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Towards a Circular Textile Economy: Enzymatic Recycling of Textile Fibres

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To which domain did you submit your proposal?

Textiles

What are you exploring? With what objective?

We want to investigate the effect of combining hydrolytic enzymes (such as PET degrading enzymes, Figure 1) with oxidative enzymes (such as cellulose-degrading enzymes, Figure 2) for the back-to-monomer recycling of blended textiles. Enzymatic depolymerisation methods are often highly selective towards a single polymer, so they could be applied directly to blended textile waste streams. This contrasts with mechanical recycling which requires highly pure polymers as starting materials. The obtained monomers can be re-used in high-value applications. This method will provide a proof-of-principle for biotechnological recycling of blended textiles containing natural cellulose and fossil-based polyesters such as PET.

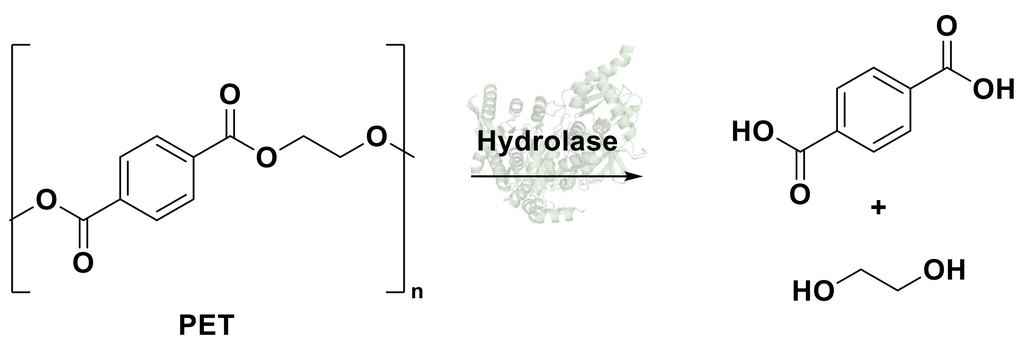

Figure 1: Activity of hydrolase enzymes towards PET.

Why is this interesting scientifically?

An obstacle to the application of hydrolytic enzymes for textile recycling is the crystalline nature of textile fibres, which makes them poorly accessible for enzymatic attack. In this project, we will explore the potential of oxidative enzymes to facilitate the degradation of crystalline polyester and cellulose fibres from textiles by hydrolytic enzymes. None of the proposed oxidative enzyme systems have been studied for textile recycling before, to the best of our knowledge, and their application to facilitate the back-to-monomer recycling of mixtures of cellulose and polyesters, such as blended textiles, is a novel approach. In this way, proof-of-concept will be generated for a novel recycling method for fibres from blended textiles.

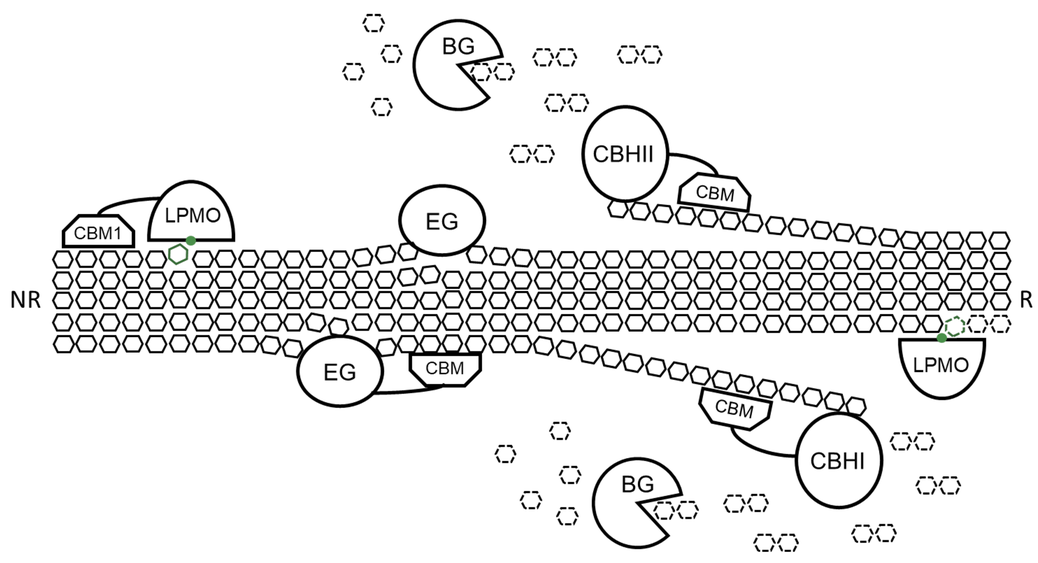

Figure 2: Activity of carbohydrate-active enzymes for the degradation of cellulose.

What are the key activities or steps?

- Selection of suitable oxidative enzymes based on literature analysis and previous experience.
- Production of selected oxidative enzymes in a heterologous host organism (or purchase if commercially available).
- Test selected oxidative enzymes for their capacity to oxidatively cleave cellulose (e.g. cotton) and polyester textile fibres, thereby increasing their accessibility to degradation by hydrolytic enzymes.
- Investigate the necessity of mild pre-treatments of the textile prior to enzymatic degradation (e.g. thermal or mechanical treatments) will also be considered.

What are key deliverables?

- An important milestone for the project is to demonstrate at a proof-of-principle level that the developed technology can be applied to an actual blended textile material. The best combination of cellulose and/or polyester degrading enzymes will be selected for this demonstration experiment. The outcome will be considered an additional deliverable, next to the deliverables from the call text (short summary document, presentations at community meetings, final report)

How is this relevant to the materials transition?

The proposed strategy will provide a solution for the recycling of currently non-recyclable textile waste, preventing emission of carbon from these materials as CO_2 upon incineration or their accumulation in landfills, thereby contributing to a circular textile economy.

On what issues would you like to get input from others?

- Do you know of some practical examples of blended textiles or blended textile waste streams that could benefit from the technology proposed here?
- Do you know of any oxidative or hydrolytic enzymes (available in-house) that could aid our study?

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