

Bath Monash Global PhD Programme in Sustainable Chemical Technologies

Project Title:	Advanced, Tuneable Encapsulates prepared from Biodegradable Polymers and Silica
Supervisor at Bath:	Professor Janet Scott
Supervisors at Monash:	Professor Bart Follink (lead) and Dr Rico Tabor
Home Institution:	Monash University
Indicative period at Host Institution:	12 months with exact dates to be confirmed

Project Summary

There is much current interest in the replacement of polymers that can be sources of microplastic pollution, in consumer goods. Microbeads made from polymers (usually fossil carbon derived) that are non-biodegradable have been banned in “rinse-off” products in many countries, including the UK¹ and recent developments in Europe² and elsewhere suggest that there will be further focus on sources of microplastics. Another potential source of microplastics in consumer goods are the shells of polymer encapsulated materials (encaps), including perfumes and active ingredients such as bleaches used in clothes wash products, thus, more sustainable alternatives for encaps would be desirable. The challenges are not insignificant, as these must be easy (and cheap!) to prepare in processes that are scalable for manufacturing, robust in formulation (not prone to degradation and not overly fragile), effective in delivery (e.g. adhering/not adhering to garments during washing depending on payload to be delivered), and amenable to breakage or bursting to deliver the payload at the correct time.

Follink *et al.*, have wide expertise in the formation of silica shells and core/shell particles³ that are tuneable with regards to robustness and surface characteristics. Their capsules have been shown to be capable of being fine-tuned to be loaded with a range of payloads with controllable release characteristics. Moreover, through appropriate surface modification of the silica shell, these capsules can be targeted to selectively adhere to specific substrate chemistries. Scott *et al.*, have developed a series of biodegradable biopolymer supported emulsions and encaps,⁴ but these can suffer from a lack of robustness (to drying, for example).

In this joint PhD project we propose to combine these technologies, bringing together the expertise at Monash and Bath universities to expand the range of encaps shells that can be produced targeting reinforced and multi-layer shells. Further, as the Bath team have demonstrated the use of continuous membrane emulsification processes⁵ to produce narrow particle size droplet distributions, such processes will be

¹ For example, The Environmental Protection (Microbeads) (England) Regulations, 2017, available from <http://www.legislation.gov.uk/uksi/2017/1312/contents/made>

² ECHA ANNEX XV RESTRICTION REPORT PROPOSAL FOR A RESTRICTION (intentionally added microplastics), 11 January 2019, available from <https://echa.europa.eu/documents/10162/82cc5875-93ae-d7a9-5747-44c698dc19b6>

³ Shane P Meaney, Bart Follink, Rico F Tabor, Synthesis, Characterization, and Applications of Polymer-Silica Core-Shell Microparticle Capsules, *ACS Appl. Mater. Interfaces*, 2018, 10, 43068-43079, and S P Meaney, R F Tabor, B Follink, Synthesis and Characterisation of Robust Emulsion-templated Silica Microcapsules, *J. Colloid Interface Sci.*, 2017, 505, 664-672

⁴ Results not yet published

⁵ J. Coombs O'Brien, L. Torrente-Murciano, D. Mattia, and J. L. Scott Continuous Production of Cellulose Microbeads via Membrane Emulsification, *ACS Sustainable Chem. Eng.*, 2017, 5, 5931–5939.

incorporated into the project to demonstrate the “manufacturability” of the encaps and the Monash expertise in nano-indentation will be employed to test strength and robustness of structures formed, including under a range of conditions simulating use or release in response to stimuli (e.g. change of pH, temperature or humidity).

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 Bath (home or EU students only) or Monash for the course duration (up to a maximum 42 months)
 - *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.

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How to apply

Please express interest for up to three projects in order of preference. Please submit your application at the Home institution of your preferred project. 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 Sunday 12 May.

Monash University

Expressions of interest (Eoi) can be lodged through <https://forms.gle/XkC1TKpqVQh4B4N1A>. The Eoi should provide the following information:

CV including details of citizenship, full transcripts of academic records, evidence of English language level (IELTS or TOEFL), nominate your host institution (ie Bath or Monash), two referees and contact details, indication of which projects are of interest.

University of Bath

Please submit an application through the following link:

https://samis.bath.ac.uk/urd/sits.urd/run/siw_ipp_lgn.login?process=siw_ipp_app&code1=RDUCH-MO01&code2=0001

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 up to three projects you are interested in and rank them in order of preference. Please also include the names of the Bath lead supervisors.