

Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Synthesis of Polyaminoboranes for Sustainable Applications
Supervisors at Bath:	David J Liptrot, Simon Freakley, Chris R Bowen
Supervisors at Monash:	Drasko Vidovic
Home Institution:	Bath
Indicative period at Host Institution:	12 months

Project Summary

Ferroelectric materials possess a spontaneous electric polarisation, reversible by the application of an external field. This generates nonlinear character that yields a range of uses, including tunable capacitors; ferroelectric memory devices; temperature sensors and actuators. An emerging class of ferroelectric materials are those derived from “flexible” polymers. The best-in class of these, poly(vinylidene difluoride) (PVDF), is unattractive due to numerous handling issues associated with its synthesis and processing. Alternative systems rely on heavy or toxic metals such as lead, barium and cadmium. One underexplored alternative are B-N-main chain polymers, such as poly(aminoboranes) (PABs). These species are isoelectronic with polyethylene derivatives, but polarized due to the nature of the B-N bond, and theoretical studies have predicted their ferroelectric performance to profoundly outstrip that of PVDF. We have already shown that B-N isosterism can lead to the development of ferroelectric-family behaviours.

Despite these highly attractive properties, PABs have never achieved their full potential as ferroelectrics, or as materials precursors, an issue principally originating from the immaturity of methods to achieve their synthesis. In this project, we will develop PABs with exquisitely controlled microstructure originating from judicious selection of substituents, and development of novel catalytic methodologies to generate the polymer. The ability to vary the microstructure of PABs offered by catalysis and substituent choice (i.e. tacticity, chain length, end groups, ability to prepare copolymers) provides a unique opportunity to develop structure-activity relationships.

The resultant polymers will be investigated for their application in several sustainability-relevant processes. Work with CRB will investigate PABs as polymeric ferroelectric materials, replacing environmentally malign systems such as barium titanate and lead zirconium titanate, in applications such as sensing, energy harvesting and wastewater treatment. Work with SF will focus on the controlled generation of bulk boron-nitride for heterogeneous catalysis from these polymers, targeting materials with controlled defect structures originating from the polymer microstructure. DV and DJL will provide synthetic approaches and work to develop new catalytic methodologies to these exciting materials based on Earth abundant catalysts.

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 2022

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.