**Faculty of Science and Engineering**

**Sample PGR Projects**

*Guidance: The below projects, for PhD and MPhil study, exemplify our areas of research expertise at the University of Wolverhampton.*

*If you are interested in completing a research degree in the below areas, or variations of them, please copy and paste the project directly into the application.*

*We can then move your application ahead with that project, which will save you needing to devise or prepare a project yourself.*

*Applications can be made via: https://www.wlv.ac.uk/research/research-degrees/*

*Any questions? Please contact us at DoctoralCollege@Wlv.ac.uk*

**Built Environment**

Innovative Sustainable Architecture: The Role of Passive Design in Delivering Self-Sufficient Buildings.

The Social Value of Regenerating Brownfield Sites for Housing and Infrastructure Development in the UK

Developing a Sustainable and Resilient Business Model for Offsite Construction in the UK

A model for implementing lean and offsite approaches for energy-efficient building retrofitting in the UK.

An evolutionary and intelligent Digital Twin to support on site construction activities.

Future management of Built Heritage Assets using emerging digital technologies

Development of a framework for human stress coping strategies in construction

Evaluating and optimising the grit removal process within the Domestic Wastewater Treatment in the United Kingdom.

AI Tools for Construction Contract Claims and Disputes and Project Management”:

Gender Equality and Women Educational Leaders in the Built Environment (WEL-BE)

Accelerating just transitions through decentalised solar energy in developing countries (AJUST)

**Biological Sciences**

Investigating Multi-Stressor Dynamics: Microplastic Ingestion, Gastrointestinal Parasites, and Declining Common Toad (*Bufo bufo*) Populations

Project Title: A physiological and molecular analysis of *Acacia senegal* and the gum exudate (gum Arabic) secreted as a wound response by this species.

Cardiac autonomic modulation due to gastric receptor stimulation in healthy humans

Developing novel tools for captive animal welfare and the conservation of endangered wildlife

**Botany**

Conservation and floral ultrastructure of a montane rain forest orchid genus (*Restrepia*)

**Molecular Biology**

The production and characterisation of curcumin-based formulations for brain cancer treatment.

Investigating the role of immunity in glioblastoma as a therapeutic strategy to overcome microenvironment immunosuppression.

Biomedical Sciences:

Exploring Novel Antimicrobial Osteogenic Biomaterials and Personalised Implants through L-PBF Additive Manufacturing

Characterisation of gut microbiome and systemic immune responses in inflammatory bowel disease patients receiving biological treatment.

The role of inflammatory mediators induced by dietary iron on the development and progression of colorectal cancer.

Understanding the pathogenesis of diabetes that develops atypically

**Cancer metabolomics for early diagnosis of gut and lung cancer in clinical and 3D cell culture scaffolds.**

Bioprinted Hybrid Scaffolds for 3D Cell Culture in Drug Discovery

*In Vitro* 3D Tissue Models from Biological Polymer Scaffolds

Antimicrobial Nanoparticle-Releasing 3D Scaffolds for Wound-Healing Applications

Development of nano albumin bound Cu-DDC and Zn-DDC complexes for pancreatic ductal adenocarcinoma treatment

Investigation of the anticancer activity and mechanisms of the PEGylated liposomal Cu-DDC and Zn-DDC in malignant mesothelioma cell lines and primary cultures

Investigating the role of cilia and ciliogenesis dysregulation in the diagnosis and progression of paediatric brain tumours.

Investigation into the impact of non-steroidal anti-inflammatory drugs on phosphorylated b-catenin localisation and function

**Chemistry**

Glycosylated Polymersomes as Cell Mimics and Nanocarriers in Medicine and Biotechnology

*Modulating guest ingression and magnetic exchange within dimeric host complexes*

*Using extended architectures to stabilise and immobilise enzymes towards novel heterogeneous catalytic materials*

*Post synthetic modification of Metal Organic Frameworks towards novel heterogeneous oxidative catalysts*

**Pharmacy**

The production and characterisation of advanced lipid-based materials infused with natural healing agents for chronic wound management.

**Engineering**

Design and 3D printing triply periodic minimal surface structures (TPMS) for rapid atmospheric water harvesting.

Optimisation of Laser Powder Bed Fusion Gas Process Composition and Laser Beam Shaping Techniques for Enhanced Additive Manufacturing of GRCop Copper Alloys

Optimisation of Laser Powder Bed Fusion Gas Process Composition and Laser Beam Shaping Techniques for High Purity Copper 3D Printing

Hybrid Subtractive and Additive Green Manufacturing Methodology for Thermal Management Components

Additive manufacturing of process-informed metallic metamaterials using laser beam forming technology

Optimisation of process parameters for additive manufacturing of novel refractory metal alloys using laser beam forming technology

Development an integrated flow-structure solver applicable to simulate very large-scale wind turbines

Laser Powder Bed fusion of bioactive titanium phosphate glasses for bone regeneration implants

Room temperature synthesis and modelling of Metal Organic Framework (MOF) for efficient Carbon Capture

Process Modelling, Cost Analysis and Life Cycle Assessment of SESMR (sorbent enhanced steam methane reforming) Process Using Different Catalysts and Sorbents

3D Printed Porous Polymeric Scaffolds for Tissue Engineering

*Tow-Steered Composites: an optimised solution to be used in novel aircraft structures.’*

Evaluating the Impact of Self-Compacting Concrete on the Performance of Structures/Foundations

Soil-Pile Interaction in Response to Variations in Loading and Saturation Supervisory

Developing Soil Stabilisation Techniques for Problematic Soils

Modelling and Evaluating the Heat Exchange Efficiency and Smart City Compliance of Geothermal Foundations

**Computer Science**

GLASER – Generative AI and Large Language Models for Academic SEarch and Recommendation

Enhancing Cybersecurity Defences Against APTs: A Data-Driven Approach with Adversarial Machine Learning

Digital Twin Cybersecurity: Enhancing Threat Detection and Response in Complex Systems

Enhancing IoT Security Through Generative AI: End-to-End Attack Scenarios and Proactive Defence Strategies

Project Title: Innovative Sustainable Architecture: The Role of Passive Design in Delivering Self-Sufficient Buildings.

Supervisory Team

* Dr Mohammad Tammo: Senior Lecture
* Dr David Heesom: Professor
* Dr Nigel Moore: Lecturer
* Olive White: Senior Lecturer

About the Project:

The construction industry has been identified as the most energy-intensive and wasteful sector and to address these challenges, the sector must transition from a linear to a circular economy bringing about change in perceptions.

As the move towards a circular approach gathers pace, it is critical to develop innovative solutions that can help reduce energy consumption, minimise waste generation, and promote sustainable practices in the construction sector. By adopting more sustainable and eco-friendly practices, the construction industry can mitigate its impact on the environment and contribute to the achievement of global sustainability goals. Circular economy, for instance, has become an essential approach to achieving innovative sustainable architecture. It emphasises reusing, repairing, refurbishing, remanufacturing, and recycling materials and products throughout their lifecycle, promoting the use of eco-friendly and renewable resources. With adaptable, durable, and disassembled buildings, architects can create structures that not only benefit the environment but also provide economic and social benefits.

The overarching aim of the research is to identify new innovative approaches to sustainable architecture using circular economy principles. By analysing material flows and carbon emissions, architectural designers can establish more locally focused circular economy representations and identify key activities for circular practices. This holistic approach can serve as a model for the transition towards a more sustainable and resilient architecture.

The methodology employed in this research will be design-driven to evaluate current design processes, investigate the creation of materials banks, design by layers, design for adaptability, and design for optimisation. The research will delve into the theoretical underpinnings of a circular economy and examine its practical application to sustainable building practices.

The outcome will be a range of actionable tools and methods for instilling circular thinking into architectural design, leading to new circular buildings that incorporate renewable raw materials and technologies.

In summary, architects and urban planners can significantly contribute to the creation of sustainable, efficient, and adaptable built environments by adopting and integrating the principles of the circular economy in design processes and architectural thinking.

For more information: For an informal discussion please contact via direct email to Dr Mohammad Tammo (M.Tammo@wlv.ac.uk)

Project Title: The Social Value of Regenerating Brownfield Sites for Housing and Infrastructure Development in the UK

Supervisory Team: (Dr Emmanuel Daniel, Prof Chaminda Pathirage, Dr Paul Hampton, Dr Hamid Pouran).

About the Project:

Regenerating brownfield sites for housing and infrastructure development in the UK is critical and timely, as the country faces a housing crisis and needs sustainable urban development. Brownfield sites, which are abandoned or underused areas of land that have the potential for redevelopment, can provide much-needed housing and infrastructure to support the growing population in the UK. The regeneration of brownfield sites for housing and infrastructure development has become an increasingly important issue in the UK, as the demand for housing continues to rise and available land for development becomes scarce. However, there is a lack of understanding and consensus on the social value of regenerating these sites, a significant gap in current research.

Previous studies have primarily focused on the economic benefits of brownfield redevelopment, such as increased property value. While these are essential aspects, the social impact of regenerating these sites has not been explored. This gap in research leaves policymakers and developers with limited information and guidance on prioritising and implementing brownfield redevelopment projects effectively. Moreover, the concept of social value is multidimensional and can include factors such as improving the quality of life, promoting community cohesion, and addressing environmental concerns. Therefore, understanding the social value of brownfield regeneration is crucial for creating sustainable and inclusive communities in the UK.

This study aims to fill this research gap by exploring the social value of regenerating brownfield sites for housing and infrastructure development in the UK. Understanding the social value of regenerating brownfield sites for housing development is crucial for informing decision-making processes and policies related to land use and sustainable development. By examining the potential social benefits and challenges of brownfield site regeneration and developing a framework, this study aims to contribute to the ongoing discussions and debates surrounding housing and infrastructure development in the UK. Multiple research methods will be adopted to achieve the research aim.

For more information: For an informal discussion, please contact via direct email to Dr Emmanuel Daniel (e.daniel2@wlv.ac.uk)

Project Title: Developing a Sustainable and Resilient Business Model for Offsite Construction in the UK

Supervisory Team: (Dr Emmanuel Daniel, Prof. Issaka Ndekugri, Dr Ezekiel Chinyio).

About the Project:

The construction industry is a vital sector contributing to the global economy. However, it also faces numerous challenges, including organisational failure. Offsite construction, also known as modular, prefabricated, or modern construction methods, has gained popularity, particularly in the UK. This method involves building structures away from the site, and its appeal lies in its potential to improve construction efficiency, reduce costs, and minimise waste and environmental impacts. Despite these benefits, offsite construction businesses face unique challenges, such as supply chain disruptions, lack of clear legal framework, shortage of skilled labour, and high upfront costs, resulting in organisational failures. Several offsite construction businesses have gone bankrupt in the UK in recent years, highlighting the need to develop a sustainable business model to prevent such failures.

One central concern is the lack of focus on creating sustainable business models for offsite construction businesses. Existing research primarily focuses on the technical aspects of offsite construction and neglects the importance of a sustainable business model that addresses legal issues. This research gap highlights the need for a study addressing the challenges faced by offsite construction businesses and providing a sustainable business model. While there are studies on sustainable business models in other sectors, a targeted approach is necessary to consider the unique challenges and opportunities in the offsite construction sector. This study aims to bridge this gap by providing insights and recommendations for developing a sustainable business model that promotes the success and growth of the offsite construction sector in the UK while addressing pertinent legal issues such as design liability, insuring the supply chain, insolvency in the supply chain and the application of the Housing Grants, Construction and Regeneration Act 1996.

By identifying and addressing these companies' challenges, this study can contribute to offsite construction's long-term viability and competitiveness in the industry. The findings can also offer valuable insights for policymakers and industry stakeholders to promote the growth of offsite construction.

A mixed-methods approach will be used to gather and analyse data, including qualitative research methods like interviews and focus groups with industry experts such as construction company managers and supply chain partners. This approach will provide a deeper understanding of the challenges faced and how existing business models address them. Quantitative data from financial statements, industry reports, and legal reports will also be analysed to identify successful business models and their impact on company performance.

For more information: For an informal discussion, please contact via direct email to Dr Emmanuel Daniel (e.daniel2@wlv.ac.uk)

Project Title: A model for implementing lean and offsite approaches for energy-efficient building retrofitting in the UK.

Supervisory Team: (Dr Emmanuel Daniel, Dr Louis Gyoh, Prof Subashini Suresh, Prof. David Heesom).

About the Project:

In recent years, there has been growing concern over buildings' impact on the environment, particularly in the UK, where the construction and operation of buildings account for around 40% of the country's total carbon emissions. This has led to a push for more sustainable and energy-efficient buildings to achieve net zero emissions. With the increasing focus on sustainable development and reducing carbon emissions, retrofitting for energy efficiency in buildings has become a crucial topic in the construction industry. Retrofitting involves improving existing structures to make them more energy-efficient, reducing their environmental impact and lowering operating costs for building owners. However, retrofitting can be complex, time-consuming, and costly, leading to a need for more efficient and practical approaches.

Lean construction focuses on eliminating waste and maximising efficiency in the building process. In contrast, offsite construction involves prefabricating building components in a factory and assembling them on-site, reducing the need for on-site construction activities. These techniques have already been successfully applied in new projects, but their potential in building retrofitting for net zero emissions has not been extensively explored.

Despite the potential benefits of lean and offsite construction in project delivery, there is a lack of research and understanding on how these techniques can be applied explicitly in retrofitting. There is also a lack of a comprehensive framework that outlines the specific steps for implementing lean and offsite techniques in building retrofitting for net zero emissions. While lean and offsite construction has been widely implemented in new construction projects, their application to retrofitting for energy efficiency has not been extensively explored.

This research aims to bridge this gap and provide insights into the potential of implementing lean and offsite construction in retrofitting projects for energy efficiency. It will also develop a model to support stakeholders in the implementation, ultimately contributing to more sustainable and efficient retrofit project delivery in the UK.

Multiple research methods will be adopted to achieve the study's aim. These would be both qualitative and quantitative approaches. Case studies, interviews, and surveys with industry experts, practitioners, and stakeholders will be used to gain valuable insights.

For more information: For an informal discussion, please contact via direct email to Dr Emmanuel Daniel (e.daniel2@wlv.ac.uk)

Project Title: An evolutionary and intelligent Digital Twin to support on site construction activities.

Supervisory Team Prof. David Heesom, Dr Nigel Moore, Dr. Emmanuel Daniel

About the Project: As the construction industry becomes more digitally enabled through the application of BIM, the concept of the Digital Twin has emerged and been defined as “The virtual representation of a physical object or system across its life-cycle…using real-time data and other sources to enable learning, reasoning, and dynamically recalibrating for improved decision making” (IBM, 2020).

Digital Twins are often used as a tool for lifecycle and asset management, however there is potential to apply the concepts to construction based activities as the project progresses and activities on site evolve. As site based activities are becoming more digitally enabled and monitored, this project will seek to develop a digital twin that evolves during CAPEX / construction phases by integrating 4D BIM with the digital twin concepts and artificial intelligence. This will lay the foundation to more effective project delivery and will provide a new evolutionary approach to the implementation of digital twin through site-based activities which can be used to better plan and manage activities.

The project will implement a Design Science Research based approach as it will seek to full understand contemporary issues in site management and develop the framework for an effective technology based solution.

For more information: For an informal discussion please contact via direct email to Prof David Heesom (d.heesom@wlv.ac.uk)

Project Title: Future management of Built Heritage Assets using emerging digital technologies

Supervisory Team Prof. David Heesom, Dr Mo Tammo, Dr Nigel Moore

About the Project: In the UK and Internationally, the number of built heritage assets are increasingly at risk. Maintaining and managing these assets is critical to our cultural heritage and whilst we have seen moves towards using digital tools and approaches, such as HBIM, to better manage these, there is still much work to do to. This project will focus on strategically integrating multiple digital technologies to support management of built heritage assets.

This project will look to develop a framework for the implementation of emerging digital tools, including Artificial Intelligence, based analysis of heritage buildings to formulate more appropriate and optimised strategies for digital data capture and heritage management. The research will utilise a Design Science based research approach to develop and implement a novel framework to support technology adoption and application. The project will involve working with technologies within the School and the National Brownfield Institute and a select number of industry collaborators.

For more information: For an informal discussion please contact via direct email to Prof David Heesom (d.heesom@wlv.ac.uk)

Project Title: Development of a framework for human stress coping strategies in construction

Supervisory Team :

* Dr Ezekiel Chinyio (Reader in Construction Management)
* Dr Paul Hampton (Head, School of Architecture and Built Environment)

About the Project:

The risky, complex and fast-paced nature of construction contributes to high levels of stress amongst construction workers who use different ways to cope. A supportive and guided approach is needed and this PhD study will investigate how construction workers currently cope with stress and go on to map these against theory. This will lead to the development of a framework that will guide managers and employers to help their workers cope better with stress.

A qualitative study involving interviews and case studies will be carried out using standard analytical techniques pertaining to qualitative data.

Outputs will include the development of a framework, guidelines and manuscripts for Journal publications (3 No) and presentation at Conferences (2 No).

For more information: For an informal discussion please contact via direct email to Dr Ezekiel Chinyio (E.Chinyio@wlv.ac.uk)

Project Title: Evaluating and optimising the grit removal process within the Domestic Wastewater Treatment in the United Kingdom.

Supervisory Team:

* Dr Alaa Hamood, Principal Lecturer and Head of the Civil Engineering Department
* Dr Julia Zakharova, Senior Lecturer in Civil Engineering

About the Project:

Grit comprises inorganic materials such as sand, gravel, broken glass, eggshells, and other minerals with a settling velocity significantly higher than that of organic material in wastewater. It enters the wastewater stream from various sources, typically through surface run-off from roads via the combined sewer system in the UK. The removal of grit is essential to safeguard mechanical equipment from abrasion and wear, prevent the accumulation of deposits in pipelines and channels, and reduce the frequency of digester cleaning required due to accumulated grit. Additionally, a secondary yet highly desirable objective of the grit removal system is to separate grit from organic material in the wastewater. This separation enables subsequent treatment processes to focus more effectively on treating organic material.

The existing grit removal systems comprise traditional gravity settlement chambers situated at the inlet of treatment plants, constituting an essential component of the preliminary treatment process. Other methods include filtration, physical separation, and the application of specialised spiral settlement tanks.

The existing treatment process fails to effectively remove the smallest targeted particles, resulting in the persistence of grit in subsequent downstream stages, including primary settlement, biological treatment, and secondary settlement. This presence of grit significantly hampers the efficiency of biological processes and contributes to increased abrasion and wear on mechanical equipment. As a result, more frequent maintenance and cleaning procedures are required to improve efficiency, placing substantial financial pressure on water companies and local authorities.

The primary aim of this study is to evaluate the effectiveness of existing grit removal systems in wastewater treatment within the UK, and to investigate and devise novel approaches to enhance and optimise the process.

The research objectives are outlined below in order to achieve the primary goal:

* Gain understanding of the existing grit removal processes within the UK wastewater treatment sector.
* Understanding the composition of grit and its particle size distribution
* Evaluating the efficiency of current systems for grit removal.
* Quantifying the damages resulting from insufficient grit removal and assessing the financial resources required to manage these consequences.
* Developing innovative approaches for grit removal or enhancing existing techniques through the use of specialised CFD modelling software such as Ansys Fluent
* Constructing and testing a physical prototype for grit removal, informed by the outcomes of the software modelling.

The research methodology comprises conducting thorough literature reviews, visiting sites, meeting specialists, collecting wastewater and grit samples from multiple local and national treatment plants, performing analytical tests, using CFD modelling, and constructing physical models.

For more information: For an informal discussion please contact via direct email to Dr Alaa Hamood (a.hamood@wlv.ac.uk)

Possible PhD topics within “AI Tools for Construction Contract Claims and Disputes and Project Management”:

* intelligent drafting and auditing of construction contracts
* preparation, negotiation and settlement of construction contract claims
* time management and intelligent drafting of documents for dispute resolution processes
* Any other topic within general project management.

Project Title: subject to discussion with candidate.

Supervisory Team: will comprise 3 of the following depending on the topic.

Professor Issaka Ndekugri

Dr Emmanuel Daniel

Dr David Heesom

Dr Nigel Moore

For more information: For an informal discussion please contact via direct email to Professor Issaka Ndekugri (I.E.Ndekugri@wlv.ac.uk)

Project Title: Gender Equality and Women Educational Leaders in the Built Environment (WEL-BE)

Supervisory Team : Dr Komali Yenneti; Dr Louis Gyoh

About the Project:

 Since the 1980s, an international movement developed that aimed to provide ‘new ways of thinking’ about Gender equality. This agenda focused on enabling elimination of discrimination against women in education and work-place (e.g., Athena Swan in the UK) led to gender equality becoming an international buzzword (Global Campaign for Education, 2012; Barnard 2017). Gender equality in many countries has been influenced by numerous international conventions and declarations in the past 30 years (Shah 2020). Yet gender inequality is widespread across certain societies and more pronounced in certain sectors such as: leadership positions and tertiary education in STEM and other underrepresented subjects (Casad et al., 2021). Cultural and societal norms in developing countries, for example, South and East Asia, sub-Saharan Africa, Middle East and North Africa societies worsen gender disparity, and increases barriers like limited education, discriminatory laws, early marriages, and traditional gender roles (Jayachandran 2015). The underrepresentation of women in higher education leadership restricts the access to female role models for early career academics, discourages young women from pursuing careers in higher education, impedes opportunities for research partnerships, perpetuates gender stereotypes and biased decision-making, potential for diverse perspectives and innovation, reduces ‘bargaining power’ of intended aspirations and career choices, and further reinforce gender inequalities in tertiary education environment (Ballenger 2010; Madera 2017).

Set against this background, the key objectives of this proposed project are to:

* Investigate the situated constructions and conceptualisations of diversity and gender equality in built environment.
* Explore the drivers, opportunities, and challenges that impact diversity in leadership and female academics’ progression to leadership positions in built environment.
* Develop an evidence on gender equality in built environment and propose recommendations to improve diversity, leadership and outcomes in built environment in developing countries.

This study focuses on built environment subject within the higher education as it is often identified as one of the most male-dominated sectors around the world (Adeyemi et al., 2016; Bryce et al., 2019). Built environment refers to a group of sectors that ‘facilitate the creation and continuity of the built environment, including policy, planning, procurement, design, development, construction, and maintenance’ (Lawlor 2021, p. 6). The scope of the educational leader in this study could include Professor, Head of a Department or School, Dean, and other decision-making.

The project will employ a mixed mode data collection strategy to reach a wide spectrum of female leaders working in a variety of roles in higher education within the built environment subject. This approach will provide an opportunity to further investigate the personal experiences of a selected group of individuals and explore the relationship between diversity and leadership. The development process of the data collection instruments thoroughly considers social, cultural, language and regional practices. Ethics will be thoroughly considered in planning the data collection methods and approval will be sought from the university and respondents.

This project would positively impact gender diversity and representation of women in leadership roles in higher education by highlighting the knowledge and experiences of both female leaders and early career academics in higher education.

For more information: For an informal discussion please contact via direct email to Dr Komali Yenneti (komaliy@wlv.ac.uk)

Project Title: Accelerating just transitions through decentalised solar energy in developing countries (AJUST)

Supervisory Team : Dr Komali Yenneti; Dr Louis Gyoh

About the Project:

The project (AJUST) aims to improve the conceptual understanding of the just transitions, and the accelerating sustainability transitions through community engagement and reducing socio-technical inequalities (Sovacool et al, 2021; Sovacool & Dunalp, 2022). It focuses on identifying distinct modalities of local engagement looking particularly at the decentralised solar energy technologies/strategies used by local communities to promote more equitable and decentralized decision-making processes. Importantly, AJUST aims to improve the conceptual understanding of the distributional inequalities, power imbalances, and the unintended impacts of sustainability transitions (Avelino, 2021). The project takes the perspective that the local communities should not be seen as always vulnerable but also as empowered resilient actors. The local communities use their adaptive capacities to seek solutions that support their interests both within and outside the formal institutional structures and decision-making process (e.g., Dannevig & Dale, 2018).

The project takes a holistic and interdisciplinary perspective by drawing upon insights from the field of sustainability transitions, innovation studies, Science, Technology and Society (STS), Human Geography, anthropology, institutional theory, policy and governance studies, and energy law. Empirically, the project focuses on understanding the development of decentralised solar energy projects in Asia and Africa and how those projects contribute to just transitions.

The primary objective is to develop novel conceptual insights for accelerating just transitions through addressing the power imbalances and engagement of local communities during the acceleration phase of decentalised solar energy in Asia and Africa.

Secondary objectives:

1. Identify the unintended effects of socio-technical transitions and improve the conceptual understanding of just transitions by synthesizing insights from different bodies of energy justice literature.

2. Analyse the different institutional strategies and legitimation narratives utilized by different actors engaged in the transition process.

3. Examine the empowerment strategies of the local communities that support inclusive sustainability transitions

4. Examine the distributive and participatory outcomes of decentralised solar energy projects in Asia and Africa.

The project utilises a qualitative case study approach and draws upon different sources of data such as semistructured interviews with industry, policy, and civil society representatives, focus group interviews, and participant observations. The project draws upon the analysis of archival data such as policy documents, records of public consultations, data available on social media sites, published scientific articles, media analysis of the national and regional print and online newspapers, and an analysis of the public records of the important court hearings and debates, etc. For empirical research, the project focuses on specific regions (e.g. South Africa, Nigeria, India, Indonesia, Brazil) and localities where there are ongoing and upcoming decentralised solar energy projects. The project improves the existing conceptual approaches in the field of sustainability transitions for bringing in greater sensitivity to the emergent failures involved in the transition process and developing novel knowledge on accelerating just transitions through renewable energy projects.The project will develop novel inclusive governance models that will help the policymakers and the industry understand and address the benefits and risks associated with upcoming solar energy projects.

For more information: For an informal discussion please contact via direct email to Dr Komali Yenneti (komaliy@wlv.ac.uk)

Project Title: Investigating Multi-Stressor Dynamics: Microplastic Ingestion, Gastrointestinal Parasites, and Declining Common Toad (*Bufo bufo*) Populations

Supervisory Team : Dr Natasha Kruger (Lecturer in Animal Ecology), Prof Iza Radecka (Professor in Biotechnology)

About the Project:

Background

Amphibians represent the most threatened vertebrate group, with 41% of species being in danger of extinction (IUCN, 2023). The common toad (*Bufo bufo*) native to the UK, has been reportedly facing major declines within the last decade (Wilkinson, 2019). Although there are potentially numerous, non-mutually exclusive causes of these declines, one particular concern is the effect of microplastics (MP) (Boyero *et al.,* 2020). Over the last decades plastic production and use have increased exponentially, resulting in large quantities of plastic waste (Geyer *et al.,* 2017). Plastic waste that ends up in aquatic environments can be broken down into smaller particles by chemical and photochemical reactions (Güven *et al.,* 2017). Frogs can ingest MPs directly or via prey, these accumulate in the tissues and can impair survival, body condition and function (Boyero *et al*., 2020) However, little is known about the multi-stressor effect of MPs interacting with gastrointestinal parasites. The presence of these parasites is predicted to influence the retention of MPs in the gastrointestinal tract by increasing the surface area for adhesion and retention (ex., Hernandez-Milian *et al.,* 2019). Additionally, they can also act as a vector for other contaminants, such as pathogens increasing transmission between individuals (Gkoutselis *et al.,* 2021). MPs are ubiquitous, abundant and persistent over time, which highlights the need for understanding these multi-stressor effects in declining populations of common toads.

Aim

1. To investigate the effect of microplastic (MP) ingestion and accumulation on common toad body condition and gastrointestinal parasite composition.

Objectives

1. To assess MPs in the freshwater breeding habitats of common toads in urban and rural areas.
2. To characterise the type of MPs present in the gastrointestinal tract of common toads collected from these breeding sites.
3. To identify the gastrointestinal parasite composition of common toads from different breeding sites.
4. To determine individual common toad body condition in relation to type and number of MPs identified in the gastrointestinal tract.
5. To determine individual common toad parasite composition in relation to type and number of MPs identified in the gastrointestinal tract.
6. Thorough analysis of the data and literature leading to publication.

References

Boyero, L., López-Rojo, N., Bosch, J., Alonso, A., Correa-Araneda, F. and Pérez, J., 2020. Microplastics impair amphibian survival, body condition and function. Chemosphere, 244, p.125500.

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Hernandez-Milian, G., Lusher, A., MacGabban, S. and Rogan, E., 2019. Microplastics in grey seal (Halichoerus grypus) intestines: Are they associated with parasite aggregations?. Marine Pollution Bulletin, 146, pp.349-354.

Wilkinson, J. 2019. Interviewed by IUCN SSC Amphibian Specialist Group. September 2019, UK.

For more information: For an informal discussion please contact via direct email to Dr Natasha Kruger (N.Kruger@wlv.ac.uk)

Project Title: A physiological and molecular analysis of *Acacia senegal* and the gum exudate (gum Arabic) secreted as a wound response by this species.

Supervisory Team

Dr Timothy Baldwin (Reader in Plant Cell biology)

Professor Paul Dupree (University of Cambridge)

Professor Peter Williams & Dr Jixin Yang (Glyndwr University)

About the Project:

*Acacia senegal* is a species of legume, native to the Sahelian region of Africa. When wounded, mature trees of this species secrete a valuable plant gum exudate (termed gum Arabic) to seal the damaged region of the plant. This gum is comprised of a variety of macromolecules commonly associated with the plant cell wall. This exudate has been harvested on a commercial basis for thousands of years and is widely used in the food industry.

The chemical, biochemical and biophysical/physicochemical properties of gum Arabic have been intensively studied for over sixty years. However, little work has been conducted on the cellular and molecular wound response which is responsible for the biosynthesis of the gum. The objectives of the proposed project, therefore, would be to investigate the molecular structure and composition of the plant cell wall in seedlings of this species (Dr Baldwin: University of Wolverhampton), in conjunction with chemical and biochemical analyses of gum samples (harvested from the seedlings’ parent plants) (Professor Williams and Dr Jixin Yang: Glyndwr University). In addition, the proposed project will also include a transcriptomic study of the molecular basis of gummosis that will be performed in the laboratory of Professor Paul Dupree (University of Cambridge).

*Methodology*

The proposed project will consist of four main areas of study: 1) analytical chemistry/biochemistry 2) light level and transmission electron microscope level immunocytochemistry 3) molecular analyses of gum synthesis.

The initial phase of the project will mainly focus on chemical and biochemical analyses of gum Arabic samples. The bulk of this work will be performed at Glyndwr University in collaboration with Professor Williams and Dr Yang. This will involve the determination of the sugar composition using HPLC, and molecular mass distribution using GPC coupled to MALLS/RI/UV detectors, FTIR etc. The biochemical studies will include determination of total nitrogen content, monosaccharide and amino acid composition analyses, SDS-page, Western blots and immuno-dot blots.

At the same time, *Acacia* seeds obtained from Nigeria (Rubber Research Institute) will be germinated and the resultant seedlings grown, in the glasshouse facility at UoW. At six months post germination, plant material from the stem and branches from several of the seedlings will be harvested, fixed and embedded in L.R. white resin. The resin embedded samples will subsequently be sectioned and screened against a panel of anti-cell wall antibodies using light level and transmission electron microscope level immunocytochemistry, to investigate the structure and molecular composition of their cell walls.

The final phase of the study will involve an investigation of gene expression related to gum synthesis (using a transcriptomics approach) will be performed on RNA extracted from the *A.senegal* seedlings, in collaboration with Professor Paul Dupree based at the University of Cambridge.

For more information: For an informal discussion please contact via direct email to

Dr Timothy Baldwin (T.Baldwin@wlv.ac.uk)

Project Title: Cardiac autonomic modulation due to gastric receptor stimulation in healthy humans

Supervisory Team

Director of Studies: Dr Paul Barrow, Senior Lecturer in Physiology and Pharmacology

About the Project:

 The human gastric wall contains a variety of receptors detecting, among other things, temperature, stretch and osmolarity. These are linked to afferents in the autonomic nervous system and cause a variety of systemic consequences, including modulation of cardiac autonomic control resulting in acute changes in heart rate, cardiac output and blood pressure. We have already shown that stimulation of gastric TRPM8 cold receptors by menthol results in an acute increase in cardiac parasympathetic tone and concomitant reduction in heart rate and blood pressure, counteracting the increase in cardiac sympathetic activity caused by gastric stretch via TRPV4 receptors when both receptors are stimulated by a cold meal (Kazadi *et al.*, 2018. https://doi.org/10.1113/EP087058). Using analysis of respiratory sinus arrhythmia as a measure of cardiac parasympathetic tone (Task Force of the European Society of Cardiology *et al.*, 1996. https://doi.org/10.1161/01.CIR.93.5.1043) and QTc analysis of ECG as a measure of cardiac sympathetic tone, you will further investigate the effects of other gastric receptor activation on acute cardiac autonomic control. Research will be undertaken in the physiology research laboratory on the Wolverhampton City campus. This research will lead to the submission of a thesis for the award of Doctor of Philosophy (PhD) and will be published at research conferences and in scientific journals as the data warrant.

For more information: For an informal discussion please contact via direct email to Dr Paul Barrow (p.a.barrow@wlv.ac.uk)

Project Title: Developing novel tools for captive animal welfare and the conservation of endangered wildlife

Supervisory Team:

Dr Stefano Vaglio (Reader in Animal Behaviour)

Dr Colin Dubreuil (Lecturer in Conservation Biology)

Dr Andrew Gascoigne (Senior Lecturer Mathematics & Computer Science)

Dr Jacob Dunn (Associate Professor in Evolutionary Biology – Anglia Ruskin University)

About the Project:

Modern zoos are involved in captive breeding and reintroduction programmes and, thus, play a pivotal role in fighting biodiversity loss. However, several endangered animal species are currently showing a low success rate in captive breeding, which impair them from possibly serving as a buffer against extinction. In the zoo environment, the lack of stimuli and the repetitive routine can lead to boredom and to the display of stereotypic behaviours, as well as endocrinological dysfunction, which may be linked with decreased reproductive fitness of captive populations. Nevertheless, captivity is a human-controlled environment and, therefore, it is possible to enhance captive breeding via evidence-based facilitation of reproductive behaviours and environmental enrichments.

This project aims to develop novel techniques for captive animal welfare based on the supervisory team experience in olfactory and acoustic communication. We will initially focus our research on critically endangered primate species that can be difficult to breed and maintain in captivity (i.e., lemurs and tamarins). The PhD student will gather behavioural data and samples for analysis, focussing on two main areas of research for commercialisation:

1) Olfactory enrichment: the PhD student will study the scent-marking behaviour of primate groups and, with the assistance of zoo staff, will gather olfactory samples for laboratory analysis. The chemical profiles of the samples will be examined using solid-phase microextraction and gas chromatography-mass spectrometry techniques. This will allow for the identification of specific compounds associated with the biology and behaviour of the individual primates. Compounds of interest (e.g., those relating to female fertility or affiliative behaviour) will then be isolated, synthesised, and used in olfactory enrichment experiments – i.e., presented to other individuals to evaluate their responses. Such approaches have been proven to improve welfare and reproductive success in domestic animal species (e.g., the Feliway© cat calming pheromones on sale to the public), but little is known about this in non-human primates or wildlife more broadly.

2) Acoustic communication: the PhD student will study the behaviour of the animals and will simultaneously record all vocalisations using active and passive acoustic recording. This will allow us to analyse individual calls associated with the biology and behaviour of specific individuals. Acoustic data will be analysed, and machine learning methods will be developed to automatically detect and classify calls. We will analyse calls that are related to positive and negative experiences (e.g., feeding vs. aggressive interactions) to understand how acoustic analysis could be used as a novel welfare monitoring technique. Such methods have previously been used with domestic animals (e.g., chickens), but have not yet been implemented in wildlife.

The expected outputs of this project will include:

* Training for the PhD student, who will work with us and learn new field and lab skills.
* Data towards the development of two different technical approaches to animal welfare and conservation (olfactory enrichment and acoustic monitoring).
* Data for high-quality peer-reviewed publications, presenting our findings and supporting an impact case study, currently being developed by Dr Vaglio on the theme of animal welfare and conservation.

For more information: For an informal discussion please contact via direct email to Dr Stefano Vaglio (S.Vaglio@wlv.ac.uk)

Conservation and floral ultrastructure of a montane rain forest orchid genus (*Restrepia*).

Supervisory Team

Dr Timothy C. Baldwin (Reader in Plant Cell Biology)

Dr Steven Bachman (Royal Botanic Gardens, Kew)

About the Project:

Tropical montane rain forests are biodiversity hotspots, uniquely threatened by climate change and deforestation. Characterised by cool temperatures, high humidity and periodic or persistent cloud immersion, these ecosystems host many endemic species specialised for life in high moisture environments. As the climate warms, cloud bases will rise, and the duration of cloud immersion will consequently decrease. The impact of this climate disruption is often exacerbated by forest fragmentation, resulting in extreme risk of extinction for many species endemic to this environment.

Current evidence suggests that declining humidity and the loss of cloud immersion will strongly affect epiphytes, particularly drought-sensitive taxa. Moreover, little is known of the pollination syndromes and breeding systems of the majority of these species. Many are poorly recorded, and often still unidentified. One such genus of epiphytes, is the Andean orchid genus *Restrepia*, which the supervisory team (Dr Baldwin and Dr Bachman) have studied for many years.

Considering the issues described above, the objectives of this project will be to undertake the first, International Union for the Conservation of Nature (IUCN) validated, study of current threats posed to *Restrepia* and trends in extinction risk over time (Red List status and Index) this will be performed in collaboration with the Royal Botanic Gardens, Kew under the supervision of Dr Bachman. In conjunction with the Red Listing component of the proposed study, a detailed analysis of the floral ultrastructure of a model species (*R. brachypus*) using both light and transmission electron microscopy (supervised by Dr Baldwin at the University of Wolverhampton), will be performed, to further our understanding of the reproductive biology of these plants, which is crucial to the proposed analysis of the continued genetic viability of the genus.

The expected outputs for this project will result include the completion of Red List assessments for all 61 species of *Restrepia* and the identification of the major threat drivers and conservation actions required. In addition, trends in extinction risk over time will be charted, using the Red List Index covering the past three decades. Assessments will be submitted for publication on the IUCN Red List with a supporting dataset of digitised and georeferenced *Restrepia* occurrences. In conjunction with a better understanding of the reproductive biology of these species, the published Red List assessments will underpin potential conservation interventions made through regional (e.g. Colombia Plant Specialist Group) and international agencies (e.g. IUCN). As well as publication on the IUCN Red List, knowledge dissemination of the outputs of this research will occur via research conferences and publication in open access journals, with the broadest possible reach.

For more information:

For an informal discussion please contact via direct email Dr Timothy Baldwin (T.Baldwin@wlv.ac.uk)

About the Project: Project Title: The production and characterisation of curcumin-based formulations for brain cancer treatment.

Supervisory Team

Dr Abhishek Gupta

School of Pharmacy, Faculty of Science and Engineering (FSE), University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

Research Institute of Healthcare Science (RIHS), Faculty of Science and Engineering, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

Dr Aikaterini Karakoula

School of Pharmacy, Faculty of Science and Engineering (FSE), University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

Research Institute of Healthcare Science (RIHS), Faculty of Science and Engineering, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

About the Project:

Glioblastoma remains as the most common and aggressive malignant brain tumour, standing with a poor prognosis and treatment prospective. Despite the aggressive standard care, such as surgical resection and chemoradiation, median survival rates are low; about 15 months from the diagnosis and a 5-year survival rate of only 5%. Treatment resistance arises from a wide variety of mechanisms, including the blood–brain barrier (BBB), inter- and intra-tumoral heterogeneity, and a profoundly immunosuppressive tumour microenvironment.

Curcumin (CUR), chemically known as diferuloylmethane, obtained from Curcuma longa plant, is a polyphenolic compound that is well known for its pharmacological benefits like, antitumor, anti-inflammatory, and antioxidant. The anticancer properties of CUR are attributed to its unique abilities of inducing apoptosis and inhibiting proliferation and invasion of tumours by suppressing cellular signalling pathways in various cancers, including malignant gliomas. Furthermore, several studies have demonstrated that CUR is able to cross the BBB as well as to interact synergistically with commonly used chemotherapeutics making it an attractive therapeutic agent for malignant brain tumours. However, the biomedical application of CUR is greatly hindered by its hydrophobicity and low bioavailability. The poor bioavailability of CUR might be associated with its poor absorption, quick metabolism and rapid systemic elimination. Several research attempts have been made to produce structural modifications in CUR molecule to enhance its solubility and selective toxicity towards cancer cells. Moreover, different delivery systems have been produced to improve its physiochemical properties.

Microencapsulation of medicinal substances in a suitable carrier is a common practice in pharmaceutics for drug delivery. Cyclodextrins (CDs) are naturally occurring cyclic oligosaccharide obtained from starch by enzymatic cyclisation that are used as pharmaceutical adjuvants. Our group has reported the production of water-soluble CUR inclusion complex with hydroxypropyl-β cyclodextrins (HPβCD) by solvent evaporation method. CUR:HPβCD has demonstrated reduced viability (*in vitro*) against the range of tested cancer cell lines demonstrating that CUR maintains its anticancer properties in the inclusion complex.

Techniques associated with this project:

The current project will involve the production of a CUR:HPβCD complex and evaluating its anticancer properties against malignant glioma cells using a wide range of cellular and molecular biology/genetics techniques.

Key references:

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Zhuang W. *et al*., 2012. Curcumin promotes differentiation of glioma-initiating cells by inducing autophagy. *Cancer Sci*, 103: 684–690.

For more information: For an informal discussion please contact via direct email to Dr Abhishek Gupta (a.gupta@wlv.ac.uk) and/or Dr Aikaterini Karakoula (a.karakoula@wlv.ac.uk).

Project Title: Investigating the role of immunity in glioblastoma as a therapeutic strategy to overcome microenvironment immunosuppression.

Supervisory Team

Dr Omar Hafid, School of Life Sciences and Research Institute of Healthcare Science (RIHS), Faculty of Science and Engineering, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

Dr Aikaterini Karakoula, School of Pharmacy and Research Institute of Healthcare Science (RIHS), Faculty of Science and Engineering, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

About the Project:

Glioblastoma remains as the most common and aggressive malignant brain tumour, standing with a poor prognosis and treatment prospective. Despite the aggressive standard care, such as surgical resection and chemoradiation, median survival rates are low. Treatment resistance arises from a wide variety of mechanisms, including the blood–brain barrier (BBB), inter- and intra-tumoral heterogeneity, and a profoundly immunosuppressive tumour microenvironment.

Metabolic adaptation processes are believed to provide cancer cells, including glioblastoma, with proliferation and survival benefits over normal cells. However, these processes can also make cancer cells selectively dependent or addicted to certain nutrients and metabolic pathways. The overlapping metabolic reprogramming of cancer and immune cells is a putative determinant of the antitumor immune response in cancer. Increased evidence suggests that cancer metabolism not only plays a crucial role in cancer signalling for sustaining tumorigenesis and survival, but also has wider implications in the regulation of antitumor immune response through both the release of metabolites and affecting the expression of immune molecules.

Recent work in our lab has confirmed that overexpression of a key glycolytic enzyme hexokinase 2 (HK2) is associated with a shorter overall survival in glioblastoma patients. HK2 is an important facilitator of aerobic glycolysis in GBM, enabling survival and proliferation of the tumour microenvironment. A significant decrease in cell proliferation was established through CRISPR-mediated knockout of the HK2 gene in our patient-derived glioblastoma cell cultures, suggesting the potential of HK2 as a therapeutic target in glioblastoma patients. Results from CRISPR-treated glioblastoma cultures using RNA-sequencing analysis revealed significant deregulated immune-related signalling pathways including Toll-like receptors (TLR1, TLR2, TLR4, TLR5, TRL6), immune-checkpoint inhibitors (HAVCR2 and PDCD1LG2), JAK-STAT signalling pathway (STA1, 2, 4, 5A, 6), cytokine-mediated signalling and response to inflammation (IL6R, IL6ST). Activation of TLRs indicates an inflammatory profile within the tumour microenvironment. This can lead to the recruitment of inflammatory immune cells and the production of proinflammatory cytokines, chemokines and growth factors which can promote tumour development and progression. Reduction in glioblastoma low-grade inflammation may render tumour cells susceptible to cancer drugs and anti-tumour immune responses.

More recently, attention has been given to the impact of alterations in glycolytic pathways on not only proliferating tumour cells but also the tumour microenvironment and resulting changes in immune cell metabolism and function. Metabolic reprogramming within tumour cells diminishes the function of effector immune cells through depletion of essential metabolites and promotes enrichment of suppressive immune populations.

In this 3-year research project, we plan to further explore the effects of GBM aerobic glycolysis and immunosuppression through HK2 to identify potential therapeutic targets and pathway interactions within the heterogeneous tumour microenvironment. We also plan to assess the inflammatory profile within the glioblastoma microenvironment by investigating the production of proinflammatory as well as Th2 type cytokines and chemokines that signal via the JAK-STAT pathway. This project will provide extensive training in a wide range of cell and molecular biology, and analytical techniques, including but not limited to RT2 Profiler PCR Arrays, flow cytometry, confocal, immunofluorescence and Luminex technology.

Key references:

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Choudhary N., Osorio R.C., Oh J.Y., Aghi M.K. (2023). Metabolic Barriers to Glioblastoma Immunotherapy. *Cancers* 15(5):1519.

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For more information: For an informal discussion please contact via direct email to Dr Aikaterini Karakoula (A.Karakoula@wlv.ac.uk) and/or Dr Hafid Omar (H.Omar6@wlv.ac.uk).

Project Title: Exploring Novel Antimicrobial Osteogenic Biomaterials and Personalised Implants through L-PBF Additive Manufacturing

Supervisory Team; Dr Abhishek Gupta, Senior Lecturer in Physiology and Pharmacology, Aaron Vance, Lecturer in Engineering, Professor Neil Ashwood, Consultant Orthopaedic Surgeon

About the Project:

This project requires a candidate with interdisciplinary knowledge and/ or the commitment to explore beyond their previous experience.

This research endeavour presents a captivating opportunity to delve into revolutionary antimicrobial osteogenic biomaterials through Laser Powder Bed Fusion (L-PBF), marking a potential breakthrough in bone tissue engineering. By utilising the versatility of L-PBF technology and incorporating antimicrobial agents into osteogenic biomaterials, this study aims to meet the critical demand for personalised implants capable of both bone regeneration and innate resistance to microbial infections, especially crucial in orthopaedic procedures. The combination of osteogenic attributes with antimicrobial functionality will hold significant promise for customising implant materials and greatly enhancing patient outcomes.

The project materials innovation phase will identify emerging antimicrobial agents such as antimicrobial peptides, silver nanoparticles, or antibiotic-eluting polymers, and seek to embed them within osteogenic biomaterial matrices. Through rigorous experimentation, including the optimisation of L-PBF parameters and comprehensive characterisation, the research will aim to craft antimicrobial osteogenic biomaterials distinguished by heightened structural integrity, biocompatibility, and antimicrobial effectiveness. This pioneering approach will not only tackle current clinical challenges but also set the foundation for innovative strategies to combat implant-related infections, potentially diminishing the need for antibiotic therapy and revision surgeries.

Moreover, the exploration of antimicrobial osteogenic biomaterials via L-PBF will offer a compelling avenue for personalisation, facilitating the translation of research outcomes into practical applications tailored to individual patient needs. The opportunity to collaborate with clinical partners will provide invaluable insights into real-world challenges and further refine biomaterial development to match clinical requirements. The use of Finite Element Analysis (FEA) and Computational Fluid Dynamics (CFD) will enable the simulation of mechanical behaviour and fluid dynamics surrounding the fabricated implants under physiological conditions, providing crucial insights into their long-term functionality, and ensuring suitability for clinical use. Furthermore, this research will hold promise for commercialisation, with opportunities for patentable innovations. By bridging the gap between research and clinical practice, this ambitious project aims to advance both scientific understanding and patient care, driving innovation in bone tissue engineering and beyond.

For more information: For an informal discussion please contact via direct email to Dr Abhishek Gupta (a.gupta@wlv.ac.uk)

Characterisation of gut microbiome and systemic immune responses in inflammatory bowel disease patients receiving biological treatment.

Supervisory Team

Dr Omar Hafid

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Professor Matthew Brookes

Research Institute of Healthcare Science (RIHS), Faculty of Science and Engineering, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

Background

The gastrointestinal tract is in contact with a huge variety of diverse pathogenic and commensal microbiota. Therefore, a balance between immunity and immune tolerance is required. Crohn’s disease (CD) is a chronic relapsing incurable inflammatory bowel disease (IBD) affecting 165/100000 people in the UK. The role of the gut microbiota is increasingly considered to be an important factor in the aetiology of IBD.

The cytokine milieu in the intestine is also an important factor in the maintenance of the immune balance and in IBD this balance is dysregulated resulting in mucosal inflammation. For example, in CD we found that the levels of proinflammatory cytokines are elevated, whereas levels of anti-inflammatory cytokines were reduced.

Dysbiosis or changes in bacterial diversity plays a major role in the progression of CD and associated with changes in the cytokine profile. While manipulating gut flora with probiotics has been effective in prevention of inflammation and maintenance of remission, probiotics are still ineffective in treating an established inflammation.

The application of biotherapeutics such as monoclonal antibodies against certain cytokines have revolutionised the treatment of various diseases including IBD. However, different gut bacteria may enhance different cytokine profile in the gut, particularly, during inflammatory conditions which may affect the efficacy of the biological drug.

Most investigations on the interaction between the gut immune system and the gut bacteria have been carried out on animal models and information on this interaction from human studies are sparse. In addition, we still do not fully know the effect of biological drugs on the bacterial composition and in relation to the systemic cytokine profile in CD patients.

Hence, we will investigate bacterial diversity and immune responses in patients with CD who are under biological treatment.

Aims

We aim to characterise the persistent dysbiosis in CD and examine concurrent changes in both gut flora and serum cytokine profiles in response to Infliximab.

Research Plan

Blood and stool samples will be obtained from IBD patients at three time points: before treatment, 6-8 weeks post treatment and 9 months post treatment. Blood and stool samples will also be obtained from healthy participants as a control group. Systemic TH1 and TH2 cytokines will be determined using Multiplex Bead-Based Immunoassay and flow cytometry techniques. Bacterial DNA will be extracted from the stool samples and the bacterial diversity will be assessed by 16s RNA gene sequence and microbial bioinformatic analysis.

The project will include a wide range of molecular biology and analytical techniques, including NGS, microbial DNA qPCR array, flow cytometry, immunofluorescence, Multiplex Bead-Based Immunoassay, 16S rRNA sequencing and bioinformatic analysis.

Anticipated outcome

Generated data will further our understanding of the bacterial composition/diversity in the human gut and whether changes in this diversity during inflammatory bowel disease is associated with a specific systemic cytokine profile. Results may also lead to optimisation of probiotic preparations for CD treatment.

For an informal discussion please contact via direct email to Dr h.omar6@wlv.ac.uk

The role of inflammatory mediators induced by dietary iron on the development and progression of colorectal cancer.

Dr Omar Hafid

School of Life Sciences, FSE, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK. Research Institute of Healthcare Science (RIHS), Faculty of Science and Engineering, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

Dr Abhishek Gupta

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Professor Matthew Brookes

Research Institute of Healthcare Science (RIHS), Faculty of Science and Engineering, University of Wolverhampton, Wulfruna Street, Wolverhampton, UK.

Background

Colorectal cancer (CRC) is a major cause of cancer-related mortality worldwide with an estimated 1.3 million cases diagnosed every year. Tumour bearing individuals are characterised by defects in immune mechanisms that normally eliminate incipient carcinoma. Growing evidence linked inflammation and CRC suggesting that pro-inflammatory microenvironment promotes tumour progression and invasion.

Inflammation is a complex process implicating the interaction of many inflammatory mediators. These include recruitment and activation of various inflammatory immune cells such as neutrophils, basophils, T cells, macrophages and dendritic cells (DC) as well as production of pro-inflammatory cytokines and mediators of inflammation. Interactions between all or some of these mediators can cause damage to the intestinal mucosa and may promote proliferation and metastasis of tumours.

Anaemia is associated with colorectal cancer but its treatment with oral supplementation of iron may prove inappropriate because the accumulation of iron in the intestinal tract can involve the generation of oxidative radicals and inflammatory mediators. This may also lead to infiltration of further inflammatory cells; in particular tumour associated macrophages (TAMs) promoting tumour progression as TAMs may provide tumours with iron rather than withholding it. Infiltration of DC may also play a major role in inducing inflammation. DC are the most potent antigen presenting cells that bridge the innate and adoptive immune systems and can initiate a cytotoxic immune response against cancer cells. However, the tumour may produce factors that induce DC migration to lymph nodes leading to tumour metastasis, especially at early stages of the disease. In addition, L-selectin facilitate the entry of T cells into secondary lymphoid tissues via high endothelial venules. However, we don’t know the effect of oral iron supplementation on DC recruitment into tumours or their migratory function.

Aims

The aim is to compare in normal and tumour tissues as well as serum from iron deficient patients who received either oral or systemic iron supplementation before surgery the following:

1. Infiltration of immune cells and their phenotype in colorectal tumour tissues.

2. Compartmentalisation of immunity and inflammatory markers in colorectal tumour tissues.

3. Iron haemostasis related cytokines in tumour tissues and cytokine profile in the serum.

4. Functional studies to investigate the effects of oral versus systemic iron supplementation on dendritic cell migration, T cell phenotype and activation and on Wnt signalling in peripheral blood mononuclear cells from healthy donors.

A wide range of techniques and protocols will be used in the course of this project including; RT-PCR, qPCR, ELISA, flow cytometry, luminex technology, immunohistochemistry and immunofluorescence microscopy.

Anticipated Outcome

The outcome may reveal whether oral iron supplementation is related to tumour development via changes in the immune profile either systemically or in the tumour microenvironment. The data could be harnessed to devise logical, evidence-based therapy targeting the innate and adaptive immune systems in colorectal cancer patients with iron deficiency anaemia.

For an informal discussion please contact via direct email to Dr h.omar6@wlv.ac.uk

Project Title: Understanding the pathogenesis of diabetes that develops atypically

Supervisory Team: Dr. Opeolu Ojo (DOS), Dr. Gavin McNee (Second Supervisor)

About the Project:

Several studies have indicated the link between type 2 diabetes and Parkinson's disease (PD), and how one disease could lead to the development of the other. Specifically, it has been reported that oxidative stress associated with type 2 diabetes could lead death of brain cells observed in PD. Epidemiological studies have also indicated that 32% of people with type 2 diabetes will eventually develop PD. However, studies investigating how PD can contribute to the development of type 2 diabetes are lacking. PD is also associated with significant oxidative stress and the role that oxidative stress characterising PD plays in development of insulin resistance is not yet fully understood.

This project aims at investigating whether physiological changes associated with early stages of PD (including oxidative stress and differential expression of the alpha synuclein gene - a key biomarker for PD) could trigger metabolic changes observed in type 2 diabetes.

This project will employ cutting techniques in cellular and molecular biology to examine how oxidative stressors characterising PD affect metabolic processes in cells involved in glucose homeostasis (such as beta cells, adipocytes and muscle cells). Moreover, changes in glucose uptake and metabolism in cells transfected to over-express alpha synuclein gene will be studied. In addition, this project will observe changes in glucose homeostasis (and other parameters) in fruit fly model of PD in addition to protective effects of some novel incretin-based therapies.

For more information: For an informal discussion please contact via direct email to Dr Opeolu Ojo (o.ojo2@wlv.ac.uk)

Project Title: **Cancer metabolomics for early diagnosis of gut and lung cancer in clinical and 3D cell culture scaffolds.**

Supervisory Team

Director of Studies: Professor Olivia Corcoran, Senior Lecturer in Forensic Analysis, SOLS

Second Supervisor: Dr Hamid Omar, Reader in Immunology, RIHS

Third Supervisor: Dr Ahmed Eissa, Senior Lecturer in Organic Chemistry, SOLS

About the Project:

 **Cancer metabolomics to earlier diagnose gut and lung cancer in clinical and 3D biomaterials.**

A hallmark of cancer progression is the fast metabolic reprogramming of cells in epithelial diseases such as gut and lung cancer. Yet, the 5-year prognosis for gut and lung cancer patients remains stubbornly low. The University of Wolverhampton’s Research Institute for Health Sciences (RIHS) has been successfully externally funded over many years to study the genetic basis of metastasis in brain cancers, from a genomics and proteomics perspective.

This project aims to develop a state-of-the-art metabolic profiling platform thereby extending the global analysis for small molecule prognostic markers for, and therapeutic targets against, epithelial cancers that may metastasise to the brain, ultimately resulting in clinical benefit.

Biomaterials (hydrogels and porous polymer materials) serving as scaffolds for 3D cell culture and tissue engineering are developed in Eissa’s group using modern synthetic chemistry and bioconjugation methods. The supervisory team’s recent work to build an in-house metabolomics database has shown that GC-MS and LC-HRMS technologies are capable of quantifying thousands of small molecule signatures for many diagnostic samples including human lung tissue and faecal samples from a myriad of gut diseases (Corcoran and Omar, 2024). The aim of the proposed work is to extend the 3D scaffold into fast-growing cancer cells to identify prognostic metabolic markers for, and therapeutic targets against, epithelial tumours that may metastasise to the gut, lung and brain.

This interdisciplinary project will create a range of complex architecture materials to serve as scaffolds for culturing gut and lung cells and, ultimately, tissue in 3D. This will involve progressive emulsion templating and additive manufacturing 3D printing technologies. One produced, accurately optimised and validated, scaffolds will be used to establish optimal in vitro tissue models of gut and lung cancers. Gold standard cancer drugs and novel plant-based natural products will be tested for anticancer potential. The outcome will be a robust analytical platform for investigating diverse cancer metabolic signatures in clinical and 3D in vitro models. This will have significant implications for RIHS, increasing the efficiency of the discovery process and translation of biomaterials and deliver a ‘step change’ in accelerating cancer therapy development.

Experience is required in subject areas including Chemistry, Immunology, Biomedical Science, Bioinformatics or a related field. This multidisciplinary project will involve working at the interface between materials chemistry and immunology. Prior experience is desirable but appropriate training in the full range of chemical and biomedical techniques will be provided to the successful candidate. Laboratory work will be in the Rosalind Franklin Building, which houses a broad range of state-of-the-art research facilities suitable for cell culture alongside recently installed state-of-the-art GC-MS and LC-HRMS. The project will involve collaborations with external research groups at the University of Warwick, Imperial College Department of Surgery & Cancer, and groups in Brazil, China and Mexico.

Applications are particularly welcomed from students of all backgrounds that are suitably qualified and highly motivated.

For more information: For an informal discussion please contact via direct email to (Professor) Olivia Corcoran (o.corcoran@wlv.ac.uk)

Project Title: Bioprinted Hybrid Scaffolds for 3D Cell Culture in Drug Discovery

Supervisory Team:

Dr Ahmed M. Eissa (Senior Lecturer); Professor Weiguang Wang (Chair); Dr Mark Morris (Reader); Dr Vinodh Kannappans (Senior Research Fellow)

About the Project:

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| Bioprinting is an emerging technology that enables the generation of precisely controlled 3D cell models and tissue constructs. Bioprinting process requires bioinks that contain living cells and biomaterials that mimic the extracellular matrix (ECM) environment; supporting cell adhesion, proliferation and differentiation after printing. There are many different biomaterials (natural or synthetic or a combination of the two as hybrid materials) reported as bioinks for 3D bioprinting. An ideal bioink should possess appropriate mechanical and biological properties of the target tissues and organs, which are essential to ensure correct functionality of the bioprinted tissues and organs. Hydrogels of natural polymers have been widely used in 3D bioprinting as they provide the desired microenvironment mimicking the native ECM for cell attachment and proliferation; however, they usually process poor shape fidelity and limited rigidity. While synthetic polymers may lack the ability to promote cellular adhesion when compared to natural polymers, they are promising candidates as they allow tuneable mechanical and morphological properties. Precursors of porous polymer scaffolds that recapitulate both mechanical and biochemical properties of the native ECM could potentially be utilised as a novel alternative to existing bioinks to generate functional bioprinted tissues. Porosity enables cell infiltration, tissue growth and vascularisation within the structural constructs.  |

In this project we will utilise the bioprinting technology to develop novel hybrid scaffolds (hydrogels and macroporous polymers) to create an advanced *ex vivo* 3D tissue model in order to explore efficacy of novel drugs (e.g. anticancer). Recent work involved the synthesis of designed monomers and crosslinkers which can serve as a reactive ‘handle’ for subsequent chemical modification of the resulting biomaterials. The pore diameter and properties of materials can be tailored to a high extent, making them suitable for 3D cell culture, tissue engineering and regenerative medicine. Gelatine-based hydrogels will be synthesised and imbedded within the macroporous of polymer scaffolds to provide integrin-binding RGD motifs, promoting cell infiltration. Development of such novel hybrid polymer scaffolds will be trialed using modern polymerisation / chemical approaches.

This a multidisciplinary project that involves development of the polymeric material and optimisation of their morphological and mechanical characteristics as well as investigations of the use of these scaffolds in 3D cell culture and drug screening assays.

This project is part of ongoing research, so is suitable for either Chemistry or Biomedical Sciences PhD students as the direction of work can be adapted and shifted from one aspect to another with support from the team.

Relevant recent references:

* S. A. Richardson, et al., “Covalent Attachment of Fibronectin onto Emulsion‐Templated Porous Polymer Scaffolds Enhances Human Endometrial Stromal Cell Adhesion, Infiltration, and Function”, *Macromolecular Bioscience* 2019, 19(2), 1800351.
* A. M. Eissa, et al., “Enhanced Differentiation Potential of Primary Human Endometrial Cells Cultured on 3D Scaffolds”, *Biomacromolecules* 2018, 19, 8, 3343-3350.
* A. S. Hayward, A. M. Eissa, et al., “Galactose-functionalised polystyrene-based polyHIPE scaffolds for use in routine three dimensional culture of mammalian hepatocytes”, *Biomacromolecules* 2013, 14 (12), 4271–4277.

For more information: For an informal discussion please contact via direct email to Dr Ahmed Eissa (A.M.Eissa@wlv.ac.uk)

Project Title: *In Vitro* 3D Tissue Models from Biological Polymer Scaffolds

Supervisory Team:

Dr Ahmed M. Eissa (Senior Lecturer); Dr Mark Morris (Reader); Professor Weiguang Wang (Chair); Dr Vinodh Kannappans (Senior Research Fellow)

About the Project:

In this project, we will exploit the highly porous polymer scaffolds to create in vitro 3D tissue models. Recently, we have shown that emulsion-templated porous polymer scaffolds are capable of supporting 3D growth of many cell types including human pluripotent stem cells, human primary epithelial and stromal endometrial cells and human haematopoietic stem cells. Herein, we will broaden the scope of application of these scaffolds to address other biomedical problems including carcinoma by creating functional 3D cancer tumour models.

Polymerised high internal phase emulsions (polyHIPEs) will be first produced by emulsion templating whereby the continuous, oil-based phase of the emulsion is polymerised in the presence of the aqueous phase droplets, yielding a highly porous solid foam material. We will tailor the morphological and mechanical properties of our polyHIPE materials, making them more suitable for the culture of carcinoma tumours. We will also utilise different post-polymerisation approaches to functionalise our polyHIPE scaffolds by attaching interesting biomolecules/biomacromolecules that can facilitate notch signalling and therefore lays the foundation for biomimicry of the tissue niche. In collaboration with biomedical scientists and oncologists, the utility of the newly developed functional polyHIPE scaffolds will be fully characterised and exploited for the development of therapeutic strategies.

This a multidisciplinary project that involves development of the polymeric material and surface functionalisation with extracellular matrix proteins and/or polysaccharides as well as investigations of exploitation of its use for the development of cancer therapeutic strategies.

This project is part of ongoing research, so is suitable for either Chemistry or Biomedical Sciences PhD students as the direction of work can be adapted and shifted from one aspect to another with support from the team.

Relevant recent references:

* C. E. Severn, A. M. Eissa, et al., “*Ex vivo* culture of adult CD34+ stem cells using functional highly porous polymer scaffolds to establish biomimicry of the bone marrow niche”, *Biomaterials 2019,* 225, 1195332.
* J. L. Ratcliffe, M. Walker, A. M. Eissa, et al., “Optimized peptide functionalization of thiol-acrylate emulsion-templated porous polymers leads to expansion of human pluripotent stem cells in 3D culture”, *Journal of Polymer Science Part A: Polymer Chemistry* 2019, 57, 1974.
* S. A. Richardson, et al., “Covalent Attachment of Fibronectin onto Emulsion‐Templated Porous Polymer Scaffolds Enhances Human Endometrial Stromal Cell Adhesion, Infiltration, and Function”, *Macromolecular Bioscience* 2019, 19(2), 1800351.
* A. M. Eissa, et al., “Reversible surface functionalisation of emulsion-templated porous polymers using dithiophenol maleimide functional macromolecules”, *Chemical Communication* 2017, 53, 9789 - 9792.
* C. Chen, A. M. Eissa, et al., "Emulsion-templated porous polymers prepared by thiol-ene and thiol-yne photopolymerisation using multifunctional acrylate and non-acrylate monomers", *Polymer* 2017, 126, 395–401.
* A. S. Hayward, A. M. Eissa, et al., “Galactose-functionalised polystyrene-based polyHIPE scaffolds for use in routine three dimensional culture of mammalian hepatocytes”, *Biomacromolecules* 2013, 14 (12), 4271–4277.

For more information: For an informal discussion please contact via direct email to Dr Ahmed Eissa (A.M.Eissa@wlv.ac.uk)

Project Title: Antimicrobial Nanoparticle-Releasing 3D Scaffolds for Wound-Healing Applications

Supervisory Team :

Dr Ahmed M. Eissa (Senior Lecturer); Professor Iza Radecka (Chair); Dr Leigh Jones (Senior Lecturer); Dr Abhishek Gupta (Senior Lecturer)

About the Project:

Antimicrobial materials are essential in many medical applications including wound-healing. Due to their morphological similarity to the extra cellular matrix of skin, porous polymer scaffolds hold great potential for skin tissue engineering. Over the past couple of decades, metallic nanoparticles (e.g. gold and silver nanoparticles) have been extensively explored in wound-healing applications as efficient antimicrobial agents. Nevertheless, the use of metallic nanoparticles has raised concerns as these particles can penetrate into the stratum corneum of skin, or even diffuse into the cellular plasma membrane. Therefore, there is a real need for the development of polymer scaffolds with controlled release of metallic nanoparticles and preferably programmable release of different antimicrobial / anti-inflammatory agents as well.

In this project, we will utilise the three-dimensional (3D) structured emulsion-templated macroporous polymers (known as polyHIPEs) as biocompatible scaffolds to enable the incorporation of both traditional and metal based antimicrobial agents with programmable release. Our approach will allow the creation of customised antimicrobial 3D structures for a broad range of tissue engineering applications, with particular emphasis in wound-healing applications. The incorporation of a uniform, continuous layers of metallic nanoparticles/antimicrobial agents in the polyHIPE scaffolds will be verified by XPS analysis. Electron microscopy will be used to investigate morphological features of the scaffolds. The mechanical properties of the scaffolds will also be studies in details using compression/tensile testing and DMA. The antimicrobial efficacy of the antimicrobial scaffolds against a range of gram +ve and gram –ve bacterial e.g. (Staphylococcus aureus and Escherichia coli) will be determined by industry-standard AATCC protocols. Cytotoxicity analyses of the antimicrobial scaffolds toward human epidermal keratinocytes and human dermal fibroblasts will be performed using quantitative analyses of cell viability and proliferation.

In this project will involve close collaboration with microbiologists and biomedical scientists where investigations of the use of these antimicrobial scaffolds for skin tissue engineering / wound-healing applications will take place.

This project is part of ongoing research, so is suitable for either Chemistry, Microbiology or Biomedical Sciences PhD students as the direction of work can be adapted and shifted from one aspect to another with support from the team.

Relevant recent references:

* A. M. Eissa, et al., “Reversible surface functionalisation of emulsion-templated porous polymers using dithiophenol maleimide functional macromolecules”, *Chemical Communication* 2017, 53, 9789 - 9792.
* C. Chen, A. M. Eissa, et al., "Emulsion-templated porous polymers prepared by thiol-ene and thiol-yne photopolymerisation using multifunctional acrylate and non-acrylate monomers", *Polymer* 2017, 126, 395–401.
* A. M. Eissa, et al., “Glycosylated nanoparticles as efficient antimicrobial delivery agents”, *Biomacromolecules* 2016, 17, 8, 2672-2679.

For more information: For an informal discussion please contact via direct email to Dr Ahmed Eissa (A.M.Eissa@wlv.ac.uk)

Project Title: Development of nano albumin bound Cu-DDC and Zn-DDC complexes for pancreatic ductal adenocarcinoma treatment

Supervisory Team:

Professor Weiguang Wang and Dr Vinodh Kannappans

About the Project:

Pancreatic ductal adenocarcinoma (PDAC) is the 4th most common malignancy with very dismal prognosis. The findings indicate that PDAC are heterogeneous tumours containing cancer stem cells (CSCs). CSCs are highly metastatic and resistant to conventional chemotherapies becoming the primary source of PDAC relapse. CSCs are commonly located in poorly vascularised hypoxic regions. Tumour hypoxia is typically associated with chemo- and radio-resistance. Our previous study demonstrated that both hypoxia and NFκB pathway activation were co-detected in cells expressing CSC markers isolated from the core region of tumour spheres(*1*). High NFκB activity can be induced by hypoxia and detected in chemoresistant cancer(*2, 3*). It may also play a pivotal role in hypoxia-induced CSC characteristics and chemoresistance. Elucidation of the relationship between hypoxia, NFκB and CSCs may shed light on PDAC CSC-targeting.

Due to the time and costs for new drug development, repositioning of old drugs for new indications is an emerging drug R&D strategy in recent years. Disulfiram (DS), an anti-alcoholism drug used in clinic for over 60 years, demonstrates excellent activity against a wide range of cancers without toxicity to normal cells(*1, 3-5*). DS also potentiates the cytotoxic effect of anticancer drugs and increases the therapeutic index(*4, 6*). The anticancer effect of DS is copper (Cu) and zinc (Zn) dependent(*7*). Cu and Zn plays a crucial role in redox reactions and triggers the generation of reactive oxygen species (ROS) which induce apoptosis. The transport of Cu into the cell is strictly mediated by the trans-membrane Cu transporter Ctr1. DS can be promptly converted into diethyldithiocarbamate (DDC) which is a strong divalent metal ion chelator, DS chelates Cu(II) and Zn(II) forming a Cu-DDC or Zn-DDC complex which improves the transport of Cu and Zn into cancer cells. Cu-DDC and Zn-DDC complexes are much stronger ROS inducers than Cu and Zn alone. The ROS induced by conventional anticancer drugs is commonly counterbalanced by ROS-activated NFκB which inhibits ROS-induced cytotoxicity. The Cu-DDC and Zn-DDC complex not only induces ROS it also inhibits NFκB activity in cancer cells(*5, 8*). It abolishes CSCs population in culture and completely reverses the chemoresistance and cross-resistance in chemoresistant cancer cells(*3, 4, 6*). The data from Professor Wang’s lab shows that Cu-DDC and Zn-DDC block the sphere reforming activity and potentiates cytotoxicity of gemcitabine, paclitaxel and 5-fluorouracil in PDAC, while also blocking cancer invasion at very low concentrations. Although the anticancer activity of DS has been known for more than two decades, its use as a cancer treatment is limited when administered orally. The half-life of DS in the bloodstream is less than 4 minutes(*7*), which may explain the lack of encouraging results from several clinical trials (<http://www.clinicaltrials.gov/>) using oral administration. Nanotechnology-based drug delivery system (NDDS) is a rapidly evolving interdisciplinary field. Nanoparticles (NPs) can protect drugs from metabolism on their way to the cancer. We have successfully encapsulated DS into liposome, PLGA and gold NPs demonstrating improved anticancer efficacy in several mouse cancer models. These promising pilot data prompt us to develop biodegradable long-circulating NAB-encapsulated Cu-DDC and Zn-DDC to target PDAC CSCs.

The demand for novel anti-PDAC treatments is urgent while drug development is slow and costly, mainly due to the large risk of toxicity of novel molecules. The repurposing of clinically available drugs into new treatment areas allows for the clinical development of safe drugs for new indications at much reduced time, risk and cost. DS shows very promising anti-CSC activity in other types of cancer. This project aims to translate its derivatives, Cu-DDC and Zn-DDC into PDAC treatment.

1. P. Liu *et al.*, Liposome encapsulated Disulfiram inhibits NFκB pathway and targets breast cancer stem cells in vitro and in vivo. *Oncotarget* 5, 7471 - 7485 (2014).

2. S. Liu, M. S. Wicha, Targeting breast cancer stem cells. *J Clin Oncol* 28, 4006-4012 (2009).

3. P. Liu *et al.*, Disulfiram targets cancer stem-like cells and reverses resistance and cross-resistance in acquired paclitaxel-resistant triple-negative breast cancer cells. *British journal of cancer*, (2013).

4. P. Liu *et al.*, Cytotoxic effect of disulfiram/copper on human glioblastoma cell lines and ALDH-positive cancer-stem-like cells. *Br J Cancer* 107, 1488-1497 (2012).

5. N. C. Yip *et al.*, Disulfiram modulated ROS-MAPK and NFkB pathways and targeted breast cancer cells with cancer stem cell like properties. *Br J Cancer* 104, 1564-1574 (2011).

6. X. Guo *et al.*, Disulfiram/copper complex inhibiting NFkappaB activity and potentiating cytotoxic effect of gemcitabine on colon and breast cancer cell lines. *Cancer Lett* 291, 104-113 (2010).

7. P. E. W. Tawari, Z.; Najlah, M.; Tsang, C. W.; Kannappan, V.; Liu, P.; McConville, C.; He, B.; Armesilla, A. L.; Wang, W., The cytotoxic mechanisms of disulfiram and copper(II) in cancer cells. *Toxicology Research* 4, 1439 - 1442 (2015).

8. X. Guo *et al.*, Disulfiram/copper complex inhibiting NFkappaB activity and potentiating cytotoxic effect of gemcitabine on colon and breast cancer cell lines. *Cancer letters* 290, 104-113 (2009).

For more information: For an informal discussion please contact via direct email to Professor Weiguang Wang at w.wang2@wlv.ac.uk

Project Title: Investigation of the anticancer activity and mechanisms of the PEGylated liposomal Cu-DDC and Zn-DDC in malignant mesothelioma cell lines and primary cultures

Supervisory Team:

Professor Weiguang Wang and Dr Vinodh Kannappans

About the Project:

Malignant mesothelioma (MM) is one of the most dreadful malignancies, which is commonly diagnosed at very late stage. The treatment outcomes in many other cancers have been significantly improved but the prognosis of MM remains very dismal. With most comprehensive treatment, MM patients can only survive for 9 – 12 months. Although it is a rare malignancy, the incidence of MM will significantly increase, especially in the developing nations. Due to the difficulty of getting rid of cancer tissues by surgery and the damaging effect of radiotherapy on the surrounding vital organs, chemotherapy becomes a major choice for MM treatment. Unfortunately, only two drugs (cisplatin and pemetrexed) are available for MM chemotherapy and MM cells are commonly resistant to all conventional anticancer drugs. Therefore, the current chemotherapy is more palliative rather than curative. The previous studies indicate that MM is heterogeneous containing cancer stem cells (CSCs). CSCs are highly invasive and resistant to conventional chemotherapies. CSCs are commonly located in poorly vascularised hypoxic regions. Tumour hypoxia is typically associated with chemo- and radio-resistance. Our previous study demonstrated that both hypoxia and NFκB pathway activation were co-detected in cells expressing CSC markers isolated from the core region of tumour spheres(*1*). High NFκB activity can be induced by hypoxia and detected in chemoresistant cancer, including MM(*2, 3*). Elucidation of the relationship between hypoxia, NFκB and CSCs may shed light on MM treatment.

The demand for novel anti-MM drug with low/non systemically toxic and highly efficacious is urgent but new drug development is a time (~15 years/drug) and cash ($1.5 billion/drug) consuming procedure. The repurposing of clinically available drugs into new treatment areas allows for the clinical development of safe compounds for new indications at much reduced time, risk and cost.

Disulfiram (DS), an antialcoholism drug without systemic toxicity to patients, shows very strong toxicity in CSCs from a wide range of cancer types including MM. In our pilot experiments, DS was highly toxic to MM cells and demonstrated curative effect on MM developed in mouse abdominal cavity. DS also blocked the expression of PD- L1, a protein compromising immune surveillance in MM patients. All of these findings indicate that DS is a very promising candidate for MM treatment. The studies from our and other groups indicate that the anticancer activity of disulfiram is copper (Cu) and zinc (Zn) dependent. DS can be promptly converted into diethyldithiocarbamate (DDC) which is a strong divalent metal ion chelator. DS chelates Cu(II) and Zn(II) forming a Cu-DDC or Zn-DDC complex which improves the transport of Cu and Zn into cancer cells. Cu-DDC and Zn-DDC complexes are strong reactive oxygen species (ROS) inducers. The ROS can also be induced by conventional anticancer drugs which are counterbalanced by ROS-activated NFκB which inhibits ROS-induced cytotoxicity and apoptosis. The Cu-DDC and Zn-DDC complex not only induces ROS it also inhibits NFκB activity in cancer cells(*4, 5*). It abolishes CSCs population in culture and completely reverses the chemoresistance and cross-resistance in chemoresistant cancer cells(*3, 6, 7*). Therefore, the functional anticancer compounds are Cu-DDC and Zn-DDC. This study intends to investigate the anti-MM activity of a novel injectable version of Cu-DDC and Zn-DDC, which is applicable in chest and abdominal cavities. We have developed PEGylated liposomal Cu-DDC and Zn-DDC (PEGlipo/Cu-DDC and PEGlipo/Zn-DDC) with promising drug loading contents and very stable shelf life in solution. The PEGlipo/Cu-DDC and PEGlipo/Zn-DDC showed very strong killing effect on other cancer cell lines. In this project, the effect of the new formulation of Cu-DDC and Zn-DDC on MM will be examined in cell culture and in mouse models. The molecular anticancer mechanisms, especially in CSCs and immune system, will be investigated.

Development of disulfiram derivatives in an anticancer setting will benefit MM patients and have significant financial implications for the NHS.

Relevant recent references:

1. P. Liu *et al.*, Liposome encapsulated Disulfiram inhibits NFκB pathway and targets breast cancer stem cells in vitro and in vivo. *Oncotarget* 5, 7471 - 7485 (2014).

2. S. Liu, M. S. Wicha, Targeting breast cancer stem cells. *J Clin Oncol* 28, 4006-4012 (2009).

3. P. Liu *et al.*, Disulfiram targets cancer stem-like cells and reverses resistance and cross-resistance in acquired paclitaxel-resistant triple-negative breast cancer cells. *British journal of cancer*, (2013).

4. N. C. Yip *et al.*, Disulfiram modulated ROS-MAPK and NFkB pathways and targeted breast cancer cells with cancer stem cell like properties. *Br J Cancer* 104, 1564-1574 (2011).

5. X. Guo *et al.*, Disulfiram/copper complex inhibiting NFkappaB activity and potentiating cytotoxic effect of gemcitabine on colon and breast cancer cell lines. *Cancer letters* 290, 104-113 (2009).

6. X. Guo *et al.*, Disulfiram/copper complex inhibiting NFkappaB activity and potentiating cytotoxic effect of gemcitabine on colon and breast cancer cell lines. *Cancer Lett* 291, 104-113 (2010).

7. P. Liu *et al.*, Cytotoxic effect of disulfiram/copper on human glioblastoma cell lines and ALDH-positive cancer-stem-like cells. *Br J Cancer* 107, 1488-1497 (2012).

For more information: For an informal discussion please contact via direct email to Professor Weiguang Wang at w.wang2@wlv.ac.uk

Project Title: Investigating the role of cilia and ciliogenesis dysregulation in the diagnosis and progression of paediatric brain tumours.

Supervisory Team:

P. Goggolidou, Reader in Molecular Genetics, A. Karakoula, Senior Lecturer in Pharmacy

About the Project:

Certain types of brain tumours develop much more aggressively and rapidly than others. Glioblastoma is a tumour that is known for its aggressive growth and resistance to treatment. Recent studies on glioblastoma biopsies have shown that many tumour cells have a reduced number of cilia (Sarkisian and Semple-Rowland, 2019). The primary cilia are microtubule organelles that project from the surface of cells (Bergmann, 2018) and have various functions including transportation of fluid into and out of the cell, epithelial structural functions, and sending and receiving signals into the cellular environment. Studies have shown that cilia are intimately involved in cell division therefore, it is possible that mutations that disrupt ciliogenesis could promote tumorigenesis as a result of a loss of cell cycle control (Plotnikova et al., 2008; Basten and Giles, 2013). Currently, it is largely unknown how the primary cilia are involved in these brain tumours and whether the cilia play a role in regulating the progression of cell growth.

The aim of this study is to determine whether the cilia is indeed involved in these paediatric brain tumours and to establish whether there is a link between the stage of the tumour progression and the stage of ciliogenesis dysregulation.

This research will investigate the rate of ciliogenesis in paediatric patient-derived tumour cells (GBM and ependymoma) using confocal microscopy. This will be compared to the number of cilia and rate of ciliogenesis with frozen sections of tumours from patient biopsy samples. Using RNA sequencing and qPCR analysis, we are planning to identify if there are any specific genes involved in the processes being studied and measure the expression levels of genes associated with deregulated pathways in ciliogenesis.

The results will provide an insight into the involvement of cilia in paediatric brain tumour cell proliferation and identify novel potential therapeutic targets for this type of malignancy.

For more information: For an informal discussion please contact via direct email to Dr Goggolidou (p.goggolidou@wlv.ac.uk)

Project Title: Investigation into the impact of non-steroidal anti-inflammatory drugs on phosphorylated b-catenin localisation and function

Supervisory Team

Dr Iain D. Nicholl, DOS, Senior Lecturer in Biomedical Science

Dr Evi Goggolidou, Co-supervisor, Reader in Biomedical Science

About the Project:

There is clear epidemiological evidence that aspirin has a chemoprotective effect in colorectal cancer (CRC) development. Prophylactic aspirin use is thus currently considered when managing individuals that carry an identified mutation in highly penetrant genes that predispose them to familial CRC, including Lynch Syndrome (caused by mutations in DNA Mismatch Repair Genes) and Familial Adenomatous Polyposis (caused by mutations in the *APC* gene). As aspirin acts as a non-steroidal inflammatory (NSAID) agent, its effect on reducing inflammation is considered to be a primary mechanism for this observed chemoprotective effect. However, there is emerging evidence that aspirin and other NSAIDS can reduce tumour cell growth through additional mechanisms unrelated to inflammation. For example, Greenspan *et al* (2011), have indicated that NSAIDS including ibuprofen and aspirin can inhibit the activation of b-catenin - a key player in the Wnt signaling pathway that can drive cellular proliferation - by increasing b-catenin phosphorylation by a component of the APC destruction complex (GSK-3b) which is traditionally interpreted to enhance b-catenin degradation.

We have examined this phenomenon in preliminary experiments using confocal analysis and find an increased level of phosphorylated b-catenin at the centrosome in SW480 CRC cells incubated with aspirin – an unexpected result. b-catenin has additionally and traditionally been identified as a core component of the Zonula Adherens protein complex, playing a role in cell-cell adhesion and mechano-transduction bridging the cadherins and actin cytoskeleton (Farago *et al*, 2021). More recent experimentation is revealing that b-catenin processing at the centrosome may impact on the Wnt signaling pathway (Vora *et al*, 2020).

We thus wish to explore phosphorylated b-catenin localisation in CRC derived cell lines treated with a range of NSAIDS in detail, using immunochemical approaches including immunofluorescence analysis and confocal microscopy. We will additionally seek to isolate the centrosome using classical biochemical fractionation and identify interacting partners of phosphorylated b-catenin employing immunoprecipitation and mass spectrometry. This approach will provide insight into a) the molecular action of NSAIDS as anti-cancer agents and b) the centorosme-related function of b-catenin and is likely to result in high quality publications given the novelty of the experimental approach.

Farago, B., I.D. Nicholl *et al*, (2021) Activated nanoscale actin-binding domain motion in the catenin–cadherin complex revealed by neutron spin echo spectroscopy PNAS (USA) 118 (13) e2025012118; <https://doi.org/10.1073/pnas.2025012118>

Greenspan EJ, Madigan JP, Boardman LA, Rosenberg DW. Ibuprofen inhibits activation of nuclear {beta}-catenin in human colon adenomas and induces the phosphorylation of GSK-3{beta}. Cancer Prev Res (Phila). 2011 Jan;4(1):161-71. doi: 10.1158/1940-6207.CAPR-10-0021.

Vora SM, Fassler JS, Phillips BT. Centrosomes are required for proper β-catenin processing and Wnt response. Mol Biol Cell. 2020 Aug 1;31(17):1951-1961. doi: 10.1091/mbc.E20-02-0139.

For more information: For an informal discussion please contact via direct email to Dr Iain Nicholl (I.Nicholl@wlv.ac.uk)

Project Title: Glycosylated Polymersomes as Cell Mimics and Nanocarriers in Medicine and Biotechnology

Supervisory Team :

Dr Ahmed M. Eissa (Senior Lecturer); Dr Leigh Jones (Senior Lecturer); Professor Iza Radecka (Chair)

About the Project:

The aim of this project is to develop synthetic multivalent ligand systems based on glycosylated polymersomes with tunable rigidity, permeability and size as a simple mimic of biological cells and a new delivery system for bioactive molecules.

Polymer vesicles (polymersomes) are spherical soft-matter (nano)capsules consisting of a bilayer membrane enclosing an aqueous compartment and are generally formed by spontaneous self-organisation from amphiphilic block copolymers. Compared to lipid vesicles (liposomes), they have a relatively thick and robust membrane formed by polymeric amphiphiles with a relatively high molecular weight, which can increase their biological stability and prolong the circulation time in blood. Furthermore, polymersomes can present biologically active functionalities, such as sugars, on their external surface by self-assembly of functionalised amphiphilic polymers. Many biological processes in mammalian cells, such as fertilisation, viral and microbial infections, inflammation and cancer cell metastasis, are mediated by sugar-protein (lectin) interactions. Multivalent glycosylated macromolecules (glycopolymers) bind to lectins with high avidity and so provide an attractive therapeutic strategy for tackling diseases that involve sugar-lectin binding during disease progression. Moreover, these sugar molecules through interaction with cell-surface lectins can promote uptake of nanoscale particles by cells (e.g. galactose binds specifically to liver cells that possess high levels of the receptor ASGP-R). Sugar-decorated polymersomes (glycopolymersomes) therefore hold great promise in nanomedicine as vectors for targeted delivery and a simple model of biological cells.

In this project, we will synthesise well-defined amphiphilic block glycopolymers using the recently developed photo-induced reversible deactivation radical polymerisation and study their self-assembly, by different methods, into both small and giant unilamellar vesicles. Molecular characterisation will be performed by NMR, MALDI-tof MS and GPC, and extensive studies of the aqueous solution behaviour of these polymers (solubilities, cloud point, critical aggregation concentration, dynamic light scattering (DLS) and transmission electron microscopy (TEM)) will also be performed. Loading of the vesicles with model compounds and therapeutics, as well as studies of the membrane permeability will be explored.

This project is part of ongoing research, so is suitable for either Chemistry or Biomedical Sciences PhD students as the direction of work can be adapted and shifted from one aspect to another with support from the team.

Relevant recent references:

* Y. Li, Y. Chang, D. M. Haddleton, N. R. Cameron and A. M. Eissa “Comprehensive Glycoscience 2nd edition, Volume 4: Glyconanotechnology, Chapter 00114. Glycopolymer Functionalized Nanoparticles and Their Applications” by the Elsevier 2021, 209-249.
* A. R. Hall, J. T. Blakeman, A. M. Eissa, et al., “Glycan–glycan interactions determine Leishmania attachment to the midgut of permissive sand fly vectors”, *Chemical Science* 2020,11, 10973-10983.
* L. Martin, et al., “Polydimethylsiloxane-Based Giant Glycosylated Polymersomes with Tunable Bacterial Affinity”, *Biomacromolecules* 2019, 20, 3, 1297-1307.
* Y. Luo, et al., “Synthesis of glycopolymers with specificity for bacterial strains via bacteria-guided polymerization”, Chemical Science, 2019, 10, 5251-5257.
* J. Binfield, et al., “Imaging Proton Transport in Giant Vesicles through Cyclic Peptide–Polymer Conjugate Nanotube Transmembrane Ion Channels”, *Macromolecular Rapid Communications* 2018, doi.org/10.1002/marc.201700831.
* A. Kubilis, et al., “Giant polymersome protocells dock with virus particle mimics via multivalent glycan-lectin interactions”, *Scientific Reports* 2016, 6, 32414.
* A. M. Eissa, et al., “Glycosylated nanoparticles as efficient antimicrobial delivery agents”, *Biomacromolecules* 2016, 17, 8, 2672-2679.
* A. M. Eissa, et al., “Polymersome‐forming amphiphilic glycosylated polymers: Synthesis and characterization”, *J. Polym. Sci. Polym. Chem.* 2013, 51(24), 5184-5193.

For more information: For an informal discussion please contact via direct email to Dr Ahmed Eissa (A.M.Eissa@wlv.ac.uk)

Project Title: Modulating guest ingression and magnetic exchange within dimeric host complexes

Supervisory Team: Dr Leigh Jones (SL Chemistry) and Dr Ahmed Eissa (SL Chemistry)

About the Project:

Recent work emanating from the Jones group has described the synthesis of the novel ligand “*divan”* (LH2) that upon Cu(II) metalation forms the complex [(MeCN)⊂Cu(II)2(L)2] (1; Fig. 1) [1]. The two singly deprotonated L- ligands in 1 twist away from one another to form the dimeric Cu(II) structure. The distorted square planar metal geometries exhibit long apical Cu-NMeCN interactions formed through the accommodation of a guest MeCN molecule to give *pseudo* square based pyramidal topologies at both metal sites. Moreover, the guest MeCN has formed a formal Cu-N-Cu magnetic pathway in 1. This PhD project will explore further the chemistry of this prototype molecule as described below in the form of two work packages (WP1-2).



Figure 1 (a) Chemsketch of the ligand *divan* (LH2; R = Br). (b) Crystal structure of [(MeCN)⊂Cu(II)2(L)2] as viewed perpendicular (b) and parallel (c) to the space-fill represented acetonitrile guest moiety. Colour code: Cu (green), C (grey), N (dark blue), O (red), Br (yellow). All hydrogen atoms have been omitted for clarity.

Work package 1: We will explore further the guest accommodating ability of this dimeric complex. Through careful guest selection we will be able to modulate and fine tune the resultant Cu(II)…Cu(II) magnetic exchange. Potential guests include (not exhaustive) pyrimidine (correct topology to forge 2 disparate Cu-Npyrimidine interactions); benzene / toluene (correct fit and would produce strong intermolecular interactions) and the azide (N3¯) anion can force ferromagnetic magnetic exchange. We will also investigate potential solution host-guest behaviour using NMR titration and / or UV-vis titration techniques [2].

Work package 2: Work would also focus on ligand modification towards molecular cavity modulation and therefore fine-tuning guest affinity with respect to the resultant host complex. Potential changes include Br replacement using Suzuki coupling transformations with (for instance) various commercially available boronic acid; [3] and the reduction of the imine C=N functional groups with NaBH4 or sodium triacetoxyborohydride (STAB) [4]. The initial change would potentially increase the molecular cavity size while the latter would significantly alter the ligand topology and would inevitably lead to a different complex topology upon metalation. In the same vein, we will also investigate the coordination ability of these novel ligands with other transition metals towards different magnetic behaviour. Likewise, diamagnetic Zn(II) analogues to 1 would be sought towards the aforementioned NMR titration studies.

The target material described here will be characterised via numerous techniques such as XRD (powder and single crystal); SQUID magnetometry and EPR (in conjunction with the University of Manchester). In summary, the successful execution of this project would give rise to a novel family of host-guest materials capable of hosting targeted guest molecules either towards their stabilization / sequestration or alternatively, fine-tuning magnetic exchange between the host magnetic metal centres.

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Project Title: Using extended architectures to stabilise and immobilise enzymes towards novel heterogeneous catalytic materials

Supervisory Team: Dr Ahmed Eissa (SL, Chemistry) and Dr Leigh Jones (SL, Chemistry)

About the Project:

The functionality, thermal stability, tuneable porosity and significant surface areas of both Metal-Organic Frameworks (MOFs)1 and Biopolymers2 has rendered them extremely promising hosts for the encapsulation (and immobilisation) of enzymes, thus allowing their use outside of the cell (Cell Free Enzymatic Catalysis). This project will combine the strengths of the PIs (Dr Leigh Jones: Metal-Organic Frameworks and Dr Ahmed Eissa: Biopolymers)towards the design and synthesis of novel host architectures (MOFs or biopolymers) that will then be employed to accommodate guest enzymes towards catalytic studies. Both MOF / Biopolymer surface adsorption as well as complete encapsulation of our target enzymes will be explored here. The target material described here will be characterised via numerous techniques such as XRD (powder and single crystal); SEM-EDX and TEM. All porous polymers will be assessed using (for instance) GC-MS and NMR studies.

In summary, the successful execution of this project would give rise to a novel family of heterogeneous host-guest enzyme catalysts. Furthermore, the candidate will glean vital experience in the fields of enzyme kinetics, coordination chemistry (MOF design, synthesis and characterisation)and biopolymer chemistry (e.g. porous polymer scaffolds).

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Project Title: Post synthetic modification of Metal Organic Frameworks towards novel heterogeneous oxidative catalysts

Supervisory Team: Dr Leigh Jones (SL, Chemistry) and Dr Ahmed Eissa (SL, Chemistry)

About the Project:

In 2016, Dr Leigh Jones and his co-workers discovered that the monometallic complexes of general formula: [Mn(III)F3(H2O)(L)] (where L = 1,2-diimine ligand; Fig 1a and 1b) were extremely easy to synthesise in high purity and good yields (>65%) in a short space of time (< 5 mins).1 More recent unpublished results have shown that these complexes are able to catalyse the oxidation of trans-stilbene and the sulfoxidation of 4-nitrothioanisole and 4-nitrophenyl phenyl sulphide in competitive yields (75-95%).2



Figure 1 Crystal structures of [Mn(III)F3(H2O)(1,10-phen)] (a) and [Mn(III)F3(H2O)(2,2-bipy)] (b). (c) Schematic illustrating the potential binding sites within the MOF UiO-67-bipy.

This project will focus on using Post-Synthetic Modification (PSMet) techniques) to coordinate fluoride bound transition metal centres (starting with Mn(III) and Fe(III); both of which are commercially available) into the empty diimine sites located within the Metal-Organic Framework (MOF) UiO-67-bipy (Fig. 1c). Upon successful production of these novel materials ([TMF2/3(sol)*x*-bpy-UiO]), their ability to catalyse various oxidations (e.g. trans-stilbene) will be probed.3 The structure of the precursor MOF UiO-67-bipy comprises {Zr(IV)6} metal cluster nodes connected via linear 2,2′-bipyridine-5,5′-dicarboxylate ligands to give a porous extended architecture (BET surface area = 2277 m2 / g; pore size = 7.2 Å) along with the required uncoordinated bipyridyl sites required for metal ingression (as propose here). Indeed, Manna and co-workers have shown how Ir and Pd centres can be successfully integrated into bpy-UiO (with only small reductions in pore size) towards forging highly efficient heterogeneous catalysts.4

The target MOF material will be characterised using a number of techniques. Powder XRD will ascertain whether integration was successful upon comparison with the spectrum of the UiO-67-bipy precursor. ICP-MS, EDX and XRF will be employed to analyse the degree of TM loading (Zr:TM ratio). The extent of metal (TM / Zr host metal node) leaching post-reaction(s) will be monitored using ICP-MS, while p-XRD will assess MOF stability post use.

In summary, the successful execution of this project would mean that manganese and iron fluorides salts (among others) were effective and commercially cheap starting materials (w.r.t. rare earth metals such as Pd) in the production of novel heterogeneous MOF materials. It is worth stating that a plausible alternative / additional project direction would be to carry out H2 gas storage assessments upon production of such F- rich MOFs (driven by strong H…F hydrogen bonding interactions) using our newly acquired gas adsorption isotherm technology.

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Project Title: The production and characterisation of advanced lipid-based materials infused with natural healing agents for chronic wound management.

Supervisory Team:

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About the Project:

Wound healing a complex physiological process involving several stages. The completeness and length of time to resolution depends on whether the wound is acute or chronic. Market research analysis has reported the current (2024) advanced wound care market values at US $11.66 billion which is expected to rise to US$16.12 billion by 2034 (Advanced Wound Care market). This is due to the rise in prevalence of chronic wound disorders in high-risk population like diabetics, elderly, and immunocompromised patients. There is a plethora of wound care products, yet the pervasiveness of chronic wounds is on the rise, highlighting the ongoing necessity for the development of efficacious wound dressings.

Mother nature has always been an excellent source for potent compounds with healing properties. With an objective to enrich patients' quality of life and mitigate the socioeconomic impact associated with chronic wounds, our group has been working on biosynthetic hydrogels for wound management (Gupta *et al*., 2016, 2019, 2021). To further improve healing process, selected lipids can be introduced to the topical formulations/hydrogels due to their promising moisturising properties (Gope et al., 2022, de Albuquerque et al., 2023). In addition, the immergence of antibiotic resistant microbial strains necessitated search for newer alternative antimicrobial agents. The emergence of nanotechnology, enabling the production of metal nanoparticles, has served a new therapeutic modality. Attributing to their characteristic antimicrobial properties, metal nanoparticles have received increased interest in biomedical applications.

The current project will underpin the development of advanced lipid-based materials infused with natural healing agents for wound dressing applications. A range of lipids, from animal and vegetable sources, together with selected metal nanoparticles will be investigated.

The antimicrobial and associated healing properties of nanoparticles and lipid will be evaluated both individually and in synergy. The results of the study will determine whether nanoparticles will be blended with the selected lipid and incorporated into the biosynthetic matrix for potential wound dressing application, either combined or loaded separately. Various methods for blending lipids with nanoparticles may be investigated. Once the potent material is produced, a range of physicochemical and biological characterisation studies will be undertaken to evaluate the suitability of these materials for wound management as dressings. These methods will include the assessment of the chemokine and the cytokine profiles of immune cells associated with wound healing using Luminex technology based on cytokine/chemokine multiplex techniques. Functional studies will also be carried out to determine the effects of nanoparticles-lipid complex on the capacity of immune cell migration and recruitment.

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Project Title: Design and 3D printing triply periodic minimal surface structures (TPMS) for rapid atmospheric water harvesting.

Supervisory Team: Dr. Alex Askounis, Mr. Aaron Vance

About the Project:

Extreme weather events, i.e. extensive droughts and extreme floodings, are being a regular occurrence in several countries globally due to climate change. In the UK, several regions declare drought and water usage regulations on an increasing basis. Therefore, the demand for a cheap, scalable solution to replenish drinking water stocks is increasing.

Triply periodic minimal surface structures (TPMS) are a potential solution due to their unique and complex geometries, based on a base unit cell, that render them with three unique advantages: enhanced surface area, enhanced strength, great scalability. As such, they have attracted considerable scientific and industrial attention recently in several areas including fluid transport to mixing to heat exchangers. In this project, we aim to develop a TPMS cell that will need the least amount of energy input, effectively passive, to collect large amounts of water with the largest possible surface area.

We will combine generative design and topology optimisation principles to develop optimal unit cells for atmospheric water harvester concepts. Benchtop concepts will be 3D printed at our UK Centre of Excellence for Additive Manufacturing. Rigorous testing of mechanical properties, such as strength and longevity, together with controlled fog harvesting experiments will be conducted in our multiscale thermofluids lab.

The successful candidate is expected to train in metal 3D printing using our state-of-the-art AMCM M 290-1 FLX and will be provided with opportunities for networking and showcasing their work. The expected outcomes will be shared in national and international conferences. The candidate will be encouraged to engage with our industrial partners for potential commercialisation.

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Project Title: Optimisation of Laser Powder Bed Fusion Gas Process Composition and Laser Beam Shaping Techniques for Enhanced Additive Manufacturing of GRCop Copper Alloys

Supervisory Team:

Prof Arun Arjunan, Director of the Centre of Engineering Innovation and Research (CEIR)

Dr John Robinson, Additive Manufacturing Research Commercialisation Manager

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Background/Context

Originally developed at NASA’s Glenn Research Center, GRCop alloys represent a class of copper-based alloys tailored for high-temperature aerospace and space applications. Comprising copper (Cu), chromium (Cr), and niobium (Nb), these alloys exhibit exceptional thermal conductivity, creep resistance, low-cycle fatigue life, and elevated temperature strength. They are extensively utilised in the manufacture of critical components such as rocket engine combustion chambers, liners, and fuel injector face plates. With the evolution of additive manufacturing (AM) technologies, particularly Laser Powder Bed Fusion (L-PBF), there has been a paradigm shift in the fabrication of rocket engine components. L-PBF offers unparalleled design freedom and manufacturing potential, enabling the production of complex geometries that surpass the performance of conventionally manufactured components. However, the integration of next-generation laser beam shaping and process chamber gas composition control in emerging L-PBF machines presents new opportunities for advancing the additive manufacturing of GRCop alloys.

Rationale/Problem

Despite the success of L-PBF in manufacturing aerospace components, there remain challenges in optimising the process for GRCop alloys. Achieving precise control over laser energy and process gas composition is critical for ensuring the quality and integrity of printed components. Traditional L-PBF processes may not fully exploit the unique properties of GRCop alloys, leading to suboptimal mechanical properties and microstructural characteristics. By leveraging advancements in laser beam shaping and gas composition control, this project seeks to address these challenges and unlock the full potential of GRCop alloys in additive manufacturing applications.

Methodologies

The research will entail experimental investigations conducted on a next-generation L-PBF machine equipped with advanced laser beam shaping capabilities and process chamber gas composition control. Through systematic experimentation and computational modelling, the project will evaluate various gas compositions and laser beam shaping techniques to optimise the additive manufacturing process for GRCop alloys. Material characterisation techniques, including microscopy, spectroscopy, and mechanical testing, will be employed to assess the microstructural evolution and mechanical properties of printed components. Furthermore, thermal analysis methods will be utilised to evaluate the thermal conductivity and heat dissipation capabilities of the manufactured GRCop alloy components. The interdisciplinary nature of the project will facilitate collaboration with experts in materials science, aerospace engineering, and additive manufacturing.

Expected outputs

1. Development of optimised laser powder bed fusion gas process compositions for enhanced additive manufacturing of GRCop copper alloys.
2. Evaluation of novel laser beam shaping techniques for improving build quality and mechanical properties of printed GRCop alloy components including identification of microstructural evolution and thermal properties of additive manufactured GRCop alloys.
3. Experimental validation of the feasibility and efficacy of integrating laser beam shaping and gas composition control technologies for GRCop alloy additive manufacturing.
4. Dissemination of research findings through peer-reviewed publications and presentations at international conferences.
5. Establishment of collaborations with aerospace industry partners for technology transfer and application in real-world aerospace components.
6. Enhancement of research infrastructure and capabilities in the field of additive manufacturing at the Elite Centre for Manufacturing Skills and Telford Innovation Campus facilities.

Project Title: Optimisation of Laser Powder Bed Fusion Gas Process Composition and Laser Beam Shaping Techniques for High Purity Copper 3D Printing

Supervisory Team :

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Background/Context

Copper (Cu) holds a pivotal role in various applications owing to its excellent thermal and electrical properties. With the global shift towards net-zero initiatives, the demand for copper is poised to escalate, particularly in renewable energy and electrified transportation sectors. Additive Manufacturing (AM) presents a promising avenue for fabricating custom copper components, offering opportunities to enhance efficiency through optimized materials, bespoke geometries, and integrated cooling strategies. However, Laser Powder Bed Fusion (L-PBF), the leading AM technology for metals, faces significant challenges when processing highly reflective and conductive metals like copper. These challenges stem from inadequate energy absorption by conventional infrared laser wavelengths (1060–1090 nm), resulting in high laser reflectivity. Additionally, copper’s propensity for oxidation further complicates the printing process by leading to the formation of oxide layers on powder feedstock. Addressing these challenges requires a comprehensive understanding of the material-laser interaction to maximise material absorptivity while minimising laser reflectivity.

Rationale/Problem

Current approaches to mitigating the challenges of L-PBF processing of copper include alloying, alternative wavelength lasers, and higher power lasers. However, these approaches have limitations, necessitating innovative solutions for successful fabrication of copper components. Emerging advancements in L-PBF technology, such as next-generation laser beam shaping and process chamber gas composition control, offer promising avenues for overcoming these challenges. By harnessing these advancements, it becomes possible to achieve precise control over laser energy and oxygen levels during printing, thereby enhancing process reliability and component quality. This project seeks to capitalise on recent investments in beam shaping technology and leverage the expertise of the Centre for Engineering Innovation and Research in L-PBF material and process development to explore the feasibility of integrating laser beam shaping and gas composition control for enhanced copper component manufacturing.

Methodologies

The research will involve conducting experiments on a next-generation L-PBF machine equipped with advanced laser beam shaping and process chamber gas composition control capabilities. Through a combination of experimental investigations and computational modelling, the project will evaluate the effectiveness of different gas compositions and laser beam shaping techniques in improving material absorptivity and minimizing laser reflectivity during copper 3D printing. Material characterisation techniques, including microscopy and spectroscopy, will be employed to analyse the microstructural and chemical properties of printed components. Additionally, thermal analysis methods will be utilised to assess the thermal performance of printed copper components. The interdisciplinary nature of the project will facilitate collaboration with experts in material science, laser technology, and additive manufacturing.

Expected outputs

1. Development of optimised laser powder bed fusion gas process compositions for enhanced copper 3D printing.
2. Evaluation of novel laser beam shaping techniques for improving material absorptivity and minimizing laser reflectivity during copper printing including identification of the material-laser interaction mechanisms governing the successful L-PBF processing of copper.
3. Experimental validation of the feasibility and efficacy of integrating laser beam shaping and gas composition control technologies for copper component manufacturing.
4. Dissemination of research findings through peer-reviewed publications and presentations at conferences.
5. Enhancement of research infrastructure and capabilities in the field of additive manufacturing at the Elite Centre for Manufacturing Skills and Telford Innovation Campus facilities.

Project Title: Hybrid Subtractive and Additive Green Manufacturing Methodology for Thermal Management Components

Supervisory Team:

Prof Arun Arjunan, Director of the Centre of Engineering Innovation and Research (CEIR)

Dr John Robinson, Additive Manufacturing Research Commercialisation Manager

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Background/Context

The challenges posed by thermal transfer and heat dissipation are well-documented across diverse industries. In recent years, with the advent of electric vehicles (EVs), renewable energy systems, high-power LEDs, and quantum computing, the need for effective thermal management has become even more pronounced. The demand for efficient heat dissipation solutions stems from the increasing power densities and miniaturisation trends in electronic devices and systems. Traditional thermal management approaches, such as heat sinks and heat exchangers, have been extensively studied and utilised, but they face limitations in meeting the evolving requirements of modern applications. Our research has highlighted the importance of developing advanced materials and manufacturing processes to address localised high heat fluxes and non-uniform heat dissipation challenges.

Rationale/Problem

The rationale for exploring hybrid subtractive and additive manufacturing methodologies lies in addressing the inherent limitations of both approaches. Subtractive manufacturing processes, including CNC machining, are known for their precision but often result in significant material wastage, as highlighted in various studies on sustainable manufacturing practices. On the other hand, additive manufacturing techniques, such as Laser Powder Bed Fusion (L-PBF), offer the potential to reduce material waste and enable the fabrication of complex geometries. However, challenges remain in processing materials like copper efficiently and cost-effectively using AM methods, as reported in previous research. Therefore, there is a compelling need to explore novel approaches that leverage the strengths of both subtractive and additive manufacturing to achieve greener and more sustainable fabrication processes.

Methodologies

Building on the wider literature on manufacturing processes and materials science, the proposed methodology involves a comprehensive assessment of hybrid manufacturing techniques for thermal management components. Drawing from studies on advanced manufacturing technologies, such as hybrid machining and additive/subtractive integration, the project aims to develop innovative solutions that minimize material wastage while maintaining high precision and cost-effectiveness. Leveraging the expertise of interdisciplinary research teams and state-of-the-art facilities, the project will explore the feasibility of integrating laser beam shaping and oxygen control technologies into next-generation L-PBF systems. Insights from recent advancements in laser processing and metallurgy will inform the development of optimized parameters for manufacturing enhanced copper components with superior thermal properties.

Expected outputs

1. Optimization guidelines for integrating subtractive and additive manufacturing processes to minimize material wastage while maintaining precision and cost-effectiveness.
2. Insights into process parameters and design considerations for enhancing thermal performance and manufacturability of components including experimental validation of the feasibility and efficacy of the proposed hybrid manufacturing approach.
3. Contribution to sustainable manufacturing practices through the reduction of material waste and energy consumption.
4. Advancements in the fabrication of thermal management components with superior heat dissipation properties.
5. Dissemination of findings through peer-reviewed publications in relevant academic journals and presentations at conferences. Contribution to the broader scientific community by providing insights and methodologies applicable to diverse industrial sectors.

Project Title: Additive manufacturing of process-informed metallic metamaterials using laser beam forming technology

Supervisory Team:

Prof Arun Arjunan, Director of the Centre of Engineering Innovation and Research (CEIR)

Dr John Robinson, Additive Manufacturing Research Commercialisation Manager

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Background/Context

Additive manufacturing (AM), commonly known as 3D printing, has revolutionised manufacturing processes by enabling the production of complex geometries with unprecedented precision and efficiency. Metamaterials, engineered materials with unique properties not found in nature, offer tremendous potential for applications ranging from aerospace to biomedical devices. However, traditional manufacturing methods often limit the design possibilities and performance of metamaterials due to their complex structures. Laser beam forming technology, a subset of Laser Powder Bed Fusion (L-PBF), utilises high-powered lasers to selectively melt and fuse metallic powders layer by layer, allowing for the creation of intricate structures. By leveraging this technology, we can overcome the limitations of conventional manufacturing for the creation of process-informed metallic metamaterials.

Rationale/Problem

The conventional manufacturing processes cannot fabricate process-informed metamaterials with intricate architectures that are essential for achieving targeted porosity, stiffness and strength. Moreover, existing metamaterial fabrication techniques often involve complex and costly processes, hindering their widespread adoption and personalisation. This project aims to address these challenges by developing a novel approach that combines the versatility of the beam forming with the design freedom offered by metamaterials. By using laser beam forming technology, we can precisely control the deposition of material, allowing for the creation of customised metamaterial structures tailored to specific applications.

Methodologies

Identify suitable metallic powders with properties conducive to metamaterial applications. Characterise their mechanical, thermal, and electromagnetic properties to ensure compatibility with the desired functionalities. Utilise computational tools such as finite element analysis (FEA) and topology optimization algorithms to design metamaterial architectures tailored to the targeted properties and performance metrics. Develop optimised laser beam forming parameters, including laser power, scanning speed, and powder feed rate, to achieve precise control over the fabrication process and ensure the integrity of the metamaterial structures. Evaluate the mechanical, acoustic, and electromagnetic properties of the fabricated metamaterials through experimental testing and validation. Iterate the design and fabrication process based on the performance feedback to further enhance the material properties.

Expected outputs

1. Fabrication of intricate metamaterial architectures with tailored stiffness and strength properties, surpassing the limitations of conventional manufacturing techniques.
2. Experimental validation of the designed metamaterials, demonstrating their superior performance compared to existing materials for specific applications.
3. Development of guidelines and best practices for the additive manufacturing of process-informed metamaterials using laser beam forming technology, facilitating the adoption of this approach in various industries.
4. Publication of research findings in peer-reviewed journals and presentation at conferences to contribute to the advancement of additive manufacturing and metamaterial research.

Project Title: Optimisation of process parameters for additive manufacturing of novel refractory metal alloys using laser beam forming technology

Supervisory Team:

Prof Arun Arjunan, Director of the Centre of Engineering Innovation and Research (CEIR)

Dr John Robinson, Additive Manufacturing Research Commercialisation Manager

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Background/Context

Additive manufacturing (AM) has emerged as a revolutionary technology in the manufacturing industry, offering unprecedented design flexibility and manufacturing freedom. Laser beam forming (LBF) technology, a subset of Laser Powder Bed Fusion (L-PBF), holds promise for the production of complex components, especially those made from refractory metals and their alloys. Refractory metals, characterised by their high melting points and excellent mechanical properties, are widely used in aerospace, automotive, and medical industries for their ability to withstand extreme conditions. However, the successful AM of refractory metal alloys poses significant challenges due to their high reactivity, complex thermo-mechanical properties, and susceptibility to defects. Thus, optimizing process parameters becomes crucial to unlock the full potential of laser beam forming technology for refractory metal alloy manufacturing.

Rationale/Problem

Despite the growing interest in using laser beam forming for refractory metal alloy AM, there is a lack of comprehensive understanding regarding the optimal process parameters required to achieve high-quality components. Existing studies often focus on a limited range of parameters or overlook the intricate interactions between various factors, leading to suboptimal outcomes. Consequently, there is a pressing need to systematically investigate and optimise the process parameters involved in LBF-based AM of novel refractory metal alloys to enhance part quality, mechanical properties, and production efficiency.

Methodologies

This research project will employ a multifaceted approach to address the optimisation of process parameters for AM of novel refractory metal alloys using LBF technology. Initially, a comprehensive review of the literature will be conducted to identify the key process parameters, material characteristics, and challenges associated with refractory metal alloy AM. Subsequently, experimental investigations will be carried out to systematically explore the effects of various process parameters, including, beam shape, laser power, scan speed, layer thickness, powder characteristics, and inert gas atmosphere, on the quality and properties of fabricated components. Design of experiments (DOE) methodologies coupled with statistical analysis and artificial intelligence (AI) algorithms will be employed to systematically study the parameter interactions and optimize the process conditions. Advanced characterization techniques such as X-ray computed tomography (XCT), X-ray diffraction (XRD), and mechanical, thermal and acoustic testing will be utilized to evaluate the microstructural evolution, phase transformations, and performance of the manufactured parts.

Expected outputs

1. A comprehensive understanding of the effects of process parameters on the quality, microstructure, and properties of AM-fabricated refractory metal alloy components.
2. Optimization guidelines for selecting optimal process parameters to enhance part quality, mechanical properties, and production efficiency in LBF-based AM of novel refractory metal alloys.
3. Novel insights into the microstructural evolution and phase transformations occurring during the AM process, enabling informed process design and control strategies.
4. Publication of research findings in peer-reviewed journals and presentation at relevant conferences to disseminate knowledge and contribute to the advancement of additive manufacturing technologies.
5. Contribute new insights, methodologies, and guidelines for the additive manufacturing of refractory metal alloys using laser beam forming technology. Provide recommendations for optimizing process parameters to enhance the efficiency, quality, and reliability of AM processes in industrial applications.
6. Explore potential applications in aerospace, automotive, and medical industries, leading to improved performance, reduced lead times, and cost savings in the production of refractory metal alloy components.

Project Title: Development an integrated flow-structure solver applicable to simulate very large-scale wind turbines

Supervisory Team: Dr Mohammad Ahmadi – Lecturer in Mechanical Engineering

Development an integrated flow-structure solver applicable to simulate very large-scale wind turbines

Background: Aerodynamic force acting on turbine blades is affected by the turbulence, wind velocity and attack direction. The unsteady wind velocity and its constantly varying direction cause the structure vibration and dynamic stall. This is particularly true for the next generation of large composite blade structures of offshore wind turbines. The use of larger turbine blades would result in significant improvements in efficiency and reductions in wind energy cost, but large lightweight blades are more susceptible to aero-elastic influences. Therefore, accurate prediction of the aerodynamic loading and the structural response of turbine blades is of vital importance to determine the electricity output, the turbine blade design and materials used. This is especially true for large turbines due to the lack of available experimental data on large turbine blades.

There are three major weak points in the currently available fluid-structure coupled simulation frameworks applied to wind turbines:

1. Lack of accuracy in numerical simulation of flow over turbine blades using the Unsteady Reynolds Averaged Navier-Stokes (URANS) which benefits from low computational cost.
2. Extremely high computational cost of using high fidelity approaches Large Eddy Simulation (LES) and Direct Numerical Simulation (DNS) making them impractical choice.
3. Two standalone codes (one for flow simulation and one for structural analysis) are used and data need to be transferred at every time-step between two codes, which is very inefficient and also may lead to inaccurate results.

Aim and objectives:

Aim: Development an integrated flow-structure solver applicable to simulate very large-scale wind turbines addressing the above weaknesses

OBJ1. Develop a numerical technique coupling a flow solver, a turbine model and a structure solver.

OBJ2. Validate the developed numerical method against available experimental data.

OBJ3. Apply the developed numerical method to simulate very large wind turbines.

Methodology: A hybrid method coupling LES and actuator line modelling (ALM) (Ahmad & Yang 2020) will be employed in the proposed project to provide a very accurate prediction of flow field and aerodynamic loading on turbine blades. Turbine blades will be modeled by the ALM technique so that this hybrid approach reduces the computational cost significantly and gets rid of grid structure complexity around turbine blades compared with a pure LES approach. Our flow simulation code based on this hybrid approach has been developed and used to simulate wind/tidal turbine flows accurately (Ahmadi & Yang 2021, 2022). The structural analysis will be carried out using the Geometrically Exact Beam Theory (GEBT), which is a nonlinear aero-elastic model suitable for the investigation of large, flexible rotor blades (Dose et.al. 2018). The structural analysis model will be implemented in our flow simulation code under the OpenFOAM framework without the explicit data transfer between two standalone codes, greatly improving the fluid-structure coupled simulation efficiency.

For more information: For an informal discussion please contact via direct email to Dr Mohammad Ahmadi (Ahmadi.M@wlv.ac.uk)

Project Title: Laser Powder Bed fusion of bioactive titanium phosphate glasses for bone regeneration implants

Supervisory Team: Dr Abul Arafat, Lecturer in Materials Engineering

About the Project:

Recently, there has been a rapid increase in the number of bone deformities due to traffic accidents, sports injuries, and various illnesses. Bone defects can arise as a result of fracture, infection, and surgical removal of bones. As a result, worldwide, more than 2 million patients receive bone grafts each year. The clinical and financial burden related to bone abnormalities has logically increased with time, as seen by the 33.4% increase in new bone fracture occurrences over the last three decades. Bone abnormalities are more common than expected, which leads to both chronic pain and more importantly, a loss of bone function, which dramatically lowers patients' quality of life. An appropriate bone scaffold with certain qualities is required to solve this problem. Among them, (i) excellent biological qualities like biocompatibility, bioactivity, and biodegradability (to allow for new bone formation); (ii) interconnected pores with varying pore size; (iii) osteoconductive properties; and (iv) shape and size tailored to the defect size. Following the clarification of the need, several materials such as metals, alloys and polymers that address these features have been developed via additive manufacturing and investigated for their potential in the healing of bone defects. However, metals and polymers are minimally resorbable, biocompatible, and cause little toxic reactions or foreign body reactions. Additive manufacturing of phosphate glass can be utilised as an alternative material of the aforementioned issues. A high-precision, patient-specific geometry and precise control of the complicated porosity structure are only a couple of the advantages of using AM in the manufacture of glass tissue engineering scaffolds. Phosphate glass is an excellent biomaterial due to its biodegradability, high calcium content, biocompatibility, and controllable rate of degradation. The advantages of phosphate glasses over other glasses are their lower melting temperatures, high thermal expansion coefficient and ability to accommodate high concentrations of metal oxides. However, little attention has been made on additive manufacturing of glasses to shape it into necessary geometry due to its amorphous structure, lack of ductility and high melting temperature which makes it challenging. To overcome these, titanium will be incorporated in the phosphate glass as titanium will induce bioactivity and improve mechanical stability. Tetravalent titanium in phosphate glass is found to ionically cross-link the phosphate units, disrupting the glass network and resulting in a decrease in hydrolyzable P-O-P bonds, which is essential for bioactivity. As a result, the surrounding media's ability to become acidic is hindered, which leads to the precipitation of bioactive hydroxyapatite. As such, titanium phosphate-glasses in the system 40P2O5–25Na2O–(35-x)CaO–xTiO2 (0≤x≤10) are considered in this study which will be prepared via melt quenching and solid spherical glass particles (63-80 µm) will be produced via a flame spheroidisation process. Among different additive manufacturing techniques, this research will focus on the laser powder bed fusion (LPBF) process of titanium phosphate glasses and optimisation of the process parameters such as laser power, layer thickness and scanning speed will be carried out which will enable the formation of complex geometry, necessary for bone regeneration implants.

For more information: For an informal discussion please contact via direct email to Dr Abul Arafat (a.arafat@wlv.ac.uk)

Project Title: Room temperature synthesis and modelling of Metal Organic Framework (MOF) for efficient Carbon Capture

Supervisory Team: Dr Abul Arafat, Lecturer in Materials Engineering and Dr Tohid N. Borhani, Senior Lecturer in Chemical Engineering

About the Project:

Global warming has taken lot of attention in the twenty-first century, owing to the world's fast population growth and energy use. According to the Energy Information Administration, energy consumption is predicted to grow by 57% between 2004 and 2030. Many scientists think that greenhouse gas emissions are responsible for the bulk of environmental issues. CO2 is one of the most major anthropogenic greenhouse gases and the emissions of CO2 are responsible for around 60% of global warming. Carbon dioxide emissions can come from four different sources such as industrial operations, fossil-fuelled power plants, de-carbonisation and transportation. Carbon dioxide emissions undoubtedly influence human health and well-being. As a result, it is vital to limit its emissions using specialised filters and absorbers. Various materials (zeolites, activated carbon) have already been tested in CO2 absorption. Zeolite's limitations include limited CO2 adsorption capability and instability in the presence of water. Activated carbons (AC) adsorb more CO2 than zeolites, particularly at high pressure. However, AC showed little CO2 selectivity. As a result, in terms of carbon capture, we must identify an adsorbent material that is chemically stable, easy to renew with minimum energy, and simple to synthesise with a cheap capital cost.

Metal organic frameworks (MOFs) are new emerging crystalline porous materials with excellent features such as high surface area (up to 10,000 m2/g, higher than zeolites and activated carbon), strong thermal and chemical stabilities, higher porosity, low densities (from 0.21 to 1 g/cm−3) and have evolved as a good adsorbent material for carbon capture. MOFs are three-dimensional hybrid networks where metal ions (e.g., Al3+, Cr3+, Cu2+, or Zn2+) bonded to an organic linker, mostly via coordination bonds. Solvothermal techniques are frequently used to synthesise MOFs, which frequently produce crystals for single crystal X-ray diffraction investigation. However, this process is time consuming (from hours to weeks) and solvothermal conditions are not suited for thermally sensitive beginning materials.

In this project, rapid and simple room temperature syntheses will be applied in order to prepare Cu(II) and Zn(II) containing MOFs. These MOFs were chosen because they exhibit a range of desired features, including ultrahigh porosity, one-dimensional pores, and open metal sites which in turn attributes the high capacity and selectivity for CO2 adsorption. Several analytical characterisation methods (BET, XRD, TGA, Raman) will be performed throughout the study to investigate the properties of MOFs. In addition, carbon dioxide adsorption experiment using the synthesised MOFs will be performed in this research. After experiments process modelling and simulation will be done in Aspen Adsorption software, Moreover, the nominated MOFs will be compared with the activated carbon in terms of CO2 adsorption and desorption.

Overall, this project will demonstrate the new synthesis techniques of MOFs in a sustainable way. These MOFs structure can act as a promising candidate for CO2 capture which will reduce the impact of CO2 emission and beneficial for the human health and wellbeing.

For more information: For an informal discussion please contact via direct email to Dr Abul Arafat (a.arafat@wlv.ac.uk) and Dr Tohid N. Borhani (T.Borhani@wlv.ac.uk)

Project Title: Process Modelling, Cost Analysis and Life Cycle Assessment of SESMR (sorbent enhanced steam methane reforming) Process Using Different Catalysts and Sorbents

Supervisory Team:

Dr Tohid Borhani, Senior Lecturer in Chemical Engineering and Dr Abul Arafat, Lecturer in Materials Engineering

About the Project:

Increased greenhouse gas (GHG) emissions are the inevitable outcome of a rapidly growing population combined with both increasing industrialization and energy demands across the globe. Currently, over 40 billion tonnes of carbon are released into the atmosphere annually [1], where 34 billon tonnes per year of CO2 is result of fossil fuels [2]. Prior to the onset of the Industrial Revolution in the mid-1700s, the concentration of atmospheric CO2 stood at 280 parts per million (ppm) or lower but the current global average concentration of CO2 in the atmosphere is 421 ppm. Therefore, by 2050, a reduction of 50 percent CO2 emissions, from 1990 levels, is required [3].

Approximately 75% of the world's hydrogen is currently produced from steam methane reforming (SMR) [4], a process that emits a significant amount of CO2 into the atmosphere, resulting in what is known as grey hydrogen. It requires about 1.392 mmbtu of methane to produce 1 mmbtu of hydrogen (in LHV) [5], leading to onsite CO2 emissions of about 9.4 kg/kg H2. SESMR, or steam methane reforming with CO2 capture, offers a solution to this issue by utilizing adsorption technology to capture CO2 and produce blue hydrogen [6]. The effectiveness of both catalysts in the SMR process and sorbents in the absorption unit significantly impacts SESMR [7].

This study focuses on process modelling, cost analysis, and life cycle assessment of using different catalysts and sorbents recommended by experts to capture CO2 and convert grey hydrogen to blue hydrogen. We will screen various catalysis and sorbents and evaluate their effectiveness and efficiency in terms of carbon capture, catalyst stability and activity, and energy consumption in an experimental setup. Experimental data will be used to develop models in Aspen Adsorption and Aspen Plus software, which will be validated against the experimental results. The expected outcomes of the study include three research papers and one review paper.

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For more information: For an informal discussion please contact via direct email to Dr Tohid Borhani (t.borhani@wlv.ac.uk)

Project Title: 3D Printed Porous Polymeric Scaffolds for Tissue Engineering

Supervisory Team: Dr Ahmed M. Eissa (Senior Lecturer); Professor Arun Arjunan (Chair)

About the Project:

In this project, we will couple emulsion templating, a versatile method used to create porous polymers, with lithographic 3D printing approaches to create a range of complex architecture scaffolds for tissue engineering.

In the emulsion-templating method, a high internal phase emulsion (HIPE) is created in which the continuous, or non-droplet, phase contains one or more polymerisable monomers. Polymerisation then results in a polymeric material, known as a polyHIPE, of dimensions and shape determined by the vessel or mould in which the HIPE was contained. Recent work has created biodegradable and biocompatible materials by photochemical thiol-ene polymerisation employing commercially available multifunctional thiols and acrylates.In this project, microstereolithography (μSL) / Digital Light Processing (DLP), which uses a finely focussed projected light source to selectively solidify a photocurable polymer resin, will be used to create porous scaffolds with well-defined and complex geometries. Successive images representing cross-sections of a 3D computer-aided design (CAD) file are shone onto a thin film of polymer precursor in order for it to solidify. An accurate motion stage raises the polymer film by a preselected amount and a further layer of polymer resin is solidified. In this way, geometrically complex 3D objects can be manufactured in a layer-by-layer fashion without the need for moulds or machining.

The project will have 3 phases:

1. Development of novel curable resins for creating porous 3D scaffolds. Commercially available multifunctional monomers for thiol-ene polymerisation, including acrylates, vinyl ethers, allyl compounds and thiols will be trialled in this regard.
2. Creation of 3D printed scaffold test-pieces, including tubes and blocks with internal chambers, channel arrays and interconnected channel networks.
3. In partnership with internal and external biomedical researchers, investigation of the use of these scaffolds for the 3D culture of a variety of cell types, including epithelial cells and endometrial stem cells.

This project is part of ongoing research, so is suitable for either Engineering or Chemistry PhD students as the direction of work can be adapted and shifted from one aspect to another with support from the team.

Relevant recent references:

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* A. M. Eissa, et al., “Enhanced Differentiation Potential of Primary Human Endometrial Cells Cultured on 3D Scaffolds”, *Biomacromolecules* 2018, 19, 8, 3343-3350.
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For more information: For an informal discussion please contact via direct email to Dr Ahmed Eissa (A.M.Eissa@wlv.ac.uk)

Project Title: Tow-Steered Composites: an optimised solution to be used in novel aircraft structures

Supervisory Team: Dr Morteza Abouhamzeh, Lecturer of Aerospace engineering

About the Project:

Summary and focus:

As climate change is of special concern in the aviation world, highly efficient wing designs are of interest with novel configurations. One promising idea is the highly flexible wing with high aspect ratios. These wings, when composed from composite materials, bring comparably higher aerodynamic efficiencies and eventually need less fuel. Although laminate unidirectional composites are maturely designed and manufactured in the aviation industry, novel composite types like tow-steered are on the edge of research and require further developments. The latter type of composites, when produced by automatic fibre placements, has the opportunity to optimise the paths with different objectives. For this purpose, validated modelling approaches are required. The focus of this research would be the development of such reliable models. The development of the validated model enables the application of novel composite configurations in the structural components of a civil aircraft like the wing and hydrogen tanks for the future hydrogen-powered aviation.

# Introduction

For an introduction to the topic and the open areas of research, please refer to the article in the magazine CompositesWorld:

<https://www.compositesworld.com/articles/tow-steering-part-2-the-next-generation>

There have been papers for related work performed by the University of Michigan as the pioneers of multi-disciplinary optimisations (Brooks et al., 2016; Brooks and Martins, 2018) and further published works in aircraft and wind turbine applications (Barr and Jaworski, 2019; Stodieck et al., 2017).

# Research phases.

Below, you can see suggestions for the research phases. The focus would be on the development of appropriate models. At each phase, described below, the candidate is expected to publish the outcomes in highly reputed scientific journals.

1. Literature review
2. Conceptual design for the type of the composite with respect to the needs and the works available in the literature
3. Development of a low-fidelity model (beam-type as an example) incorporation the aeroelastic loads and the dynamic response in flutter.
4. Development a high-fidelity model capable of TRL 2-3 targeting decarbonizing aviation.
5. Development of an optimisation framework and optimise the structure.
6. Plan the future steps and opportunities arising from application of the developed predictive and optimisation frameworks.

# References

Barr, S.M., Jaworski, J.W., 2019. Optimization of tow-steered composite wind turbine blades for static aeroelastic performance. Renew Energy 139, 859–872. https://doi.org/10.1016/j.renene.2019.02.125

Brooks, T.R., Kennedy, G., Martins, J.R.R.A., 2016. High-fidelity Aerostructural Optimization of a High Aspect Ratio Tow-steered Wing. 57th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference. https://doi.org/10.2514/6.2016-1179

Brooks, T.R., Martins, J.R.R.A., 2018. On manufacturing constraints for tow-steered composite design optimization. Compos Struct 204, 548–559. https://doi.org/10.1016/J.COMPSTRUCT.2018.07.100

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For more information: For an informal discussion please contact via direct email to Dr Morteza Abouhamzeh (*morteza.abouhamzeh@wlv.ac.uk*)

Project Title: Evaluating the Impact of Self-Compacting Concrete on the Performance of Structures/Foundations

Supervisory Team

Director of Studies: Dr Kenneth Imo-Imo I. Eshiet

Position: Senior Lecturer in Civil Engineering

Subject Lead: Geotechnical Engineering

About the Project:

Self-compacting concrete are high performance concrete which are more workable and consolidate easier in comparison to normal concrete. However, design mixes for self-compacting concrete adopted in practice are wide-ranging and there are no protocols to monitor and assess their performance. The use of self-compacting concrete in infrastructure projects has far-reaching implications because of the impact on the stock of aggregate, binders and other materials required;the mixing process; and other factors such as time and cost. This research project would investigate common designs of selfcompacting concrete as well as introduce alternative design mixes that optimises the process of its production. This would be lab-based but supplemented by numerical modelling. The project would also predict the short- and long-term behaviour of self-compacting concrete viz-a-viz normal concrete, including the manner this affects reinforcement requirements. Key outcomes constitute a validated range of designs for self-compacting concrete suitable for reinforced concrete structures such as foundations, retaining walls, canals, and buildings.

Project Title: Soil-Pile Interaction in Response to Variations in Loading and Saturation Supervisory Team:

Director of Studies: Dr Kenneth Imo-Imo I. Eshiet Position: Senior Lecturer in Civil Engineering

Subject Lead: Geotechnical Engineering

About the Project:

Soil-pile interaction is integral to the performance of deep foundations and often impact on the ability of piles to resist long-term actions as well as the behaviour of adjoining soil environments. The study will explore influences such as pile cross-sectional shape and length, material properties of pile and soil, pile-head fixity, pile bending stiffness, pile-head embedment, etc. To this end, numerical and analytical models would be developed that would serve as tools to predict the influence of pile sectional properties on its performance under different soil conditions and to quantity the short- and long-term behaviour of soils within the vicinity of deep foundations. Expected outcomes comprise a better understanding of soil-pile interactions under different underground conditions and the establishment of a procedure to modify pile designs and installation processes based on prevailing action loads and underground conditions.

Project Title: Developing Soil Stabilisation Techniques for Problematic Soils

Supervisory Team:

Director of Studies: Dr Kenneth Imo-Imo I. Eshiet Position: Senior Lecturer in Civil Engineering Subject Lead: Geotechnical Engineering

About the Project: The use of admixtures for soils stabilisation is well established and been in application since the 1970s. There are many admixtures used in practice with varying effect on soil properties and behaviour. They are generally known to increase soil strength and decrease hydraulic conductivity and compressibility. Selecting the right admixture is crucial and dependent on factors such as soil type, loading conditions, intended land use, etc. However, there are problematic soils which are generally difficult to improve because of their sensitivity and adverse reactions to additives and other forms of stabilisation methods. These are categorised as either swelling, collapsible or dispersive soils. A sulphur-rich soil is a typical problematic material that is difficult to treat due its high potential for expansion. This has huge implications on infrastructure development resulting in high capital and maintenance costs. This project would explore different ways in which problematic soils can be improved to make them suitable for a variety of infrastructure development. The research project would comprise a combination of field/laboratory-based investigations and numerical modelling, involving large-scale longitudinal research. The key outcomes would include the development of models for the treatment and recovery of problematic soils, the production of a chart to guide the selection of type and quantity of admixtures based on a matching system, and the identification and comprehensive evaluation of the merits and demerits of a selected range of key admixtures.

Project Title: Modelling and Evaluating the Heat Exchange Efficiency and Smart City Compliance of Geothermal Foundations

Supervisory Team:

Director of Studies: Dr Kenneth Imo-Imo I. Eshiet Position: Senior Lecturer in Civil Engineering Subject Lead: Geotechnical Engineering

About the Project: Geothermal piles are foundation piles used to extract and release ground source heat using exchanger systems. Ground heat is a clean and renewable source of energy that can be used to warm buildings during winter, but the heat exchangers can also be used to release heat from building to the ground during summer. These can serve as key contributors towards the achievement of aspects of the UN sustainability goals. Although there are some strides towards the design and operation of geothermal foundations, these are not very efficient and often installed as isolated infrastructures linked to singular buildings. Using a combination of numerical and experimental modelling routines, this research project would explore the prospects of integrating geothermal foundations into smart cities, develop models for the design, construction and installation of thermal piles, and evaluate the efficiency of Ground Source Heat Pump (GSHP) systems and Ground (source) Heat Exchangers (GHE). The key outcomes include an effective integration of thermal piles in low-cost housing and the generation of geothermal electricity with the potential to be incorporated within the state power grid.

Project Title: GLASER – Generative AI and Large Language Models for Academic SEarch and Recommendation

Supervisory Team

Ingo Frommholz, Reader in Data Science
Anirban Chakraborty, Lecturer, 2nd supervisor

About the Project

Scientific publications are an important vehicle for understanding the world around us; they contain scientific evidence that informs researchers and decision-makers, with a high impact on society. However, the rapid and large number of publications, in particular on preprint servers, causes an information overload for everybody struggling to keep up with developments in their field. This makes finding relevant information of high quality a challenging task, which requires advanced scholarly search and recommendation solutions. Recent developments in Generative Artificial Intelligence (GAI) and Large Language Models (LLMs) are having a huge impact Information retrieval and related fields. LLMs are a type of AI trained on huge amounts of text, with ChatGPT/GPT-4 and Gemini as popular examples. LLMs combined with conversational AI provide exciting new possibilities for interactive search and recommendation, but they are also suffering from severe flaws. The emerging field of Retrieval Augmented Generation (RAG) tries to mitigate some of the shortcomings of LLMs. Nonetheless the endeavour of utilising LLMs to tackle information overload in academia has only started and more research is needed.

This PhD studentship will explore how GAI and LLMs can be used to improve academic search and recommendation and what their benefits and limitations are. This may include integrating LLMs into search and recommendation services or utilising search to keep LLMs from "hallucinating". A further part of this project is to estimate the quality of publications, for instance by utilising Generative Adversarial Networks (GANs).

The PhD project provides exciting opportunities for the successful candidate to work with and critically reflect on innovative technologies at the forefront of AI that will shape our digital future. As a further incentive, the PhD candidate will be able to participate in an EU Horizon Europe Staff Exchange project, providing the opportunity to go on fully funded secondments to collaborate with an international network of researchers and industry partners.

For more information: For an informal discussion please contact via direct email to Dr Ingo Frommholz (i.frommholz@wlv.ac.uk)

Project Title: Enhancing Cybersecurity Defences Against APTs: A Data-Driven Approach with Adversarial Machine Learning

Supervisory Team: Prof. Zeeshan Pervez as Director of Studies (DoS)

About the Project:

With the increasing prevalence of Advanced Persistent Threats (APTs) targeting critical digital infrastructure, there is a pressing need for innovative approaches to enhance cybersecurity defences. APTs are sophisticated and stealthy cyberattacks orchestrated by skilled adversaries. Traditional defence mechanisms have proven inadequate against the dynamic nature of APTs, necessitating the exploration of advanced data-driven techniques such as Adversarial Machine Learning (AML) to enhance security measures. APTs pose significant risks to critical digital infrastructure due to their advanced capabilities, prolonged persistence, and ability to evade detection. Conventional cybersecurity measures, reliant on static signatures and rule-based systems, struggle to effectively detect and mitigate APT threats. AML offers a promising solution by integrating machine learning techniques with adversarial training and anomaly detection. By leveraging AML, capabilities of Security Information and Event Management (SIEM) systems can be significantly enhanced to detect and respond to APT attacks in real-time, mitigating the potential impact on critical infrastructure.

The PhD project will focus on: a) Adversarial Training: Implementing adversarial training techniques to enhance the resilience of machine learning models against APT attacks; b) Anomaly Detection: Deploying machine learning-based anomaly detection systems to identify suspicious or malicious activities indicative of APT behaviour; c) Ensemble Learning: Employing ensemble learning techniques to combine multiple machine learning models and enhance the overall robustness and reliability of the defence mechanism; d) Continuous Monitoring and Response: Establishing a continuous monitoring system to track the performance and behaviour of machine learning models in real-time.

This PhD project aims to research and develop an Adversarial Machine Learning (AML)-enabled network monitoring platform, designed to complement SIEMs, capable of detecting and mitigating APT attacks. The project is expected to make scholarly contributions through top-tier publications, as well as have a technological impact by providing open-source datasets and informing industry best practices for the development and maintenance of security in critical digital infrastructure.

For more information: For an informal discussion please contact via direct email to Prof. Zeeshan Pervez (z.pervez@wlv.ac.uk)

Project Title: Digital Twin Cybersecurity: Enhancing Threat Detection and Response in Complex Systems

Supervisory Team: Prof. Zeeshan Pervez as Director of Studies (DoS)

About the Project:

With the proliferation of edge computing, where data processing and storage occur closer to the data source, the need for robust cybersecurity measures becomes critical. Edge devices and underlying compute and networking infrastructure are often highly distributed and heterogeneous, posing challenges for traditional cybersecurity approaches. Digital Twin offers a promising solution by creating virtual replicas of edge devices, enabling real-time monitoring, simulation, and predictive analytics. However, the application of Digital Twins in edge computing cybersecurity requires further research to address the unique characteristics and requirements of distributed systems.

This PhD project aims to enhance threat detection and response capabilities in edge computing environments. By leveraging digital twin technology, it is possible to create virtual representations of edge devices, enabling continuous monitoring for anomalies and simulation of potential cyberattack. This proactive approach can significantly improve the resilience of distributed systems and reduce the impact of cyber threats on critical edge infrastructure.

The project will focus on: a) Literature Review and Framework Development: Conduct a comprehensive review of existing literature on digital twin technology and its applications in edge computing and cybersecurity; b) Digital Twin Development and Integration: Select representative edge devices and systems as a case study and develop its digital twin replica i.e., supply chain, healthcare to name a few; c) Real-Time Monitoring and Anomaly Detection: Utilize the Digital Twin to monitor the behavior and activities of the physical edge devices and systems; d) Simulation and Predictive Analytics: Leverage the Digital Twin to simulate various cyberattack scenarios targeting edge devices and systems, and employ cybersecurity countermeasures to curb attacks.

The project aims to advance the field of edge computing by providing a comprehensive understanding and developing practical methodologies for leveraging digital twins in threat detection and response within distributed systems. The project is expected to make impactful scholarly and technical contributions, enhancing the resilience of edge computing, as well as digital infrastructure and services in a broader context.

For more information: For an informal discussion please contact via direct email to Prof. Zeeshan Pervez (z.pervez@wlv.ac.uk)

Project Title: Enhancing IoT Security Through Generative AI: End-to-End Attack Scenarios and Proactive Defence Strategies

Supervisory Team: Prof. Zeeshan Pervez as Director of Studies (DoS)

About the Project:

The proliferation of Internet of Things (IoT) devices has introduced unprecedented connectivity and convenience across various domains, ranging from smart homes to industrial automation. However, the interconnected nature of IoT ecosystems also makes them susceptible to cyberattacks, posing significant security risks to both users and digital infrastructure. Traditional approaches to cybersecurity often fall short in addressing the evolving threats targeting IoT devices. Therefore, there is a critical need to develop innovative methodologies for identifying and mitigating potential attack vectors in IoT environments. Generative Artificial Intelligence (GenAI) presents a promising avenue for generating diverse and realistic attack scenarios, enabling proactive defence strategies to enhance IoT security.

This PhD project aims to leverage GenAI to generate a comprehensive range of attack scenarios targeting IoT devices and digital infrastructure. By systematically exploring various attack vectors and their potential impacts, the project seeks to provide valuable insights into the vulnerabilities inherent in IoT systems.

The PhD project will focus on: a) Data Collection and Analysis: Gather comprehensive datasets containing information on IoT device architectures, communication protocols, and common vulnerabilities; b) GenAI Model Development: Develop generative AI models, such as generative adversarial GANs or VAEs, trained on the collected data to generate diverse attack scenarios; c) Scenario Generation and Evaluation: Utilize the trained generative models to generate a wide range of attack scenarios targeting different aspects of IoT devices and networks; d)Adversarial Testing: Employ generated attack scenarios to conduct adversarial testing on IoT devices and networks; e Defense Strategy Development: Based on the insights gained from the generated attack scenarios and adversarial testing, develop proactive defence strategies and security measures to mitigate identified vulnerabilities and strengthen the overall security posture of IoT ecosystems.

The project aims to advance the understanding of IoT security vulnerabilities and empower IoT security stack to proactively defend against emerging cyber threats. By systematically generating and evaluating attack scenarios, the project is expected to make impact-full scholarly and technical contributions for enhancing the resilience of IoT devices and wider networking infrastructure.

For more information: For an informal discussion please contact via direct email to Prof. Zeeshan Pervez (z.pervez@wlv.ac.uk)