicinal chemistry-related reactions in greener solvents and in less energy-intensive set-ups.

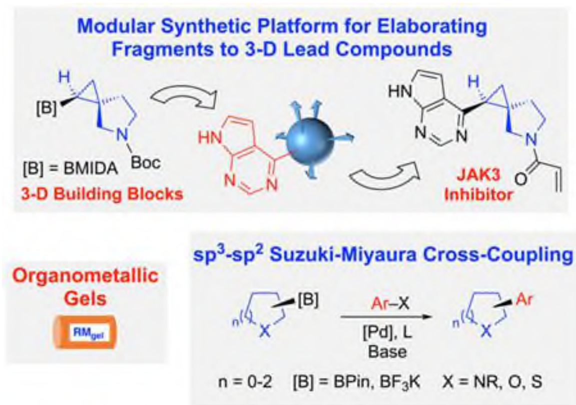
## PINZ Interests

Projects in the O'Brien group aim to develop sustainable, novel, selective and synthetically useful methods that are technically simple, high yielding and robust. There are three research themes within the group:

i. development of organometallic gels comprising different organometallic reagents and a gelator for the safer delivery of highly reactive species in synthesis;

ii. (development of a novel synthetic platform (using cyclopropyl and cyclobutyl nitrogen-containing heterocyclic scaffolds) for the elaboration of fragments in 3D and application to the discovery of lead compounds via fragment-based drug discovery;

iii. exploration of novel sp3–sp2 Suzuki-Miyaura cross-coupling reactions of stereodefined heterocyclic organoboron compounds for use in medicinal chemistry –mechanistic studies (aiming to reduce precious metal catalyst loadings) and synthetic applications for medicinal chemistry.

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# Dr Chris O'Malley

**Newcastle University**

chris.o'malley@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/chrisomalley.html


## Research Overview

Chris O'Malley is Senior Lecturer in the School of Engineering at Newcastle University and Associate Dean for Education for the SAgE faculty.

His research interests are in particular:

- Data Analysis
- Process Modelling
- Optimisation
- Brewing

He has expertise in the following areas:

- Process Control & Instrumentation
- Process Optimisation
- MATLAB

Recent projects include:

- PINZ CDT PhD with BOC
- KTP Northumbrian Water Group Ltd
- EPSRC Industrial CASE with Intertek
- EPSRC Industrial CASE with Northumbrian Water Group Ltd
- EPSRC Industrial CASE with GlaxoSmithKline
- Stu Brew Europe's first Student Run Microbrewery

## PINZ Interests

Reaching Net Zero will not just require development of new process and technologies. We will also need to operate our existing plants and processes more effectively. Process optimisation and control has a key role to play in achieving these target during the energy transition.

## Publications


- Optimisation of energy usage and carbon emissions monitoring using MILP for an advanced anaerobic digester plant, H Laing, C O'Malley, A Browne, T Rutherford, T Baines, A Moore, K Black, Energy 256, 124577 5 2022
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- Development of a biogas distribution model for a wastewater treatment plant: a mixed integer linear programming approach, H Laing, C O'Malley, A Browne, T Rutherford, T Baines, MJ Willis, Water Science and Technology 82 (12), 2761–2775 2020
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- Segmentation of epidermal tissue with histopathological damage in images of haematoxylin and eosin stained human skin, JM Haggerty, XN Wang, A Dickinson, CJ O'Malley, EB Martin. BMC medical imaging 14 (1), 7, 2014.

Professor Alison Parkin

### University of York

Alison.parkin@york.ac.uk

01904 322561

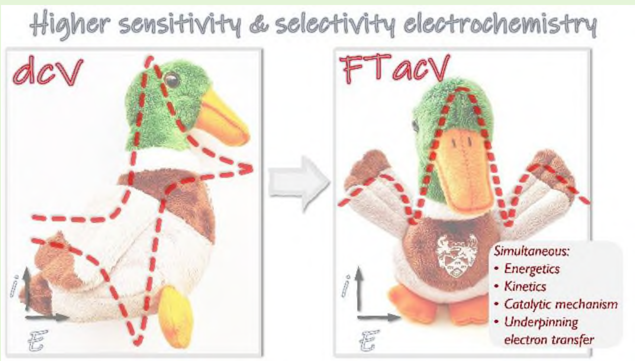
https://pure.york.ac.uk/portal/en/persons/alison-parkin

## Research Overview

Alison Parkin was awarded the 2019 Sir Edward Frankland Fellowship Award by the RSC and the 2019 Roger Parsons Medal 2019 by the Electrochemistry Group. She is Professor in the Chemical Biology research group in the Department of Chemistry.

The Parkin group develops new electroanalytical methods to probe the mechanism of redox reactions, particularly in fuel producing metalloenzymes. Fourier transform voltammetry methods enable enhanced sensitivity and selectivity in electrochemical measurements. We can simultaneously quantify electrocatalytic quantity, homogeneity, mechanisms of electrocatalysis and the underpinning electron transfer in all redox active catalysts.

We have also developed a synthetic toolkit for "wiring" molecules to electrodes in a light-activated manner, and we develop new carbon materials as both electrode materials and for sustainable bioremediation applications.

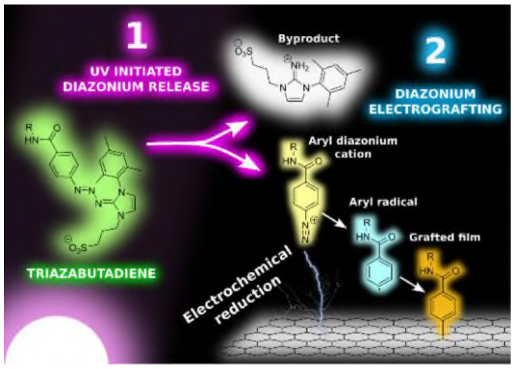



## PINZ Interests

Our electrochemical methodologies enable high sensitivity, selectivity and rapid detection of electron transfer reactions against large background signals and in complex media. We are applying this across numerous detection and sensing applications that are of importance in the Data stream of PINZ. We are interested in feedstock validation, quality control and product verification.

The metalloenzymes which we characterize are important in living energy cycles, and our methods enable us to relate DNA sequence to chemical functionality. We have longstanding expertise in studying hydrogenases, the enzymes which produce and use hydrogen as an energy source in Nature.

Our understanding of carbon production and functionalization enables the conversion of bioderived, sustainable feedstocks into useful solid state electrode-support or metal-uptake materials.




## Publications

- Polysaccharide-derived sulfur-containing mesoporous carbon materials for platinum group metal recovery. Garland, N., Gordon, R., Hopkins, I., Ward, E., McElroy, R.C., Macquarrie, D. & Parkin., Carbon, 2025, in press.
- Using Triazabutadienes as a Protected Source of Diazonium Cations to Facilitate Electrografting to a Variety of Conductive Surfaces. Yates, N. D. J., Hudson, L., Schwade, O. & Parking, A., Langmuir 2025, 41, 11, 7386–7395
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# Professor Anh Phan

**Newcastle University**

anh.phan@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/anhphan.html


## Research Overview

Anh Phan is a Professor, Chair of Circular Chemical Engineering in the School of Engineering at Newcastle University.

Her research interests include transforming waste, residues and unwanted by-products into chemicals, fuels, and valuable materials by applying process intensification concepts (integrated system, continuous flow reactor designs) and emerging technologies (e.g. cold plasma technologies).

Research in her group has a strong focus not only on environmental challenges driven solutions but also on circularity and sustainability. This involves chemical and material recycling from plastic waste, hydrogen production, resource recovery, energy storage, biomaterials and chemicals from 2nd, 3rd and 4th generation feedstock.

Her group has developed innovative technologies for chemical recycling from plastic waste, hydrogen production from waste and fractionation of lignocellulosic residues.

## PINZ Interests

Anh's PINZ related research interests are:

- Biofuels, alternative fuels processing
- Sustainable and renewable materials
- Resource recovery, chemical recycling from waste and residues
- Development of emerging technologies and process intensification for resource and energy efficiencies

## Publications


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# Dr Fernando Russo Abegão


## Newcastle University

fernando.russo-abegao@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/fernandorusso-abegao.html


## Research Overview

Fernando Russo Abegão is Senior Lecturer in the School of Engineering at Newcastle University and a member of the Process Intensification Group. His research focus on sustainable heterogeneous catalysis and reaction engineering, with interests in gaining a fundamental understanding of the synthesis processes for catalytic materials, how to obtain optimal catalyst-process integration, and how to create greener processes for biomass and carbon dioxide conversion.

He has a background in industrial catalysis and worked at Johnson Matthey as a Senior Research Scientist and Process Development Engineer. He investigated catalyst manufacturing processes and developed a new generation of manufacturing methods. He also designed catalysts for chemical, petrochemical and biorenewable applications.

During his PhD at the University of Cambridge, Fernando developed Magnetic Resonance techniques for non-invasive operando measurements of chemical composition and temperature in catalytic reactors. He investigated interactions between hydrodynamics, heat and mass transport, and chemical reactions at industrially relevant operating conditions, including hot-stops formation. For the first time, liquid-solid mass transfer coefficients were measured by direct quantification of the intra- and inter-particle liquid composition.

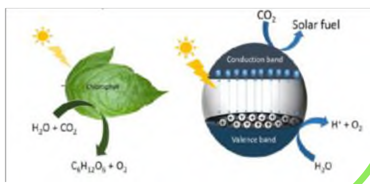
## PINZ Interests

Fernando's past and ongoing research projects have a strong sustainable catalysis and reaction engineering dimensions, with case studies and applications researched around:

1. Catalytic upgrade of biomass into biorenewable chemicals and fuels;
2. Carbon dioxide conversion into materials and fuels;
3. Intensified synthesis of heterogeneous catalysts;
4. Integrated design of catalyst and reactors in intensified processes;
5. Photocatalysis.

His research aligns with the three PINZ themes on new energy vectors (photocatalysis/light-driven reactions), circular feedstocks (valorisation of lignocellulosic and biodiesel industries by-products) and data (high-throughput catalyst development assisted by machine learning techniques).

In particular, projects have investigated: catalytic and intensified conversion purification of lignocellulosic biomass hydrolysates and hemicellulose sugars to furan-based monomers and resins; development of catalysts and intensification strategies for glycerol-base chemistries; designing of innovative and scalable photocatalysts and 3D printed photoreactors with enhanced light harvesting configurations for $CO_2$ photocatalytic conversion; intensification of reactive precipitation methods for biomass purification and for catalyst synthesis applications.


## Publications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- Carr T, Russo Abegão F, Boodhoo K. Intensification of Evaporative Precipitation of Lignin in a Spinning Disc Evaporator. Chemical Engineering and Processing - Process Intensification 2024, 199, 109734.
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# Dr Seishi Shimizu

## University of York

seishi.shimizu@york.ac.uk

01904 328281

https://www.york.ac.uk/chemistry/people/sshimizu/

## Research Overview

The difficulties surrounding solvation and sorption come from the fact that it is driven not only by specific and stoichiometric but also weak, non-specific, fluctuating interactions. Consequently, the language of solvation is statistical thermodynamics.

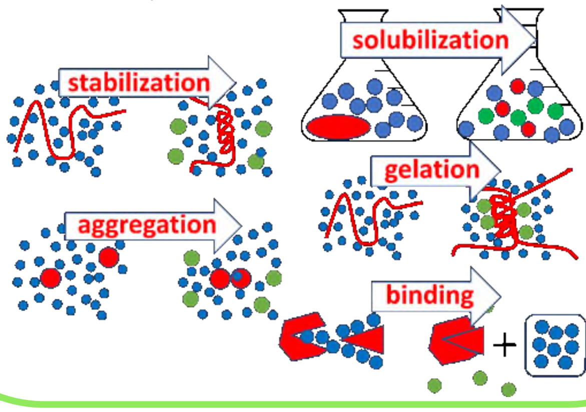
Our expertise is to link solubility, sorption isotherms, and physical properties measurements with the underlying molecular interactions with the minimum involvements or models and assumptions, directly from the principles of statistical thermodynamics. Our goals are:

- to gain a molecular-scale understanding directly from the routinely performed experiments (such as solubility, sorption isotherm, and physical properties' data);
- to attain interpretive clarity via a direct connection to the first principles with a bare minimum number of assumptions; and
- to make our theory usable for industry and experiments via user-friendly, web-based apps (written by my industrial collaborator).

## PINZ Interests

**Feedstock**: For the separation and purification of under-valorized molecules, solvents must be carefully chosen and optimized, replacing environmentally harmful ones with green alternatives. However, this task, without a fundamental understanding of solvation, leads to trials and errors that are wasteful in energy and resources. Currently, our theoretical framework is the only one that can describe not only the strong, specific interactions but also weak, fluctuating, and non-specific interactions that account for much of solvation and sorption.

**Data**: We apply our statistical thermodynamic theory, developed analytically (pen and paper) to experimental data analysis, identifying the relevant data from thermodynamic principles and guiding analytical, thermodynamic, and spectroscopic measurements, providing unambiguous interpretation on the molecular scale. Through a combination of theory and experiments, we aim to establish a rational approach to data in green solution chemistry for industrial applications.

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- Gas and liquid Isotherm: The need for a common foundation. S. Shimizu, N. Matubayasi, Langmuir 2025, 41, 2103 – 2110.
- Multiplicativity in solubility isotherms. S. Shimizu, N. Matubayasi, Ind. Eng. Chem. Res. 2025, 64, 833 – 842.
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# Dr John Slattery

**University of York**

john.slattery@york.ac.uk

01904 322610

https://www.york.ac.uk/chemistry/people/drjohnslattery/


## Research Overview

We are a highly collaborative group with interests in the development of alternative solvents and novel catalytic systems for the sustainable synthesis of small molecules. We use a range of techniques to gain fundamental understanding of liquid structure, both in the bulk and at the gas-liquid interface, small molecule activation by transition metal and main- group-element complexes, and catalytic reaction mechanisms.

These insights allow the targeted development of the next generation of catalysts that are more reactive, selective, robust and ultimately more sustainable. Fluorine chemistry has played a major role in our work, which has involved both novel fluorination and defluorination reactions and the use of fluorinated ions and ligands to modify liquid structure and properties or catalyst solvation/reactivity.

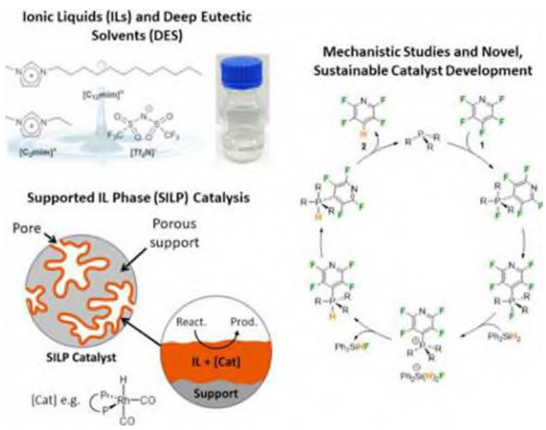
We have expertise in both experimental and computational studies, including a strong track record of securing access to large national facilities for neutron and X-ray based experiments (e.g. SAXS, SANS, reflectivity).

## PINZ Interests

**Energy**: Exploring the role of alternative solvents, such as ionic liquids (ILs) and deep eutectic solvents (DES), to support more sustainable and energy efficient processes chemistry. A particular interest is supported IL phase (SILP) catalysis, where homogeneous organometallic catalysts are heterogenised in IL films on porous solid supports to facilitate their industrial deployment in gas phase and liquid flow systems e.g. in hydrogenation reactions.

**Feedstocks**: Efficient synthesis of fluorinated molecules from a range of feedstocks, including bio-based molecules, through novel C-F bond forming reactions, or via C-F activation and functionalisation.

**Data**: Using neutron and X-ray experiments to aid catalyst development and process chemistry deployment in a data-driven way, including characterisation of materials under catalytically relevant conditions (high T and P, reactive gasses, in operando monitoring).

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- N. S. Elstone, K. Shimizu, E. V. Shaw, P. D. Lane, L. D'Andrea, B. Deme, N. Mahmoudi, S. E. Rogers, S. Youngs, M. L. Costen, K. G. McKendrick, J. N. Canongia Lopes, D. W. Bruce and J. M. Slattery, Understanding the Liquid Structure in Mixtures of Ionic Liquids with Semiperfluoroalkyl or Alkyl Chains, J. Phys. Chem. B„ 2023, 127, 7594–7407.
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# Professor Helen Sneddon

University of York

helen.sneddon@york.ac.uk

01904 322840

https://www.york. ac.uk/chemistry/people/hsneddon

## Research Overview

Helen Sneddon is Professor of Sustainable Chemistry and Director of the Green Chemistry Centre of Excellence (GCCE) - a leading international academic facility for the provision of excellence in green and sustainable chemical technologies, processes and products.

The GCCE also has strong links to the Biorenewables Development Centre, a University of York subsidiary, co-founded by the GCCE and the Centre for Novel Agricultural Products (CNAP) in the Department of Biology, looking at the development, scale up and commercialisation of biobased processes.

Much of the group's work is focussed on current sustainability challenges facing companies.

The group's research interests span the four focus areas of the GCCE: Renewable Feedstocks, Green Synthesis, Sustainable Technologies and Design for Reuse/Degradation/Recovery.

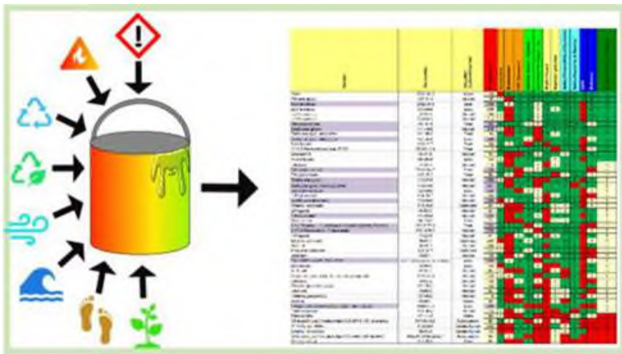
## PINZ Interests

**Renewable Feedstocks**: We are interested in the valorisation of sustainably sourced biobased feedstocks into chemicals (e.g. monomers for polymer formation, solvents).

**Green Synthesis**: We have a history of providing guides to solvent and reagent choice, and exploring ways of quantifying the sustainability credentials of processes. We are also interested in developing more sustainable approaches for key transformations.

**Sustainable Technologies**: We are interested in general in how automation can be used to optimise the sustainability credentials of processes explored using it, and the sustainability of the research itself. We are continuing to look at optimisation of conditions (solvents, coupling agents, protecting group choice) for automated solid phase peptide synthesis.

**Design for degradation**: We have projects looking at both the biodegradation of bioderived polymers for liquid formulations (such as are found in household cleaning, personal care, paints and coatings etc.), and pharmaceuticals.



## Publications


- Unifying sorption isotherms in reversed-phase liquid chromatography, W. Heamen, N. Matubayasi, H. F. Sneddon, S. Shimizu, Journal of Chromatography A., 2025, 1751, 465891
- Development of a solvent sustainability guide for the paints and coatings industry L. Pilon, D. Day, H. Maslen, O.P.J. Stevens, N. Carslaw, D.R.Shaw, H.F. Sneddon. Green Chem, 2024, 26, 9697–9711.
- Experimental and computational insights into the mechanism of the copper(i)-catalysed sulfonylative Suzuki-Miyaura reaction C. G. J. Hall, H. F. Sneddon, P. Pogdny, D. M. Lindsay, W. J. Kerr, Chem. Sci., 2023, 14, 6758–6755.
- Replacement of Less-Preferred Dipolar Aprotic and Ethereal Solvents in Synthetic Organic Chemistry with More Sustainable Alternatives A. Jordan, C. G. Hall, L. R. Thorp, H. F. Sneddon, Chem. Rev. 2022, 122, 6, 6749–6794.
- Chlorinated Solvent: Their Advantages, Disadvantages, and Alternatives in Organic and Medicinal Chemistry A. Jordan, P. Stoy, H. F. Sneddon, Chem Rev. 2021, 121, 5,1582–1622.
- Updating and Further Expanding GSK's Solvent Sustainability Guide C. M. Alder, J. D. Hayler, R. K. Henderson, A. M. Redman, L. Shukla, L. E. Shuster, H. F. Sneddon Green Chem., 2016, 18, 5879–5890.

# Dr Sharon Velasquez-Orta


## Newcastle University

sharon.velasquez-orta@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/sharonvelasquez-orta.html

Personal website: https://ebnet.ac.uk/wg-details/wg-bes/


## Research Overview

Sharon Velasquez-Orta is Senior Lecturer in Sustainable Chemical Engineering, Deputy Director for Business Innovation and Enterprise at Newcastle University.

Before pursuing her academic career, Sharon acquired experience working as a sustainability and environmental engineer for Forzaeco (water engineering company), Jumex (food manufacturer) and IGEMI (a Global environmental management initiative for companies such as Nestle, J&J, P&G and Kimberly Clark). Her industry learned approach addresses current world challenges related to sustainability, biomass valorisation and effective waste management. She aims to provide energy efficient and carbon dioxide mitigating waste conversion technologies to industry driven by the UN's Sustainable Development Goals

Sharon's researches new biologically driven Net Zero technologies that can achieve energy and product generation from wastewater, and solid waste remediation.

She has produced renewable energy and materials from liquid, gaseous and solid waste streams through biological and bioelectrochemical methods.

She studies chemical, electrochemical and thermal pre-treatment routes, to transform wastewater, organic solid wastes, sludge and microalgae into biofuels, focusing on enhancing yields, reducing transportation needs, and bypassing intermediate steps (e.g. oil extraction). Biofuels produced from biomass waste in our laboratory, include bioethanol, biodiesel, biomethane, biohydrogen and jet fuel.


## PINZ Interests

**Bioelectrochemistry –** I'm interested in microbial cells that simultaneously treat wastewater and generate electricity or hydrogen. I also explore microbial electrosynthesis, which offers a low-energy pathway to transform $CO_2$ into longer-chain organic molecules. Our group has demonstrated the economic and environmental feasibility of bioelectrochemical reactors into fermentation tanks to convert $CO_2$ into chemical products such as acetate. We have assessed the impact of the type of waste, redox mediator compounds, and organic load on bioelectricity production, organic matter removal, and microbial diversity.

**Algal Technology** - I have developed pilot-scale treatment systems that utilise microalgae-bacteria or microalgae-yeast consortia for the remediation of water, wastewater, sludge or leachate within non-centralised, nature-embedded contexts. The microalgae biomass harvested has been showcased to deliver a wide range of products, including bioplastics, fibres, nutrients, or biofuels.

**Sustainability assessment** – My studies include developing frameworks to ensure positive environmental, social and economic impacts. As a result, I have developed expertise in applying a chemical engineering approach to life cycle analysis (LCA), carbon footprint and SusOp to evaluate energy use, carbon emissions, and environmental impacts.

## Publications


- Biohydrogen production through dark fermentation of agricultural waste: Novel strain and feedstock characterisation, A Vidal, O Mohiuddin, E Chance, S Serrano-Blanco, T P Howard, J Muñoz-Muñoz, SB Velasquez-Orta, L Rios-Solis, 2025. Bioresource Technology, 434, 132839.
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- Energy from algae using microbial fuel cells, SB Velasquez-Orta, TP Curtis, BE Logan, Biotechnology and bioengineering 103 (6), 1068–1076, 2009.
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# Professor Andrew Weller


## University of York

andrew.weller@york.ac.uk

01904 326571

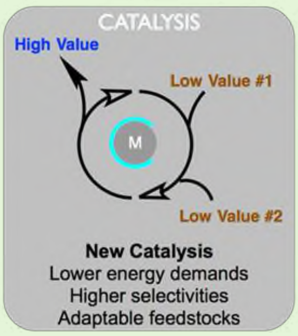
https://pure.york.ac.uk/portal/en/persons/andrew-stjohn-weller


## Research Overview

The Weller group has a long-standing, 25-year, interest and expertise in the organometallic chemistry of platinum-group (PGMs) and associated metals, especially the synthesis of novel complexes and their use in catalysis. Our expertise focusses on how holistic studies of pre-catalyst synthesis, speciation, kinetics and mechanism leads to more efficient catalysis, through a detailed understanding of the underlying synthetic, catalytic and deactivation processes operating.

Exploitation of these ideas and methods leads to, often novel, organometallic complexes that are highly efficient, selective, catalysis which work at low-loadings with feed-stock tolerance for a wide variety of important processes in both solution and molecular single-crystalline phases; the latter area being one pioneered by the Weller group. A particular area of expertise is the generation of complexes that are "operationally unsaturated" and show sigma-interactions with, and undergo bond activations of, e.g. C-H or B-H bonds. A unifying concept is the removal of any unfavourable competing pre-equilibria prior to key bond activation steps in catalytic processes. We deploy a wide variety of techniques, such as rigorously air-sensitive synthesis; solid-state and solution NMR spectroscopy; X-ray, electron and neutron diffraction; batch- and flow-catalysis.

We have long standing collaborations with world-leading experts in computation (Macgregor, StAndrews), mechanism (Lloyd-Jones, Edinburgh), NMR (Duckett, York), diffraction (National Crystallography Service / Diamond Light Source) and materials science (Grobert, Oxford).


## PINZ Interests

A particular strength in the group is the combination of challenging synthesis with rigorous kinetic and mechanistic studies that leads to mechanism-inspired developments of atom efficient and selective catalysis at very low catalyst loadings. The ability of PGM catalysts to work at very low loadings (often ppm level), with functional group and feed-stock tolerance (and often with beautiful NMR signatures) is well-known. When combined with high levels of recyclability and their outstanding opportunities for sustainable use (over 60% of PGMs are now recycled in open and closed-loop processes, that also reduce their carbon footprint by 97% compared to newly-minted metal1) molecular PGM research is an exciting area to work in. To this end, the group also takes pride in the training of the next-generation of scientists in the synthetic methods to make new PGM complexes and their use in catalysis.

Our research topics are discovery-based that can be translated into real-world applications. We continuously tension the excitement of the synthesis of new organometallic complexes and understanding their catalytic activity with the fundamental drivers that make such systems practically useful and very efficient. Catalytic applications range from hydrocarbon valorisation (e.g. bioethene or biomethane to platform chemicals), large-scale industrially-relevant processes (hydrosilylation, ethene to propene), through fine chemicals synthesis (C-H activation in complex organic molecules), to materials applications (main group polymer pre-ceramics to hex-BN and PB that are next generation advanced materials).

[1] Reclaiming the future: PGM insights for a circular economy. Johnson Matthey White Paper, 2025.

## Publications


- H. G. Lancaster, J. C. Goodall, S. P. Douglas, L. J. Ashfield, S. B. Duckett,* R. N. Perutz,* A. S. Weller* Platinum(II) Phenylpyridyl Schiff Base Complexes as Latent, Photoactivated, Alkene Hydrosilylation Catalysts ACS Catal. 2024,14, 7492
- M. R. Gyton, C. G. Royle S. K. Beaumont, S. B. Duckett,* A. S. Weller* Mechanistic Insight into Molecular Crystalline Organometallic Heterogeneous Catalysis Through Parahydrogen Based Nuclear Magnetic Resonance Studies J. Am. Chern. Soc. 2023, 145, 2629
- J. J. Race, A. Heyam, M. A. Wiebe, J. D.-G. Hernandez, C. E. Ellis, S. Lei, I. Manners,* A. S. Weller* Polyphosphinoborane Block Copolymer Synthesis using Catalytic Reversible Chain Transfer Dehydropolymerization. Angew. Chem. Int. Ed. 2023, e202216106
- C. N. Brodie, T. M. Boyd, L. Sotorn'os, D. E. Ryan, E. Magee, S. Huband, J. S. Town, G. C. Lloyd-Jones, D. M. Haddleton, S. A. Macgregor, A. S. Weller Controlled Synthesis of Well-Defined Polyaminoboranes on Scale Using a Robust and Efficient Catalyst. J. Am. Chem. Soc. 2021, 145, 21010
- A. J. Bukvic, A. L. Burnage, G. J. Tizzard, A. J. Martinez-Marti'nez, A. I. McKay, N. H. Rees, ... S. J. Coles, S. A. Macgregor* and A. S. Weller* A Series of Crystallographically Characterized Linear and Branched O-Alkane Complexes of Rhodium: From Propane to 5-Methylpentane. J. Am. Chem. Soc. 2021, 145, 5106

# Dr Charlotte Willans

## University of York

charlotte.willans@york.ac.uk

01904 324982

https://www.york.ac.uk/chemistry/people/charlotte-willans/


## Research Overview

Charlotte Willans, a Reader in synthetic inorganic chemistry at the University of York, leads a group dedicated to developing industrially relevant catalytic processes with a strong focus on achieving net zero. They employ data-driven and mechanistic approaches to inform their development.

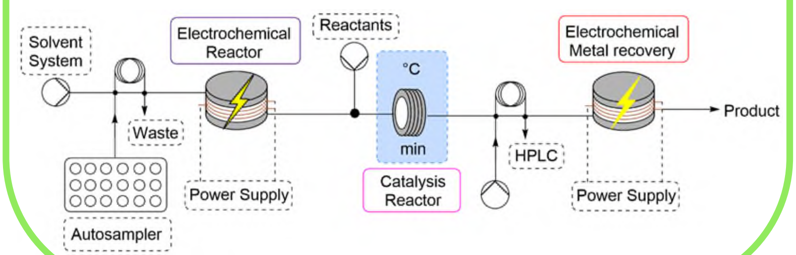
A key innovation is their electrochemical method for synthesising metal complexes under mild conditions and with exceptional atom efficiency. This process generates hydrogen as the sole byproduct, eliminating the need for traditional solvent intensive work-up and purification. This allows for on-demand catalyst preparation and direct integration into reactions, significantly reducing waste and energy consumption. The group has successfully transitioned this electrochemical batch methodology to flow technology, incorporating it into an automated flow platform for high-throughput catalyst generation and screening. Further enhancing their commitment to a circular economy and net zero, electrochemical recovery of metal catalysts for downstream processing creates a closed-loop system, minimising resource depletion and waste.

## PINZ Interests

**Sustainable Technologies**: Our work in sustainable technologies focuses on developing automated platforms for screening catalytic reactions, aiming to deliver optimised and scalable solutions for the chemicals industry. By combining electrochemical synthesis with flow chemistry in a modular setup, our technology offers broad applicability. A crucial element of our approach is closing the loop on our automated flow platform through electrochemical metal recovery. This not only lowers the toxic risks associated with metal use but also enables their reuse, directly driving a circular economy.

**Renewable Feedstocks**: Beyond sustainable technologies, renewable feedstocks are essential for achieving net zero. Our flow reactor systems are designed to efficiently examine and optimise catalytic transformations of bio-based feedstocks.

**Data**: Underpinning all of this is our robust data strategy. Our technology generates and processes large datasets to both optimise processes, including for key sustainability metrics, and provide the mechanistic understanding needed for an informed approach to development.




## Publications


- Electrochemical removal of toxic metals from reaction media following catalysis. Husbands, DR., Booth, EM., Donaldson, NWB., Kapur, N., Willans, RM., Willans, CE. Chem. Commun. 2024, 60, 8876.
- Development of a multistep, electrochemical flow platform for automated catalyst screening. Schotten, C., Manson, J., Chamberlain, TW., Bourne, RA., Nguyen, BN., Kapur, N. & Willans, CE. Catal. Sci. Technol. 2022, 12, 4266.
- Steps, hops and turns: examining the effects of channel shapes on mass transfer in continuous electrochemical reactors. Stephen, HR., Boyall, S., Schotten, C., Bourne, RA., Kapur, N. & Willans, CE. React. Chem. Eng. 2022, 7, 264.
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- A Versatile Electrochemical Batch Reactor for Synthetic Organic and Inorganic Transformations and Analytical Electrochemistry. Stephen, HR., Schotten, C., Nicholls, TP., Woodward, M., Bourne, RA., Kapur, N. & Willans, CE. Org. Process Res. Dev. 2020, 24, 1084

# Dr Jie Zhang

**Newcastle University**

jie.zhang@newcastle.ac.uk

https://www.ncl.ac.uk/engineering/staff/profile/jiezhang.html

## Research Overview

Jie Zhang is Reader in Process Systems Engineering in the School of Engineering of Newcastle University.

His research interests are in particular:

- Advanced Process Control (model predictive control, inferential control, active disturbance rejection control)
- Machine learning for data-driven process modelling (Neural networks, Neuro-fuzzy systems, ensemble networks, hybrid modelling)
- Process Monitoring (MSPC), Fault Detection and Diagnosis
- Process Optimisation through Surrogate Modelling
- Batch Process Control and Batch-to-Batch Iterative Learning Control
- Machine Learning based Soft Sensors
- Reliable Optimisation Control based on Ensemble Neural Networks

Recent research projects include:

- Research and Development in Coal-fired Supercritical Power Plant with Post-combustion Carbon Capture using Process Systems Engineering techniques
- intelligent Reactive polymer composites Moulding (iREMO)
- ECOCARB: Reduction of emissions and energy utilisation of coke oven underfiring heating systems through advanced diagnostic and control
- Knowledge Transfer Partnership, with Sellafield Ltd and National Nuclear Laboratories
- Syngenta Limited, studentship - Integration of Spectroscopic and Process Data for Enhanced Process Performance Monitoring
- Data driven decision making process for the recovery and recycling of lithium-ion batteries (Faraday Institution)
- Sustainable Sludge Valorisation Technology for Closed-Loop Resource Recovery

## PINZ Interests

Energy consumption and emission reduction through process monitoring. We have been working on process monitoring through multivariate statistical process control and machine learning techniques for over 30 years and developed many techniques. Applications to a wide range of industries such as chemical, pharmaceutical, steel making, and nuclear waste processing show that these techniques can quickly detect abnormal operating conditions and eliminate their detrimental impacts on the products and environment.

Reliable data-driven process optimisation. We have developed reliable data-driven process modelling techniques through ensemble neural networks and hybrid modelling. The reliability of the optimisation results is enhanced through incorporation of model prediction confidence intervals.

Advanced process control. We have developed different data-driven soft sensors and incorporation of such soft sensors into inferential feedback or inferential feedforward control. We also developed model based iterative learning control which is very effective for batch-to-batch control.

## Publications


- Recurrent neuro-fuzzy networks for nonlinear process modelling, J Zhang, AJ Morris, IEEE Transactions on Neural Networks 10 (2), 313–326, 1999.
- A batch-to-batch iterative optimal control strategy based on recurrent neural network models, Z Xiong, J Zhang, Journal of Process Control 15 (1), 11–21, 2005.
- Performance monitoring of processes with multiple operating modes through multiple PLS models, SJ Zhao, J Zhang, YM Xu, Journal of process Control 16 (7), 763–772, 2006.
- Operation optimization of Shell coal gasification process based on convolutional neural network models, K Wang, J Zhang, C Shang, D Huang, Applied Energy 292, article 116847, 2021.
- Prediction of water quality index (WQI) using support vector machine (SVM) and least square-support vector machine (LS-SVM), WC Leong, A Bahadori, J Zhang, Z Ahmad, International Journal of River Basin Management 19 (2), 149–156, 2021.
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# Dr Vladimir Zivkovic


## Newcastle University

vladimir.zivkovic@newcastle.ac.uk

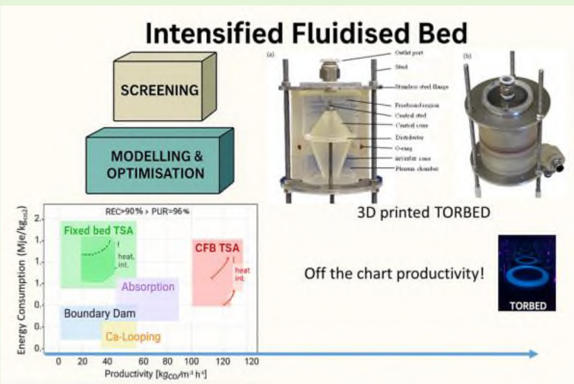
https://www.ncl.ac.uk/engineering/staff/profile/vladimirzivkovic.html


## Research Overview

Vladimir Zivkovic is an internationally recognized researcher in particle technology and multiphase flow, with a strong specialization in the process intensification of solids processing. His world-leading work in micro-fluidized beds and his extensive expertise with Torbed reactor technology, in collaboration with industry partners such as Torftech (UK), underpin his pioneering contributions to intensified fluidized bed systems. His research is characterized by a combination of experimental innovation and practical application, delivering efficient, scalable technologies for carbon capture, solid process screening, and bioreactor systems.

A central focus of his research is micro-fluidization and the development of compact, intensified platforms for carbon capture, including direct air capture. He has made significant contributions to the advancement of toroidal fluidized bed, ie. Torbed reactor technology, demonstrating its potential for sustainable $CO_2$ capture. His research has involved close collaboration with international academic and industrial partners, reflecting a sustained commitment to clean, efficient, and scalable solids processing.

Beyond carbon capture, Vladimir's broader research interests extend to novel strategies for intensifying solids processing across chemical and biochemical engineering, including compact process screening systems, sustainable bioprocessing technologies, and the integration of intensified reactors into industrial applications. His insights directly inform his teaching, particularly in the Process Intensification course, where he delivers specialized material on micro-reactors. Most recently, he co-authored a textbook on process intensification, contributing extensively to the chapters on micro-reactors and intensified fluidized beds.




## PINZ Interests

**Carbon Capture with Intensified Fluidized Beds**: My research centres on developing compact, intensified fluidized bed systems such as Torbed and micro-fluidized beds, with possible extensions to microwave-assisted, acoustic, and other field-enhanced designs, for sustainable carbon capture. We have demonstrated their potential as efficient, scalable platforms for both point-source and direct air capture. These intensified systems improve process efficiency while reducing footprint, supporting industrial decarbonisation and enabling more flexible deployment. Their ability to integrate with renewable energy and novel sorbent materials further positions them as promising technologies for large-scale climate solutions.

**Process Intensification of Solids Processing**: More broadly, I am interested in strategies for intensifying solids processing across chemical and biochemical engineering. This includes compact screening systems for rapid process evaluation, sustainable bioprocessing technologies, and the integration of intensified reactors into industrial practice. These approaches aim to reduce energy demand, minimise waste, and improve scalability while addressing the need for sustainable and resilient process technologies. By combining experimental insights with process design, I seek to advance both fundamental understanding and applied engineering.

**Big Data and AI for Solids Processing**: I am also advancing the integration of computational fluid dynamics, machine learning surrogates, and process-scale modelling (Aspen Plus/HYSYS) to optimise intensified solids processing. This data-driven framework accelerates reactor design and operation, enabling real-time optimisation while retaining physical accuracy. By linking detailed hydrodynamics with plant-scale modelling, the methodology provides a versatile toolset for rapid innovation. It is broadly applicable to carbon capture, materials processing, and bioreactor systems, supporting the transition to smarter, more adaptive, and sustainable technologies.

## Publications


- A review of process intensification applied to solids handling, H Wang, A Mustaffar, AN Phan, V Zivkovic, D Reay, R Law, K Boodhoo, Chemical Engineering and Processing: Process Intensification 118, 78–107, 2017.
- Process intensification in micro-fluidized bed systems: a review, Y Zhang, K-L Goh, YL. Ng, Y Chow, S Wang, V Zivkovic, Chemical Engineering and Processing-Process Intensification, 164, 108397, 2021.
- Rapid and intensified screening of a carbon capture adsorbent using a 3D-printed swirling fluidised bed, R Jamei, JR McDonough, DA Reay, V Zivkovic, Chemical Engineering Journal, 451(2), 138405, 2023.
- Miniaturisation of the toroidal fluidisation concept using 3D printing, JR McDonough, R Law, DA Reay, D Groszek, V Zivkovic, Chemical Engineering Research and Design, 160,129–140, 2020.
- Fluidization of fungal pellets in a 3D-printed micro-fluidized bed, Y Zhang, Y Ling Ng, K-L Goh, Y Chow, S Wang, V Zivkovic, Chemical Engineering Science, 236, 116466, 2021.

# Analytical Equipment:

## Newcastle University School of Engineering

| Technique | Equipment |
| --- | --- |
| **Gas Chromatography**<br>○ GC<br>○ GC-FID<br>○ GC-MS<br>○ Pyrolysis GC-MS | • Aglient 6890N GC-FID with Autosampler<br>• Agilent 5977 B MSD connected to Agilent 8890 GC<br>• Agilent 7890A/5975C GC-MS and Frontier Lab 3030S Pyrolyser<br>• Thermo Trace 1310/TSQ 8000 Evo GC-MS (Triple-Quad)<br>• Shimadzu GC-2014 GC-FID/ECD Gas Analyser<br>• Agilent 8890 GC-FID / Agilent 8890 GC-FID/ECD<br>• Agilent 7890B/5977B GC-MS<br>• Agilent 8890/5977B GC-MS + TCD<br>• Agilent 8890/5977C GC-MS with 8697 Headspace sampler |
| **Liquid Chromatography**<br>○ HPL<br>○ Ion Chromatography - IC<br>○ LC-MS<br>○ UPLC | • Aglient 1260<br>• Agilent MSD XT coupled to Agilent Infinity 1260 II with Autosampler<br>• Water Xevo TQ-S connected to Waters Acquity UPLC<br>• Waters Xevo G2–XS coupled with Waters Acquity i-Class UPLC<br>• Thermofinnigan LCQ Advantage connected to Thermofinnigan Surveyor HPLC |
| **Particle Size Analysis**<br>○ Laser Diffraction<br>○ Dynamic Light Scattering<br>○ Particle Measurement | • Malvern Mastersizer 3000<br>• Sympatec Qicpic<br>• Malvern Zetasizer Nano ZS |
| **Spectroscopy**<br>○ Fluorometer<br>○ FTIR<br>○ ICP<br>○ ICP-MS<br>○ ICP-OES<br>○ NMR<br>○ PXRD<br>○ Raman<br>○ SCXRD<br>○ TAS<br>○ XPS | • Horiba LabRam HR Evolution Raman<br>• Perkin Elmer Optima 8000 ICP with Autosampler<br>• Agilent 5800 ICP OES with Autosampler<br>• Agilent Cary 630 FTIR<br>• Bruker AVANCE III HD 700MHz<br>• Bruker AVANCE III HD 500MHz<br>• Bruker AVANCE II HD 400MHz<br>• Bruker AVANCE III HD 300MHz<br>• K Alpha<br>• Theta Probe coupled with Raman Spectrometer<br>• NEXUS AXIS Nova<br>• Ultrafast Systems Helios Eos<br>• Perkin Elmer Spectrum 2<br>• Thermo Nicolet<br>• Shimandzu RF-6000 |
| **Surface Area and Porosimetry**<br>○ Physisorption | • Micromeritics TriStar II Plus<br>• ThermoFisher Surfer |
| **Surface Characterisation**<br>○ HIM<br>○ SEM<br>○ AFM<br>○ SIMS | • Jeol JSM-5610LV<br>• Zeiss ORION NanoFab HIM<br>• Zeiss Capella FIB<br>• Ionoptika J105 Time of Flight Secondary Ion Mass Spectrometer (ToF-SIMS) |
| **Thermal Analysis**<br>○ DMA<br>○ DSC<br>○ STA<br>○ STA-QMS<br>○ TGA | • Netzsch STA 449 F5 Jupiter<br>• Netzsch Jupiter STA 449C interfaced to an Aeolos QMS 403 quadrupole mass spectrometer<br>• Waters TGA 550<br>• Waters DSC 250<br>• Waters DMA 850 |
| **Other**<br>○ 3D Printers; Autotitrator; Microwave digestor; TOC | • Thermoscientific Orion Star T900<br>• Elgoo Mars 4 and various other models both Resin and Filament printers |

# Equipment

## University of York Green Chemistry Centre of Excellence

| | |
|---|---|
| **Thermal Analysis** | • Stanton Redcroft STA 625<br>• TA Instruments MDSC<br>• Netzsch TGA-GC/MS |
| **Spectroscopy** | • Perkin-Elmer FT-IR Spectrum 2<br>• Perkin-Elmer FT-IR Spectrum 2<br>• Bruker Vertex 70<br>• Shimadzu UV-Vis |
| **Porosimetry** | • Micromeritics ASAP 2020<br>• Micromeritics TriStar |
| **Liquid Chromotography** | • Agilent 1220 HPLC<br>• Carson HPLC<br>• PSS Security GPC<br>• Agilent 1260 HPLC |
| **Gas Chromatography** | • Agilent 7890B GC<br>• Hewlett-Packard 6890 GC (HP 1)<br>• Hewlett-Packard 6890 GC (HP 2)<br>• Agilent 7820 GC with TCD<br>• Agilent 6890 - 5973 GC-MS |
| **Furnaces and Ovens** | • Pyrolysis Furnace<br>• Carbolite (Muffle) Furnace<br>• Variable Temperature Drying Oven<br>• Vacuum Oven<br>• Binder Oven – set at 105°C<br>• Gallenkamp Fenix Vacuum Oven<br>• Vacutherm Vacuum Drying Oven VT 6025<br>• Thermo Fisher Scientific Muffle furnace |
| **Gel Permeation Chromatography** | • Shimadzu GPC<br>• Agilent GPC |
| **Glove Box** | • MBRAUN - LABmaster-pro with touch panel TP700 |
| **Super Critical $CO_2$ Rig** | • Agilent GPCThar 500 Supercritical $CO_2$ Extractor |
| **Microwaves** | • Milestone SynthWave<br>• CEM MARS<br>• CEM Discover 2.0<br>• CEM Discover Microwave 2017 |
| **Materials Testing** | • Z5 X1200 Universal Testing Machine - AML Instruments<br>• Instron 3367 Mechanical Testing Unit<br>• Retsch Ball Mill<br>• Perkin-Elmer Spectrum 400 IR<br>• Metrohm Near-IR Spectrometer |
| **Column Chromatography** | • Teledyne autocolumn<br>• Biotage Isolera IV |

# Industry partners

PROCESS INDUSTRIES: NET ZERO

CENTRE FOR DOCTORAL TRAINING

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Email pinz.cdt@newcastle.ac.uk

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Engineering and Physical Sciences Research Council