Centre for Sustainable & Circular Technologies

Centre for Sustainable and Circular Technologies; University of Bath

Project Title:	Novel polymers from sugars: synthesis, catalysis, and applications
Lead Supervisor and co-supervisors:	Dr Antoine Buchard
International Partner:	University of Minnesota

Project Summary

Applications are invited for a 3.5 year PhD studentship in the Buchard group (www.buchardgroup.org) 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.

The monomers targeted will combine natural sugar molecules and their derivatives with diverse functional groups and linkages. These monomers will be polymerised using controlled polymerisation techniques 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. In particular, the development of novel polymeric systems to form nanostructures by supramolecular assembly, and their applications as polymeric vehicles for nucleic acid delivery and novel therapeutics, will be explored. This part of the project is a collaboration with the Reineke group (www.reinekegroup.org) in the Department of Chemistry at the University of Minnesota (UMN), and will involve regular interactions between our two groups and secondments to the US.

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, biology and material science. Synthesis of organic compounds (monomers) and polymers (via catalysis and controlled living methodologies) will be required during the project. Rigorous physicochemical 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 applications in nanomedicine is being explored, the student will work closely with our collaborators at UMN to understand the biological activity of the polymers made and test them as non-viral delivery vehicles. In vitro biological screening of delivery efficiency and toxicity will be carried out using several assays. 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

This project aims to develop innovative synthetic and catalytic methodologies to produce novel monomers and polymers for sustainable materials, and investigate their applications. It will be conducted in the Buchard group whose research 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 recently discovered a method that replaces phosgene for the synthesis of cyclic carbonate monomers. We have successfully applied this protocol to various sugar derivatives (mannose, thymidine…) and developed promising tuneable, biocompatible and biodegradable polymers, which were also used as tissue engineering scaffolds for regenerative medicine. Furthermore, we have recently reported divergent stereoselective polymerization catalytic strategies that can direct a polymer's properties between a soft amorphous material and a hard semicrystalline material, as well as some reusable heterogeneous metal polymerisation catalysts that leave little metal residue behind (see references). At UMN, the Reineke Group specialises in the synthetic chemical design, molecular characterisation, and biological study of novel macromolecules.

Group website: www.buchardgroup.org

List of publications: www.buchardgroup.org/publications

For recent publications see below:

[1] Journal of the American Chemical Society 2019, p13301;

[2] Macromolecules 2019, p1220;

[3] Journal of CO2Utilization 2018, p283;

[4] Polymer Chemistry 2018, p1577; [

5] Polymer Chemistry 2017, p1714;

[6] Macromolecules 2016, 7165.

Reineke Group website and list of publications: www.reinekegroup.org