Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Low-energy-footprint photocatalysis for H2 Evolution
Supervisors at Bath: Supervisors at Monash:	Dr Simon Freakley, Prof Frank Marken (Chemistry) Dr Cameron Bentley (Chemistry), Prof Stefan Maier (Physics & Astronomy)
Home Institution:	Bath
Indicative period at Host Institution (Monash):	12 months

Project Summary (to include a brief description of the relevance to sustainable & circular technologies)

The catalytic conversion of sustainable molecules into value added chemicals is a key enabling technology in the transition to a sustainable chemical sector. Catalytic materials based on nanoparticles (NPs) of Cu, Ag and Au (5 – 50 nm) have been widely deployed in selective reduction and oxidation processes, however, often require harsh conditions (high temperature / pressure) to pre-activate the catalysts or to perform the reactions of interest.

Cu, Ag and Au NPs show strong light absorption by surface plasmon resonance, allowing energy to be deposited directly into the catalytic sites using visible light – rather than thermal conduction through large solvent volumes from heated reactor walls. When plasmons decay in metal nanostructures, highly energetic electron/hole pairs are generated, with Fermi temperatures on the order of thousands of Kelvin. A few picoseconds later, this energy has equilibrated with the lattice, raising the local temperature in the particle. Both of these processes — hot charge carriers and raised temperatures — show great promise in overcoming activation barriers for catalysis.[1] The project will look to develop plasmonic catalysts that can release H_2 from bio-derived molecules through acceptorless dehydrogenation reactions which are highly endothermic and therefore require elevated temperatures.[2] Our aim is to reduce the thermal energy used to heat large reaction volumes and to develop the relationship between light absorption/catalytic structure/performance.

We will investigate these plasmonic photocatalytic processes via a comprehensive PhD project involving materials synthesis and reactivity evaluation (Freakley, Marken – Bath), electromagnetic modelling and nano-optical and redox activity mapping of plasmonic nanostructures (Maier, Bentley - Monash). In Monash we will employ the recently established high-resolution scanning electrochemical cell microscopy (SECCM) platform to probe the redox activity of individual nanostructures immobilized onto supporting electrodes. Information from SECCM will then be related to NP structure and properties, obtained from co-located microscopy/spectroscopy facilities, allowing the underlying structure–property relationships to be established.

This PhD studentship has the opportunity to collaborate with the EPSRC Catalytic Plasmonics Programme (www.cplas.org)) with groups in this space at Monash University.

[1] Chem. Rev. 2022, 122, 19, 15082–15176 [2] Catal. Commun, 2022, 162, 106377

Features of the programme

- PhD researchers will be registered at both institutions and will be awarded a joint PhD degree.
- PhD researchers will be jointly supervised by academics from both Monash and Bath Universities.
- All PhD researchers in the joint programme will also undertake a bespoke advanced training plan covering a range of topics focusing on sustainability.
- Applicants can apply to either Monash University or the University of Bath as their nominated home institution.
- PhD researchers will undertake a period of no less than 12 months at the partner institution.
- Up to four scholarships/studentships will be offered. Additional and suitably qualified applicants who can access a scholarship/studentship from other sources will be also considered. Evidence of funding must be provided.
- The scholarships/studentships include:
  - a *full tuition fee sponsorship* provided by Monash or Bath for the course duration (up to a maximum 42 months). Note, however, that studentships for Bath-based projects will provide cover for UK/EU tuition fees ONLY.
  - *a living allowance (stipend)* provided by Monash or Bath Universities.

Note: Overseas Student Health Cover (OSHC) must be paid by the student, unless covered by the university.

How to apply

You MUST express interest for three projects in order of preference. Please submit your application at the Home institution of your preferred project ('Home' institution details can be found in the project summary). However, please note that you are applying for a joint PhD programme and applications will be processed as such.

The deadline to submit applications is 30th January 2023

Monash University

Expressions of interest (EoI) can be lodged through https://www.monash.edu/science/bath-monash-program. The EoI should provide the following information:

CV including details of citizenship, your Official Academic Transcripts, key to grades/grading scale of your transcripts, evidence of English language proficiency (IELTS or TOEFL, for full requirements see: https://www.monash.edu/graduate-research/faqs-and-resources/content/chapter-two/2-2), and two referees and contact details (optional). You must provide a link to these documents in Section 8 using Google Drive (Instructions in Section 8).

University of Bath

Please submit your application through the following link: https://www.csct.ac.uk/bath-monash-global-phd-programme/

Please make sure to mention in the "finance" section of your application that you are applying for funding through the joint Bath/Monash PhD programme for your specified projects.

In the “research interests” section of your application, please name the three projects you are interested in and rank them in order of preference. Please also include the names of the Bath lead supervisors.