THE UNIVERSITY of EDINBURGH
School of Chemistry

EastBio DTP – Polyester depolymerisation mediated by artificial metalloenzymes

An estimated 31.9 million tonnes of mismanaged plastic waste enters the environment annually (1), contaminating oceans and terrestrial ecosystems. This poses a severe threat to the environment and wildlife, and also results in the loss of a valuable carbon source. While some plastics can be mechanically recycled, this rapidly diminishes the material properties until the recyclate is no longer useful. Chemical recycling to monomer is therefore emerging as an important complementary technique, where the monomer can be re-polymerised into materials with properties comparable to virgin plastics.

The use of biotechnology solutions to depolymerise plastic waste is a growing area of interest, with lipases, cutinases and PETases reported for poly(ethylene terephthalate) (PET) depolymerisation (2). While most enzymes can only depolymerise amorphous PET, exciting recent advances suggest that enzymes can depolymerise crystalline PET under certain conditions (3). This is a key finding, as incomplete depolymerisation can generate damaging microplastics. In contrast, most metal-based catalysts can depolymerise both amorphous and crystalline regions of PET, yet generally use harsh reaction conditions. Due to stability issues, this limits the use of ligands designed to enhance catalyst activity, although recent studies have shown that half-salen zinc catalysts can effectively depolymerise polyesters (4).

This collaborative project will harness the power of both enzymes and metal-based catalysts, by incorporating metal-salen complexes into artificial metalloenzymes designed to stabilise the metal-salen and direct the polymer towards the active site. The catalysts will be explored for polyester depolymerisation, specifically investigating poly(lactic acid) (PLA) and poly(ethylene furanoate) (PEF). These two materials are emerging as next-generation green polyesters; both are bio-based, non-toxic, and generate lower CO2 emissions than some conventional plastics. (5) Several studies, including our own research, have shown that salen complexes can be successfully incorporated into artificial metalloenzymes to deliver enhanced catalyst performance, yet the use of artificial metalloenzymes remains underexplored in depolymerisation (6). The catalysts will be optimised by modulating the salen structure, including the use of chiral salens for depolymerising PLA of different tacticity.

This project supervised by Dr Jenny Garden and Dr Amanda Jarvis would suit a student interested in sustainability and interdisciplinary research, and training will be provided in molecular biology, synthetic chemistry and analysis.

References

1. Rochman, Science, 2018, 360(6384), 28
2. Wu et al., Chem. Sci., 2024, 15, 6200
3. Kaabel et al., Proc. Nat. Acad. Sci, 2021, 118(29), e2026452118
4. Stewart et al., Catal. Today, 2025, 445, 115037
5. Kumar et al., ACS Sustain. Chem. Eng., 2024, 12(26), 9658
6. Liu et al., Proc. Nat. Acad. Sci., 2023, 120(43), e2308286120

Funding Notes

This opportunity is open to UK and international students and provides funding covering stipend and UK level tuition fees. The University of Edinburgh covers the difference between home and international fees meaning that the EastBio DTP offers fully-funded studentships to all appointees. There is a cap on the number of international students the DTP recruits. It is therefore important for us to know from the outset which fees status category applicants will fall under when applying to the University.

Please refer to UKRI website for full eligibility criteria: 'Get a studentship to fund your doctorate – UKRI' https://www.ukri.org/apply-for-funding/studentships-and-doctoral-training/get-a-studentship-to-fund-your-doctorate/

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How to Apply
Closing date is Friday 17 January 2025, 11.59 pm GMT.

This 4-year PhD project is part of a competition funded by EastBio BBSRC Doctoral Training Partnership (DTP). For detailed guidance on the application process and the EastBio Application and Reference Forms, please see:

https://biology.ed.ac.uk/eastbio/how-to-apply

Please send your completed EastBio Application Form and a copy of your academic transcripts in pdf format to the Chemistry Graduate School, email: chemistry.gradschool@ed.ac.uk

Please also contact your referees and ask them to submit their references on the EastBio reference form template to Chemistry Graduate School, email: chemistry.gradschool@ed.ac.uk by the application deadline of 17 January 2025.

Equality and Diversity
The School of Chemistry holds a Silver Athena SWAN award in recognition of our commitment to advance gender equality in higher education. The University is a member of the Race Equality Charter and is a Stonewall Scotland Diversity Champion, actively promoting LGBT equality.

The University has a range of initiatives to support a family friendly working environment.

For further information, please see our University Initiatives website:

https://equality-diversity.ed.ac.uk/inclusion/family-and-carer