Centre for Sustainable & Circular Technologies

UNIVERSITY OF BATH

Centre for Sustainable and Circular Technologies; University of Bath

Project Title:	Novel polymers from renewable feedstocks: synthesis, catalysis, and applications
Lead Supervisor and co-supervisors:	Prof Matthew Davidson; Dr Antoine Buchard chsmgd@bath.ac.uk; a.buchard@bath.ac.uk
Industrial Partner:	Multinational Polymer Manufacturer

Project Summary

Applications are invited for a 3.5 year PhD studentship across the Davidson and Buchard groups in the Department of Chemistry at the University of Bath, UK. In this project you will develop innovative synthetic and catalytic methodologies to produce novel monomers and polymers for sustainable materials, and investigate their applications, in collaboration with industrial partners.

The monomers targeted will combine natural molecules (e.g., sugars) and their derivatives (e.g., furans) with diverse functional groups and linkages (e.g., esters, carbonates, amides). These monomers will be polymerised using a range of polymerisation techniques (e.g., ring-opening polymerization, polycondensation) and the analysis of the resulting materials (thermal, mechanical, degradability) undertaken to establish their structure/properties relationship. Natural sugars are non-toxic, biodegradable, biocompatible, abundant, and a diverse resource which is highly functionalisable. By incorporating sugar units into polymer backbones, these desirable features can be imparted to the resulting polymers, and their properties can be adjusted to meet specific material needs. Furans are sugar derivatives that are promising monomers for the replacement of petrochemical feedstocks in semi-aromatic polyesters and aramids.

Training:

The student undertaking this interdisciplinary project will receive training in a wide variety of experimental and computational techniques at the molecular and macromolecular level, and will gain expertise across chemistry and material science. Synthesis of organic compounds (monomers) and polymers (via catalysis and controlled living methodologies) will be required during the project. Rigorous thermomechanical characterization of polymer materials will then be performed. These experimental skills will be complemented by training in computational chemistry (Density Functional Theory, Molecular Mechanics) for mechanistic and structural studies, including polymer modelling. As catalyst development and material applications is being explored, students will work closely with our industrial collaborators and partners in the UK Catalysis Hub to understand the structure/properties relationship of the polymers made and work towards their scale-up manufacture and real-life applications. The student will finally have opportunities to present their work at group meetings, departmental seminars and suitable national and/or international conferences, as well as to be involved in the University of Bath teaching activities.

Sustainability issues addressed

Amidst the environmental persistence and reliance on fossil-based resources of the most common polymers, polymers based on renewable resources, and which can be degraded, have been investigated as alternatives. This project aims to develop innovative synthetic and catalytic methodologies to produce novel monomers and polymers for sustainable materials, and investigate their applications. Sustainable catalyst development will focus on benign and widely earth abundant materials.

It will be conducted across the teams of Prof Davidson and Dr Buchard.

The Davidson group focuses on multidisciplinary aspects of sustainable chemistry including chemical, materials and catalytic aspects of bioplastics, biofuels & biorefineries. Pioneering work initiated in 1999-2000 has focused on the use of more environmentally friendly metals such as titanium as replacements for heavy metals such as tin, antimony and mercury in industrial polymerisation processes such as PET and PU manufacture, as well as for the ring-opening polymerisation (ROP) of lactide, including at pilot scale.

Research in the Buchard group addresses all aspects of the development of sustainable polymers. We develop new reactions for the synthesis of novel monomers from renewable feedstocks, design new polymerisation catalysts and processes, and produce innovative polymers for new technologies. Our group have for example discovered a method that replaces phosgene for the synthesis of cyclic carbonate monomers. We have successfully applied this protocol to various sugar derivatives and developed promising degradable polymers for packaging applications as well as battery electrolyte applications. We have also recently reported divergent stereoselective polymerisation catalytic strategies that can direct a polymer's properties between a soft amorphous material and a hard semicrystalline material, as well as the first example of a stereocomplex between carbohydrate polymers of opposite chirality (see references).

Recent publications from the Davidson group:

[1] ChemSusChem 2022, e20220025.

[2] Green Chemistry, 2021, p 3154.

[3] Biomacromolecules, 2021, p 3649.

[4] Green Chemistry, 2020, p 2197.

[5] Organometallics, 2020, p 1619.

For complete list of publications see: https://researchportal.bath.ac.uk/en/persons/matthew-davidson

Recent publications from the Buchard:

[1] Journal of Material Chemistry A, 2022, DOI: 10.1039/d1ta10111k.

[2] ACS Applied Polymer Materials, 2021, p 5870.

[3] Angewandte Chemie International Edition, 2021, p 4524.

[4] Journal of the American Chemical Society 2019, p 13301.

[5] Journal of CO_2 Utilization 2018, p 283.

For complete list of publications see: www.buchardgroup.org/publications

Eligibility criteria and selection process

Application:

Formal applications should be made via the University of Bath's online application form for a PhD in Chemistry. Please ensure that you state the full project title and lead supervisor name on the application form.

https://samis.bath.ac.uk/urd/sits.urd/run/siw_ipp_lgn.login?process=siw_ipp_app&code1=RDUCH-FP01&code2=0016

Funding Eligibility:

This studentship is for 3.5 years' duration and includes Home tuition fees, a stipend (£16,062 per annum, 2022/23 rate) and a budget for research expenses and training.

Information may be found on our fee status guidance webpage, on the GOV.UK website and on the UKCISA website.

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