Centre for **Sustainable & Circular** Technologies

MONASH University

UNIVERSITY OF BATH

Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Lipid cubic phases: sustainable nanomaterials to immobilize membrane proteins for biocatalysis and biosensors.
Supervisors at Bath:	Adam Squires (lead)
Supervisors at Monash:	Leonie van 't Hag
Home Institution:	University of Bath
Indicative period at Host Institution:	2 years at Bath; 18 months at Monash with exact dates to be confirmed

Project Summary

The project will investigate the use of lipid cubic phases to immobilize membrane proteins. The end goal is to harness membrane-bound enzymes in devices for biotechnological applications including sensing and catalysis.

Enzymes have value as highly specific chemical catalysts, especially when immobilised onto a solid support, for a range of new technologies, both in industrial processing (eg flow reactors) and in diagnostics (eg electrochemical biosensors for healthcare). However, achieving this immobilisation is a major challenge, especially for the significant proportion of proteins that are associated with cell membranes.

This project will investigate the use of nanomaterials known as "lipid cubic phases" (LCPs) – artificial membrane-mimicking "glues" within which membrane proteins can maintain their activity. Both supervisors have researched LCPs extensively, for membrane protein crystallization, and as templates for metal electrodeposition. LCP nanostructures form spontaneously when a lipid-coated substrate is exposed to water. They form a stable functional film under water, and can be removed after use by dissolving in ethanol. They therefore offer a sustainable route to device fabrication using low-cost, industrially compatible materials and processes, and green solvents and conditions (ethanol / water, room temperature). Furthermore, we anticipate that the morphology of the cubic phase – a continuous curved lipid bilayer extending in 3 dimensions– will allow incorporation of much more membrane protein, and therefore provide considerable signal amplification, compared with a single flat bilayer.

The project will build in complexity, as follows:

1) (Bath, months 1-12) Incorporate model proteins (eg porin OmpF) and peptides (eg gramicidin) into lipid cubic phases on electrodes, establishing fundamental thermodynamics of protein incorporation into substrates pre-coated with lipids. Studies with UV/Vis spectroscopy and small-angle x-ray scattering
2) (Monash, months 13-27) Synthesise designer functional membrane-bound peptides. Study protein structure upon immobilisation using circular dichroism spectroscopy and Fourier transform infrared spectroscopy (including using AFM-IR in the department and infrared microspectroscopy at the Australian Synchrotron). Additionally, fluorescence recovery after photobleaching (FRAP) experiments using a confocal microscope will be used to quantify peptide and protein diffusion in the film.
3) (Bath, months 28-43) Investigation of electrochemistry of redox-active membrane enzymes immobilized in lipid cubic phases (eg Cytochrome C Oxidase); device fabrication.

The student will learn biophysical sample preparation methods associated with lipids and membrane proteins, and physical chemistry techniques including x-ray and neutron scattering, electrochemistry and spectroscopy.

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 23rd February 2020

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.