Centre for **Sustainable & Circular** Technologies

MONASH University

UNIVERSITY OF BATH

Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Chemical design of a sustainable reactor for reducing oxygen and potentially carbon dioxide with industrial and climate applications
Supervisors at Bath: Supervisors at Monash:	Dr Simon Freakley Prof Louise Bennett (lead); Dr Sophie Selby-Pham
Home Institution:	Monash University
Indicative period at Host Institution:	2-2.5 years at Monash; 1-1.5 years at Bath with exact dates to be confirmed

Project Summary

It is well known that both ascorbic acid and phenolic compounds have the ability to produce hydrogen peroxide in the presence (or absence) of redox-active metals such as iron or copper. The dependencies of efficiency of reduction of oxygen is complex and dependent on the relative concentrations of electron donors, oxygen and reactive substrates. The phenolics can be either small molecules (eg, essential oils), larger compounds (eg, the secondary metabolite polyphenolic and hydrocarbon classes of plants) or very large polyphenolics (eg, lignins), although the latter system has not been well studied. Likewise, the dependence and nature of the metal on reduction efficiency is not well understood, but likely provides catalytic electron donation typical of oxidisable metals. These binary or ternary systems require further research to understand and optimize their heterogeneous catalytic properties.

We are currently investigating the efficiencies of lignin/ascorbic acid/metal systems using waste substrates from food and wood processing for production of hydrogen peroxide and potential applications such as natural food preservatives or pesticides. In the context of sustainable and circular technologies, it is also possible that the system of lignin/ascorbic acid/metal could potentially be used to reduce CO2 and be integrated into a solid scaffold for capture of unsaturated carboxy compounds. The aim is for recovery of the new material for uses in circular manufacturing processes and products, to be determined, ultimately to replace those derived from coal and oil substrates (however, the applications of the new materials is not the focus of this project). The research project will investigate and optimize the redox activity of the lignin/ascorbic acid/metal systems to produce hydrogen peroxide, and extend the model systems to natural food and wood-derived substrates. Finally, the research will also explore the feasibility of reduction of CO2 by heterogeneous catalysis involving addition of enzymes, with a view to producing higher order carbohydrates from atmospheric CO2.

The supervisory arrangement is for Prof Bennett and Dr Selby-Pham to take leadership of research studies focused on production of hydrogen peroxide from model (binary) systems based on organic substrates (ie, food, wood).

Dr Freakley will take leadership of studies with model (ternary) systems by addition of metals to the systems developed at Monash. The generation of H2O2 by the heterogeneous catalyst systems (+/- metals) will also be tested in heterogeneous biocatalytic systems involving enzymes, as developed by Dr Freakley.

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 12th July 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).