Centre for **Sustainable** Chemical Technologies

MONASH University

UNIVERSITY OF BATH

Bath Monash Global PhD Programme in Sustainable Chemical Technologies

Project Title:	Stabilising biopolymer based hydrogels for delivery of actives.
Supervisors at Bath:	Professor Janet L. Scott (lead) and Professor Karen J. Edler
Supervisors at Monash:	Professor Antonio Patti and Professor Gil Garnier
Home Institution:	University of Bath
Indicative period at Host Institution:	From February 2021 to January 2022

Project Summary

Hydrogels, polymer networks extensively swollen with water, are used in a vast range of applications, including: the production of cell scaffolds for tissue engineering, delivery of drugs and agrochemical active compounds, as thickening agents in foods and formulated products, and as superabsorbent polymers, either for sequestration of liquids, e.g. in diapers, or controlled delivery of liquids, e.g. as water reservoirs in agriculture.

Many synthetic polymer hydrogels are known, but naturally derived particulate hydrogels have recently garnered much attention and combinations of soluble biopolymer and biopolymer nanoparticles offer opportunities for the development of renewably derived and biodegradable hydrogel systems. In all cases biodegradability must be tested (not assumed) and bioresorbability can offer opportunities in medical applications such as tissue scaffolds[1] and slow release of active pharmaceutical ingredients (APIs). Biodegradable hydrogels, which are nonetheless persistent enough to deliver the benefit required, are useful as water retaining soil amendments in agriculture, particularly in climates where rainfall can be intermittent and/or low, such as Australia.

While many examples of hydrogels formed from natural biopolymers, e.g. bacterial cellulose, biopolymer particles, e.g. oxidized cellulose nanofibrils (OCNF), or soluble biopolymers, e.g. chitosan and alginate, exist, crosslinking strategies frequently rely on use of deleterious agents such as gluteraldehyde (which is even used a sterilant as it kills cells, including bacteria). New, more human- and enviro-friendly hydrogel materials and crosslinking strategies are needed.

In this project a range of crosslinking strategies will be evaluated, including use of non-toxic crosslinkers, e.g. poly-acids derived from natural sources or fermentation that can be induced to form reactive anhydrides *in situ*, and enzymatically mediated crosslinking, including of modified biopolymer particles and soluble polymers (at the University of Bath). The materials prepared will be characterized at both 'molecular' and 'materials' levels, and network form and porosity examined by a combination of advanced techniques including in collaboration with colleagues in Brazil, who are developing new NMR based methods for evaluation of porosity, swelling and gelation.[2]

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1 J. C. Courtenay, M. A. Johns, F. Galembeck, C. Deneke, E. M. Lanzoni, C. A. Costa, J. L. Scott, R. I. Sharma, Surface Modified Cellulose Scaffolds for Tissue Engineering, *Cellulose*, 2017, **24**, 253-267; 125. M. A. Johns, Y. H. Bae, F. E. G. Guimarães, E. Lanzoni, C. Costa, P. Murray, C. F Deneke, F. Galembeck, J. L Scott, R. I. Sharma, Predicting ligand-free cell attachment on next generation cellulose-chitosan hydrogels, *ACS Omega*, 2018, **3**, 937–945.

2 J. C. Courtenay, J. G. Filgueris, E. Riberio de Azevêdo, Y. Jin, K. J. Edler, R. I. Sharma and J. L. Scott, Mechanically robust cationic cellulose nanofibril 3D scaffolds with tuneable biomimetic porosity for cell culture, *J Mater. Chem B*, 2019, **7**, 53-64.

To test the materials in application, formation of hydrogel based soil amendments that provide the dual functions of water retention/slow release during times of drought and delivery of actives, including fertilisers and growth enhancers, will be examined. Trials of these materials will be conducted at Monash University and will include 'real' tests on growing plants and evaluation of these materials in formulations to improve existing novel fertilizer preparations.[3] Drying and rehydration will also be examined as this is key to use in large scale applications. Opportunities in tissue engineering will not be ignored, but will form part of a separate PhD project, providing exciting collaborative materials testing opportunities.

The expertise of the two centres is entirely complementary, yet not overlapping, making this a very balanced partnership and providing a PhD student with access to knowledge and skills that could not be gained at a single institution.

[3] B. K. Saha, M. T. Rose, V. N. L. Wong, T. R. Cavagnaro and A. F. Patti, Nitrogen Dynamics in Soil Fertilized with Slow Release Brown Coal-Urea Fertilizers, *Scientific Reports,* 2018, **8**, 14577