

Bath Monash Global PhD Programme in Sustainable & Circular Technologies

Project Title:	Enabling efficient and scalable protocols for high-precision synthesis of complex polymer architectures with real-time reaction monitoring
Supervisors at Bath:	Maciek Kopec (lead); Ulrich Hintermair
Supervisors at Monash:	Tanja Junkers
Home Institution:	University of Bath
Indicative period at Host Institution:	2.5 years at Bath; 12 months at Monash with exact dates to be confirmed

Project Summary

The development of controlled radical polymerization techniques such as atom transfer radical polymerization (ATRP) and reversible addition fragmentation transfer (RAFT) polymerization has enabled the preparation of macromolecules with unprecedented levels of sophistication.<sup>1,2</sup> This in turn opened new applications of functional polymer materials such as block copolymers, networks, gels and various (bio)hybrids in nanotechnology, energy conversion/storage and biomedicine. The recent rapid growth of photoinduced ATRP and RAFT methods has further expanded the array of advanced polymerizations to improve spatiotemporal control and allow tuning of molecular weight distributions.<sup>3,4</sup>

In the framework of this project we will conduct fundamental studies on the formation of complex polymer architectures such as branched, star-like or crosslinked (co)polymers using online reaction monitoring in real time. Photoinduced ATRP (*photo*ATRP) and photoinduced-electron-transfer RAFT (PET-RAFT) polymerizations will be combined with continuous flow chemistry to prepare well-defined, hierarchical polymer nanostructures in a fast, sustainable, and reproducible fashion. Detailed kinetic studies enabled by online reaction monitoring will allow to establish principles for rational design of more robust processes and novel materials.<sup>5</sup> Specifically, temporal control offered by photocontrolled polymerizations combined with the possibility to follow reactions in real time will significantly broaden our fundamental understanding of the formation of complex polymer architectures.

The integrated multi-technique setup at the Dynamic Reaction Monitoring Facility at the University of Bath will be crucial to precisely follow the polymerizations in solution. The combination of advanced high-resolution FlowNMR techniques (1D, 2D, homo-nuclear decoupling, diffusion measurements, etc.) with online mass spectrometry and triple-detection SEC/GPC promises new insights into the formation of precision polymers. From the Monash side, the flow process for the reactions will be developed and followed up. Online monitoring is an ideal tool for flow polymerizations as it allows to include machine-learning algorithms to create self-optimizing routines. This largely accelerates screening of reactions.

References:

1. K. Matyjaszewski, N. V. Tsarevsky, *J. Am. Chem. Soc.* **2014**, *136*, 6513.
2. G. Moad, E. Rizzardo, S. Thang, *Aust. J. Chem.* **2012**, *65*, 985.
3. M. Chen, M. Zhong, J. A. Johnson, *Chem. Rev.* **2016**, *116*, 10167.
4. N. Corrigan, J. Yeow, P. Judzewitsch, J. Xu, C. Boyer, *Angew. Chem. Int. Ed.* **2019**, *131*, 5224.
5. M. Rubens; J. V. Herck; T. Junkers, *ACS Macro Lett.* **2019**, *8*, 1437.

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 23<sup>rd</sup> 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.